

Variations Among Spanish Regions in the Use of Three Cardiovascular Technologies

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Introduction and objectives. There is evidence that some geographic variations in the use of medical technologies are not explained by differences in disease burden. The objectives of this study were to quantify variability in the use of percutaneous coronary intervention (PCI), implantable cardioverter-defibrillators (ICDs), and cardiac resynchronization therapy (CRT) in Spanish autonomous regions and to try to explain the variability found for the first two technologies.

Methods. Linear regression models were developed in which the number of procedures performed per million population (pmp) in 2003 in each autonomous region was the dependent variable. Independent variables used included indices of technology provision, regional wealth, and disease burden.

Results. For PCI, the mean utilization rate for the whole of Spain was 1038 procedures pmp, with a high-low ratio of 1.95. Differences in gross domestic product explained 21% of the variability, but there was no relationship between the number of procedures performed and disease burden. For ICDs, the mean number of procedures performed in the whole of Spain was 46 pmp, with a high-low ratio of 3.04. As for PCI, differences in regional wealth explained 40% of the variability, with disease burden making no contribution. For CRT, the mean number of procedures performed in Spain in 2003 was 15 pmp, with a high-low ratio of 15.7.

Conclusions. The considerable regional variation that exists in the use of these three medical technologies is principally explained by differences in regional wealth and not in disease burden.

Key words: Cardiovascular disease. Percutaneous coronary intervention. Implantable cardioverter-defibrillator. Cardiac resynchronization therapy.

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Variabilidad entre comunidades autónomas en el uso de tres tecnologías cardiovasculares

Introducción y objetivos. Hay evidencia de variabilidad geográfica en el uso de tecnologías médicas no explicada por diferencias en la carga de enfermedad. El objetivo de este trabajo es describir la variabilidad entre comunidades autónomas en el uso de intervenciones coronarias percutáneas (ICP), desfibriladores automáticos implantables (DAI) y terapia de resincronización cardiaca (TRC), y tratar de explicar la variabilidad encontrada en las dos primeras.

Métodos. Se construyen modelos de regresión lineal en los que se utilizan como variables dependientes el número de procedimientos realizados por millón de habitantes en cada comunidad autónoma en el año 2003. Como variables independientes se emplearon indicadores de oferta, de riqueza regional y de carga de enfermedad.

Resultados. Para la ICP, la media para todo el país es de 1.038 procedimientos/10⁶ habitantes, con una razón de variación de 1,95. El producto interior bruto explica el 21% de la variabilidad, sin que haya relación entre el número de procedimientos y la carga de enfermedad. En cuanto al DAI, el promedio de procedimientos realizados en todo el país es de 46/10⁶ habitantes, con una razón de variación de 3,04. Al igual que en el caso de las ICP, la riqueza regional explica el 40% de la variabilidad, a la que no contribuye la carga de enfermedad. Respecto a la TRC, durante el año 2003 se realizó en España una media de 15 procedimientos/10⁶ habitantes, con una razón de variación de 15,7.

Conclusiones. Hay una importante variabilidad intercomunitaria en el uso de estas tecnologías que está fundamentalmente explicada por la riqueza regional, pero no por la carga de enfermedad.

Palabras clave: Enfermedades cardiovasculares. Intervención coronaria percutánea. Desfibrilador automático implantable. Terapia de resincronización cardiaca.

ABBREVIATIONS

ICD: implantable cardioverter-defibrillators
 AMI: Acute myocardial infarction
 PCI: percutaneous coronary intervention
 GDP: gross domestic product
 CRT: cardiac resynchronization therapy

INTRODUCTION

Cardiovascular disease is the leading cause of death and hospitalization in the Spanish population and absorbs a large part of healthcare expenditures.¹ Ischemic heart disease causes the greatest number of deaths, 31%, out of the total of this group of pathological processes. Nearly two out of three deaths from ischemic disease are due to acute myocardial infarction (AMI). In 2002, the crude hospitalization rate due to ischemic heart disease in Spain was 365 per 100 000 population;² this figure increases considerably with age and triples in those older than 70 years. Congestive heart failure is the third cause of death from cardiovascular disease in Spain, after ischemic heart disease and stroke.³ This disease also causes some 80 000 hospital admissions per year, which is around 5% of all hospitalizations in those over 65 years old.⁴ Its prevalence is increasing due, among other reasons, to the aging of the population and progress in treating ischemic heart disease leading to greater survival rates among patients with AMI.⁵

Even though there has been a slight but constant decrease in mortality from ischemic heart disease in the last two decades in Spain,⁶ as in other developed countries, the burden involved in these processes on the healthcare service continues to increase.

Among the advances in preventing and treating cardiovascular disease, three technologies were introduced during different periods: percutaneous coronary intervention (PCI), implantable cardioverter-defibrillators (ICD) and cardiac resynchronization therapy (CRT).

Percutaneous coronary intervention began to be performed in the mid-1980s as an alternative to coronary artery bypass graft surgery in patients with ischemic heart disease. The method improved when stents were introduced at the beginning of the 1990s, and more recently with drug-eluting stents. Implantable cardioverter-defibrillators were introduced in Spain in 1985, although they were not disseminated until 1990, thanks to an intravenous implantation system that eliminated the need for thoracotomy. Implantable cardioverter-defibrillators are indicated in preventing sudden death due to arrhythmia in patients with AMI and reduced ejection fraction (<35%).^{7,8} The Spanish Society of Cardiology has published a Clinical Practice

Guideline on ICD.⁹ Cardiac resynchronization therapy is a more recent technique that began to be disseminated commercially at the end of the 1990s, although it continues to be used in Spain less than the two previous approaches. Its main indication is congestive heart failure with intraventricular conduction defects that produce dyssynchrony. There are devices with pacemakers (CRT-P) and defibrillators (CRT-D). The results from two major clinical trials have demonstrated that ventricular resynchronization with pacemakers improves symptoms, decreases hospitalization and reduces mortality in selected patients.^{10,11} Thus, the European Society of Cardiology recommends their use in patients with reduced ejection fraction and ventricular dyssynchrony that continues to be symptomatic despite optimal treatment.¹²

The existence of an effective technology does not guarantee that all the people who need it have access to it. Different studies have demonstrated that there is geographical variability in coronary angiography and coronary revascularization procedures that is not explained by differences in disease burden. It has been found in some countries that people more in need of healthcare are frequently those who are less likely to receive it, which been called the "inverse care law."^{13,14} For example, in the United Kingdom, some researchers have found a significant relationship between higher angina rates, lower socioeconomic level, greater mortality from coronary disease, and less use of revascularization procedures.^{15,16} Data from another study done in the United Kingdom also demonstrate significant differences between regions in ICD implantation, with fewer implantations in the most depressed regions.¹⁷ In 2000, the British National Institute for Clinical Excellence (NICE) published a guideline with recommendations on patients with indications for ICD.⁷ In that year, most European countries, including Spain, had an implantation rate per million population far lower than the NICE recommendations.^{18,19}

Different studies done in Spain have confirmed the existence of variability between regions and hospitals in treating AMI, regarding both diagnostic and therapeutic techniques.^{20,21} The results of a more recent work have study showed that the use of coronary angiography in Spain is related to regional wealth, but not to the ischemic heart disease burden.²² Similarly, it has been found that PCI rates per Spanish autonomous region are associated with wealth, but not with the incidence of AMI.²³

The distribution pattern of established medical technologies can be studied in a specific country, since their use represents local patterns over time. However, the new technologies, such as CRT, tend to be initially adopted by those at leading research centers. For these reasons, the aim of this study is to describe the variability between Spanish regions in the use of PCI, ICD and CRT, and to try to explain the variability found regarding the first two.

METHODS

Design

Explanatory models of different cardiovascular technologies in use in relation to supply, demand, and wealth variables.

Study Area

Spain and its autonomous regions in 2003 (except for Ceuta and Melilla).

Data Source

Data on the number of PCI and the centers where this is done come from the Hemodynamics Register of the Spanish Society of Cardiology (Registro de Hemodinámica de la Sociedad Española de Cardiología).²⁴ Information on the number of catheterization specialists, ICD, CRT devices, and centers where they are implanted was facilitated by the company Guidant and is based on an estimation of the entire market (personal communication). The gross domestic product (GDP) and healthcare expenditures per capita in 2003 were obtained from the Spanish National Institute of Statistics (INE) and the Spanish Ministry of Health and Consumer Affairs (Ministerio de salud y consumo, [MSC]), respectively.^{25,26} The incidence of AMI in 2002 comes from a Spanish study²⁷ where estimations were done by Spanish region, extrapolating the results of the MONICA-Catalonia,²⁸ REGICOR,²⁹ and IBERIAN²⁰ population studies to the regions that lacked population records. The data necessary for adjusting the values of ischemic heart disease rates per autonomous region in relation to the balance of patient transfer between regions were obtained from the INE.³⁰

Variables

Dependent Variables

Number of procedures (PCI, ICD, CRT) done per autonomous region (excluding Ceuta and Melilla) per million population.

Independent Variables

- Supply variables: number of centers where each procedure is done and the number of catheterization specialists.
- Regional wealth and resources allocated to healthcare: GDP and per capita healthcare expenditure.
- Demand variable: incidence of AMI.

Adjustment Variables

Balance of patients transferred between autonomous regions. The incidence estimators provide figures on

disease burden for each autonomous region. However, the actual disease burden is not the estimated number, but number of cases attended; thus, the burden indicators have to be adjusted in relation to the balance of patient transfer between regions to have a more accurate idea of the real disease burden each one serves. The interregional balance is calculated as the difference between the proportion of patients from other autonomous regions attended and the proportion of residents attended in other regions. There are no data on interregional patient transfers for the procedures under study, and thus the balance of patient transfer for ischemic heart disease (code ICD-9 410-414) has been calculated using the data from the 2003 hospital morbidity survey in Spain.

Statistical Analysis

The Kolmogorov-Smirnov test was used to verify the normal distribution of variables and a descriptive analysis was performed using measures of central tendency. The ratio and coefficient of variation were used as indicators of variability.^{31,32} The Pearson correlation coefficient was calculated between dependent and independent variables (ie, assessment of association), and between independent variables (assessment of collinearity), and in certain cases they were adjusted for disease burden. Finally, the influence of the independent variables on the number of procedures done was analyzed, adjusted for disease burden, through multiple linear regression models. An association between variables was accepted when the *P* value of the coefficient of the explanatory variable was less than .05. All the statistical analyses were done with the SPSS statistical package version 12.

RESULTS

Table 1 presents the data on the implementation of the three procedures under study, the centers where they are done, wealth, the balance of patient transfer and the disease burden (incidence of AMI) per autonomous region, listed according to per capita GDP.

Table 2 shows discharges following ischemic heart disease (code ICD-9 410-414) according to the autonomous region of residency and hospitalization data from the hospital morbidity survey of 2003. These data are the ones used for calculating the balance of transfer rate between regions.

Table 3 gives the general description of the variables. All the variables used for the analysis had a normal distribution, except for the number of CRT which shows positive skew due to the presence of abnormally high values compared to the average. The average number of procedures strongly varies between PCI (average, 1038/10⁶ population) and CRT (average, 15/10⁶ population). The variability, expressed as the ratio of variation (RV), is smaller for PCI (RV=1.9) than for

TABLE 1. Data on Procedures, Supply, Wealth, and Incidence of Acute Myocardial Infarction by Spanish Region Listed According to Gross Domestic Product

Region	Per Capita GDP (€1000)	PCI/10 ⁶ Population	ICD/10 ⁶ Population	CRT/10 ⁶ Population	Catheterization Specialists/Population	PCI Centers/10 ⁶ Population	ICD Centers/10 ⁶ Population	CRT Centers/10 ⁶ Population	Health Expenditure (€1000)	Expected AMI/10 ⁶ Population	Interregional Balance of Patient Transfer	Expected AMI Adjusted for Balance of Transfer
Extremadura	12.01	784		11	2.8	1.86		0.93	1.00	1744.56	-2.49%	1744.13
Andalusia	13.83	808	28	16	5.5	1.97	0.92	1.05	0.89	1376.49	0.84%	1376.61
Galicia	14.51	977	37	5	5.1	1.82	1.09	1.09	0.92	1905.48	0.51%	1905.58
Castilla-La Mancha	14.55	716	26	6	4.4	1.65	1.10	1.10	0.98	1792.89	-6.44%	1791.74
Asturias	15.50	737	51	3	3.7	1.86	0.93	0.93	0.99	1939.53	-1.26	1939.29
Murcia	15.73	1,211	35	13	6.7	2.36	0.79	2.01	0.94	1735.14	1.17%	1735.34
Castilla y León	16.98	879	41	13	5.2	1.61	1.61	2.01	0.97	2101.70	-4.06%	2100.85
Canary Islands	17.10	1357	38	32	6.9	3.17	1.59	1.58	0.92	1208.40	0.10%	1208.42
Community of Valencia	17.31	955	47	19	6.3	3.13	1.34	1.79	0.81	1518.24	2.53%	1518.63
Cantabria	17.79	1333	71	5	7.3	1.82	1.82	1.82	1.11	1783.23	20.87%	1786.95
Aragón	19.71	990	54	11	4.1	1.63	1.63	1.63	1.02	1997.51	-2.32%	1997.05
La Rioja	20.71								1.12	1796.79	-26.79%	1791.97
Catalonia	21.70	809	38	15	5.2	2.24	1.79	1.64	0.91	1731.21	0.56%	1731.30
Balearic Islands	22.19	1079	38		6.3	4.22	1.05		0.81	1560.58	2.88%	1561.03
Basque Country	22.66	1357	53	13	10.9	2.84	1.42	2.37	0.98	1696.64	-0.25%	1696.60
Navarra	23.00	1394	61	47	6.9	3.46	2.00	3.46	1.11	2011.84	4.88%	2012.82
Madrid	24.37	1225	79	16	9.3	3.32	1.92	1.57	0.92	1481.41	4.40%	1482.07

ICD: implantable cardioverter-defibrillator; AMI: acute myocardial infarction; PCI: percutaneous coronary intervention; GDP: gross domestic product; CRT: cardiac resynchronization therapy.

CRT devices (RV=15.7), whereas ICD occupies an intermediate position (RV=3.0). Finally, adjusting for the balance of patient transfer between regions barely has an effect on the average incidence of AMI per million population.

Percutaneous Coronary Intervention

Figure 1 shows the number of procedures and centers where PCI is done (per million population) in each Spanish region. The average for the entire country is 1038 PCI per million population, ranging between a maximum of 1394 for Navarra and a minimum of 716 for Castilla-La Mancha. No PCI was done in La Rioja. The coefficient of variation between autonomous regions is 23.4%. The average number of centers that perform this technique is 2.4/10⁶ population for the whole of Spain, varying between 1.61 for Castilla y León and 4.22 for the Balearic Islands. In addition, Figure 2 shows the number of catheterization specialists per million population, indicating an average of 6.04 for the entire country, with a minimum value of 2.8 in Extremadura and a maximum of 10.9 in the Basque Country.

Table 4 presents the correlation analysis between the number of PCI and the different variables. No correlation was found between the number of procedures and the disease burden. On the contrary, and as expected, there was a correlation between the number of procedures and the number of centers that perform them ($r=0.557$; $P=.025$), and between the number of procedures and the number of catheterization interventional cardiologists ($r=0.786$; $P<.001$). Finally, a positive correlation was found between the number of PCI per million population and regional wealth, expressed through per capita GDP ($r=0.564$; $P=.023$), similar to the one found with the number of centers ($r=0.557$) and which is maintained when adjusting for disease burden ($r=0.563$; $P=.029$). Thus, the number of PCI is not associated with disease burden, but is associated with the wealth of each Spanish region.

The high correlation between the supply variables (number of centers and catheterization specialists) and wealth (per capita GDP) presented in Table 5 indicates that there is collinearity between the two independent variables, therefore the linear regression analysis was done exclusively with the per capita GDP.

The linear relation analysis done via regression models shows that the per capita GDP explains 27% of the variability in the number of PCI between different Spanish regions ($R^2=0.269$), with 36 procedures more being done per each 1000 € increase in GDP ($\beta=36.4$; $P=.023$). This result is maintained when the effect of the disease burden on GDP is controlled for via multiple regression models. The multiple regression model explains 21% of the

TABLE 2. Discharges Following Ischemic Heart Disease (ICD-9 410-414). Survey of Hospital Morbidity 2003

Autonomous Region of Residency	Autonomous Region of Hospitalization																Total			
	Andalucía	Aragón	Asturias	Balearic Islands	Canarias	Canary Islands	Castilla y León	Castilla-La Mancha	Catalonia	Community of Valencia	Extremadura	Galicia	Madrid	Murcia	Navarra	Basque Country		La Rioja	Ceuta	Melilla
Andalusia	23082	1	1	6	0	1	5	10	29	22	11	10	98	5	13	2	1	2	0	23299
Aragón	5	3735	0	0	0	3	3	3	99	19	1	0	19	1	29	2	1	0	0	3920
Asturias	3	2	4146	2	0	3	28	0	4	14	0	15	9	8	3	0	0	0	0	4237
Balearic Islands	3	0	0	2648	1	0	0	2	18	4	3	1	8	0	0	0	0	0	0	2688
Canary Islands	5	0	0	2	4869	0	3	0	2	1	1	1	14	5	4	0	0	0	0	4907
Cantabria	1	1	3	1	0	1203	4	0	2	4	0	0	2	0	1	34	0	0	0	1256
Castilla y León	9	4	7	3	3	100	8430	19	7	39	5	14	372	4	10	100	1	0	0	9127
Castilla-La Mancha	8	3	2	4	1	1	5	5308	4	48	2	2	470	17	2	0	0	0	0	5877
Catalonia	43	23	0	8	0	6	28	10	20546	42	11	29	11	4	3	0	1	1	0	20766
Community of Valencia	20	29	5	6	0	2	6	20	19	16648	3	5	23	26	10	1	1	1	0	16825
Extremadura	12	2	0	0	0	0	40	8	11	4	3823	0	107	1	3	1	0	0	0	4012
Galicia	7	0	2	4	3	0	14	2	8	12	0	9308	28	0	7	3	0	0	0	9398
Madrid	67	3	12	8	1	13	125	102	14	129	37	27	14254	44	8	3	3	0	0	14850
Murcia	3	3	0	2	0	0	1	2	2	16	1	3	37	4052	5	2	0	0	0	4129
Navarra	1	2	1	1	1	1	3	0	4	11	0	2	1	4	1501	16	8	0	0	1557
Basque Country	9	4	1	2	0	22	33	0	9	34	11	19	11	1	12	6814	23	0	0	7005
La Rioja	1	8	1	0	0	251	5	0	0	1	0	0	1	0	28	3	608	0	0	907
Ceuta	44	0	0	0	0	0	0	0	3	0	0	0	63	1	1	0	0	200	0	312
Melilla	76	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	145	245
Foreign	91	7	2	72	33	0	10	0	104	219	1	11	11	6	0	6	1	0	14	588
Total	23490	3827	4183	2769	4912	1606	8743	5486	20885	17267	3910	9447	15563	4179	1640	6987	648	204	159	135905

variability, with no relationship between the number of procedures and the disease burden (Table 6).

Implantable Cardioverter-Defibrillators

Figure 3 presents the number of procedures and centers where ICD were implanted (per million population) in each region. In 2003, an average of 46 implantations/10⁶ population were done in Spain, with a minimum of 26 implantations/10⁶ population in Castilla-La Mancha and a maximum of 79 implantations/10⁶ population in Madrid, excluding Extremadura and La Rioja, two regions where no implantation was done. The coefficient of variation between autonomous regions is 32.6%. The average number of centers that do these procedures in the whole of Spain was 1.3 centers/10⁶ population, ranging between 0.79 centers/10⁶ population in Murcia and 2 centers/10⁶ population in Navarra.

Table 7 shows the correlation analysis between the number of ICD and other variables of interest. Similar to the case of PCI, no correlation was found between the number of ICD implantations and disease burden. The association was maintained between the number of procedures and the number of centers that do them ($r=0.679$; $P=.005$), although no relationship was found between the number of implantations and the number of catheterization specialists ($r=0.498$; $P=.059$). Once again, a positive correlation was found between the number of ICD/10⁶ population and regional wealth ($r=0.615$; $P=.015$), that is maintained and even increases when adjusted for disease burden ($r=0.636$; $P=.015$). These results indicate that the number of ICD implantations is not related to the burden of ischemic heart disease in each region, but to its wealth. Furthermore, collinearity was found between the number of centers that implant ICD and the per capita GDP (Table 5), which means that only the wealth variables were included in the regression analysis.

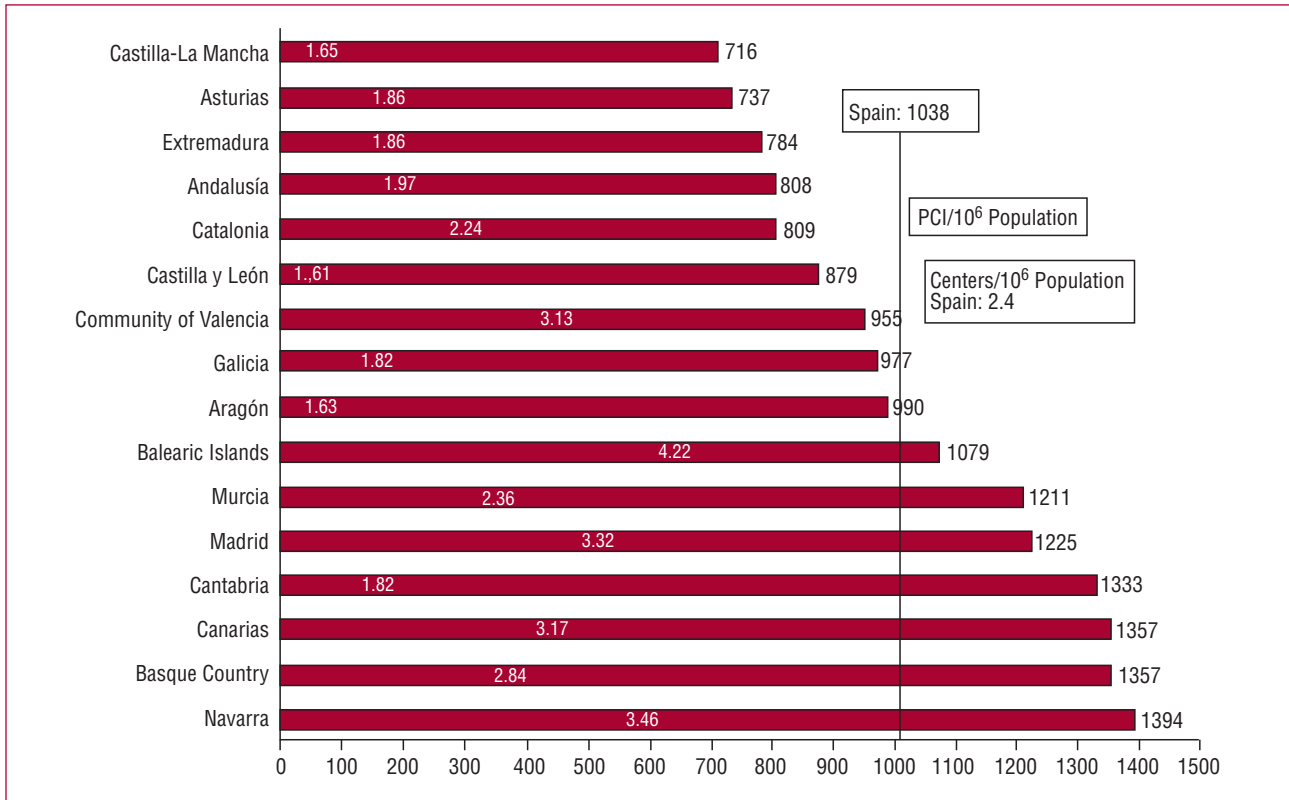


Figure 1. Number of percutaneous coronary interventions (PCI) and PCI centers per million population, according to autonomous region, 2003. Source: Spanish Registry of Hemodynamic and Interventionist Cardiology, Spanish Society of Cardiology, 2003.

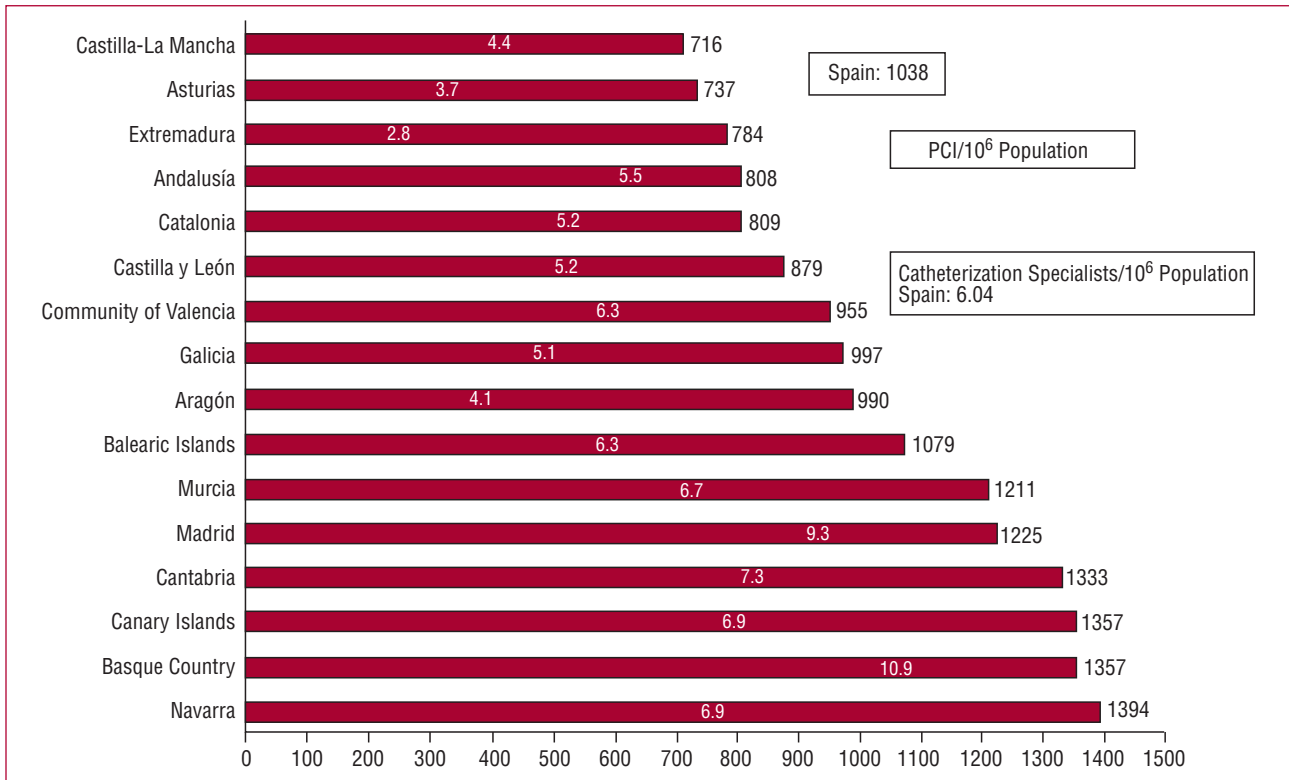


Figure 2. Number of percutaneous coronary interventions (PCI) and catheterization specialists per million population, according to Spanish autonomous region, 2003. Source: Spanish Registry of Hemodynamic and Interventionist Cardiology, Spanish Society of Cardiology, 2003 (number of PCI); Guidant, S.A. (number of catheterization specialists).

TABLE 3. Description of the Analysis Variables

Variables	No.	Mean	(SD)	Minimum	Maximum	Ratio of Variation
PCI/10 ⁶ population	16	1038.2	243.1	716	1394	1.9
ICD/10 ⁶ population	15	46.5	15.2	26	79	3.0
CRT/10 ⁶ population	15	15.0	11.3	3	47	15.7
Centers performing PCI/10 ⁶ population	16	2.4	0.8	2	4	
Centers implanting ICD/10 ⁶ population	16	1.3	0.5	0	2	
Centers performing CRT/10 ⁶ population	16	1.6	0.8	0	3	
Catheterization specialists/10 ⁶ population	16	6.0	2.0	3	11	
GDP 2003 (€1000)	17	18.2	3.7	12	24	
Health expenditure 2003 (€1000)	17	1.0	0.1	1	1	
AMI/10 ⁶ population	17	1728.3	238.3	1208	2102	
AMI adjusted for interregional balance/10 ⁶ population	17	1720.7	270.2	1210	2155	

ICD: implantable cardioverter-defibrillator; SD: standard deviation; CRT: cardiac resynchronization therapy; AMI: acute myocardial infarction; ratio of variation: maximum/minimum; PCI: percutaneous coronary intervention; N: number of autonomous regions included; GDP: gross domestic product;

TABLE 3. Correlation Analysis Between the Number of Percutaneous Coronary Interventions per Million Population and Different Variables

Variables	Pearson Correlation Coefficient	
	r	P
Centers that perform PCI (10 ⁶ population)	0.557	.025
Number of catheterization specialists (10 ⁶ population)	0.786	<.001
Incidence of AMI (adjusted for interregional balance)	-0.042	.877
Per capita GDP	0.564	.023
Per capita GDP controlling for incidence of AMI	0.563	.029
Health expenditure	0.285	.285
Health expenditure controlling for incidence of AMI	0.352	.198

AMI: acute myocardial infarction; PCI: percutaneous coronary intervention; GDP: gross domestic product.

TABLE 5. Analysis of Correlation Between Variables of Supply and Wealth

Variables	Pearson Correlation Coefficient	
	r	P
Centers performing PCI (pmp) per capita GDP	0.649	.007
Centers implanting ICD (pmp) per capita GDP	0.731	.001
Number of catheterization interventional cardiologist (pmp) per capita GDP	0.666	.005

ICD: implantable cardioverter-defibrillator; PCI: percutaneous coronary intervention; GDP: gross domestic product; pmp: per million population.

TABLE 6. Linear Regression Models for Percutaneous Coronary Intervention per Million Population, per Capita Gross Domestic Product, and Ischemic Heart Disease Burden

Explanatory Variables	R ²	β	95% CI	P
<i>Simple linear regression</i>				
Constant	0.269	380.6	-182.5 to 943.8	.169
Per capita GDP (1000 e)		36.4	5.8-67	.023
<i>Multiple linear regression</i>				
Constant	0.213	391.6	-577 to 1359.8	.398
Per capita GDP (1000 e)		36.4	4.4 to 68.5	.029
Incidence of AMI		-0.007	-0.48 to 0.46	.976

AMI: acute myocardial infarction; CI: confidence interval; GDP: gross domestic product.

TABLE 7. Correlation Analysis Between the Number of Implantable Cardioverter-Defibrillators and Different Variables

Variables	Pearson Correlation Coefficient	
	r	P
Centers that implant ICD	0.679	.005
Number of catheterization specialists	0.498	.059
Incidence of AMI (adjusted for interregional balance)	0.377	.166
Per capita GDP	0.615	.015
Per capita GDP controlling for incidence of AMI	0.636	.015
Healthcare expenditure	0.470	.077
Health expenditure controlling for incidence of AMI	0.311	.280

ICD: implantable cardioverter-defibrillator; AMI: acute myocardial infarction; GDP: gross domestic product.

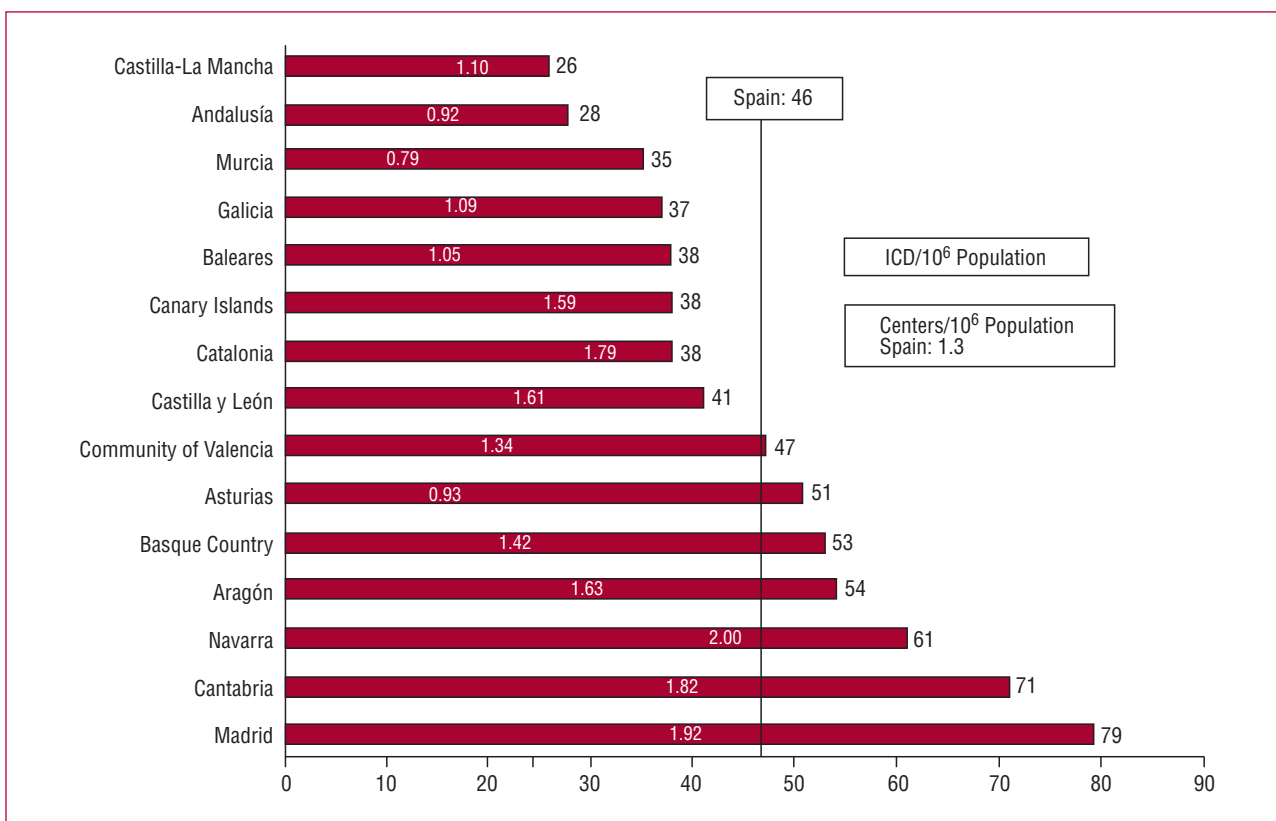


Figure 3. Number of implantable cardioverter-defibrillators (ICD) and ICD centers per million population, according to autonomous Spanish region, 2003. Source: Market study by Guidant, S.A.

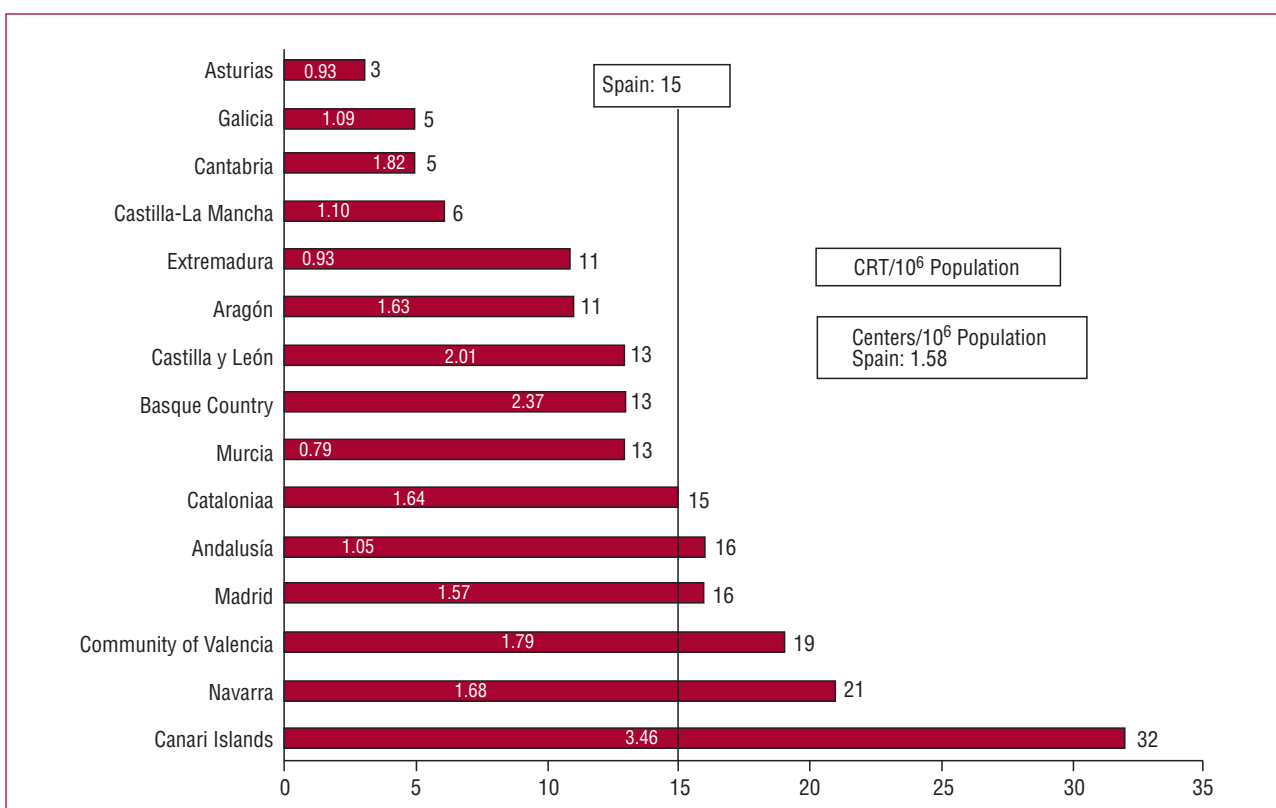


Figure 4. Number of cardiac resynchronization therapy devices (CRT) and CRT centers per million population, according to Spanish autonomous region, 2003. ICD: implantable cardioverter-defibrillator. Source: Market study by Guidant, S.A.

The simple linear regression model shows that the per capita GDP explains 33% of the variability in the number of ICD implantations per region ($R^2=0.331$), with 2.6 implantations more being done per each 1000 € increase in GDP ($\beta=2.6$; $P=.015$). This result is maintained when the effect of the disease burden is controlled for in a multiple regression model that explains 40% of the variability and where there is no association between the number of ICD implantations and disease burden (Table 8).

Cardiac Resynchronization Therapy

Figure 4 presents the number of CRT devices implanted per million population and the number of centers that do this procedure in every autonomous region. Two regions (the Balearic Islands and La Rioja) were excluded as no procedure of this type was done. Asturias was the autonomous region with the fewest procedures ($n=3$), whereas Navarra had the greatest number of devices implanted during 2003 ($n=47$). The average number of procedures done in that year throughout the country was 15/10⁶ population. The coefficient of variation between autonomous regions was 75.2%. The number of centers where CRT is practiced ranges between 0.79/10⁶ population in Murcia and 3.46/10⁶ population in Navarra, with a national average of 1.58/10⁶ population. The current stage of implementing this technology makes it impossible to do a between-regions variability analysis.

DISCUSSION

The aim of this work was to analyze regional differences in the use of three cardiovascular technologies and to study their possible relation to specific variables; supply, demand, regional wealth, and resources allocated to healthcare.

It has been shown that there is strong regional variability in the use of the three technologies, and that this variability is higher the more recent the procedure in question. The ratio of variation between the maximum and the minimum number of procedures done ranges between almost double (1.95) for PCI, introduced in Spain in the 1980s, triple (3.04) for ICD, which began to be disseminated in the 1990s, and above 15 (15.7) for CRT devices, that began to be marketed at the end of the 1990s. Such regional variability is not exclusive to Spain, and has also been confirmed in other countries. For example, a strong disparity between healthcare areas has been found in ICD implantation rates in the United Kingdom, with a fourfold difference between the areas with the minimum and maximum rates.¹⁷ As in our study, those authors point out that these differences are not explained by variations in the prevalence of coronary disease.

TABLE 8. Linear Regression Models for Implantable Cardioverter-Defibrillators per Million Population, per Capita Gross Domestic Product and Ischemic Heart Disease Burden

Explanatory Variables	R ²	β	95% CI	P
<i>Simple linear regression</i>				
	0.331			
Constant		-2.43	-40.6 to 35.8	.893
Per capita GDP (1000 e)		2.65	0.6-4.7	.015
<i>Multiple linear regression</i>				
	0.404			
Constant		-33.7	-89.4 to 22.0	.212
Per capita GDP (1000 e)		2.5	0.6 to 4.5	.015
Incidence of AMI		0.02	-0.01 to 0.04	.133

AMI: acute myocardial infarction; CI: confidence interval; GDP: gross domestic product.

Second, the number of procedures is strongly associated both with the number of centers where they are done and with the number of professionals who do them (catheterization specialists). This association is expected, because both the procedures and the centers and the professionals are collinear variables that express the same concept, the supply. Thus, an attempt was made to explain the variability in the number of procedures as a function of regional wealth and not of other supply variables, such as the number of centers and catheterization specialists.

In this regard, the results of this work show the existence of an association between the number of cardiovascular procedures — PCI and ICD — and regional wealth, an association that is independent of the ischemic heart disease burden in each Spanish region. Regional wealth, measured by per capita GDP, explains 21% and 40% of the variability in the use of PCI and ICD, respectively, with no relationship found between the number of procedures and ischemic heart disease burden. An increase of 36 procedures in PCI and of 2.5 in ICD was found per each 1000 € increase in GDP in the given region. These results are similar to those found in other countries. The inequality of access to different technologies can be explained by socioeconomic differences and not by need or disease burden. The source of such regional inequalities may be due to differences in supply factors³³ or socioeconomic differences,³⁴ although the two factors may be complementary if the relationship between regional wealth and the resources on offer is taken into account. The problem of variation in clinical practice has been a strongly debated subject in recent years and its leading causes, assuming equal

supply, are associated with the characteristics of the patients and physicians, the distribution of morbidity and the quality of the scientific evidence underlying decision-making.³⁵

Even though this study focuses on variability, its results make it possible to offer some thoughts on equity. The fact that the number of procedures is independent from the disease burden suggests the existence of a certain degree of inequity, equity being understood as equal access for equal need.³⁶ Nevertheless, this statement should be taken with a great deal of caution, since the access and need indicators used (balance of patient transfer rate between autonomous regions by ischemic heart disease and AMI incidence) are very weak and only indirectly approximate reality.

Some limitations to the present study must be noted. First, the power of the study is low due to the small number of observations. This means that the multiple regression models had to be restricted and only two independent variables were used in each model. Doing the study with data from all the provinces would have allowed us to include more independent variables and obtain greater accuracy in the estimators of association, but the data available is insufficient to conduct the study at this level. However, the regional distribution closely matches the administrative model of healthcare in Spain.

Another limitation concerns the validity of some data. On the whole, the information on the number of centers and procedures is fairly complete. The data on PCI come from the annual register of the Hemodynamics Section of the Spanish Society of Cardiology, which includes data from all public hospitals (100%) and from 93% of private ones. The ICD and CRT data, collected annually by the Guidant sales network, include almost all the available equipment in Spain, both primary implantation and replacement, and are considered very accurate since they include information on the entire market. In fact, the ICD data by region provided by Guidant are superior to those published by the Implantable Cardioverter-Defibrillator registry published by the Spanish Society of Cardiology.³⁷ The estimations of AMI incidence in 2002 should be considered as mere approximations of reality; in some regions they represent local population data, whereas in others they have been extrapolated from the results of other studies done in Spain in the 1990s, mainly the IBERIAN study.²⁷ Nevertheless, the disease burden indicators used in this study are good approximations, or at least the best available, of the true coronary disease burden and are the ones used in epidemiological studies in Spain.

Some Spanish regions do not do any of the procedures under study. This finding does not necessarily imply that residents in these regions lack access to these technologies. There is some transfer of patients between

regions, especially regarding very expensive or sophisticated techniques which are not available in all hospitals. In the case of the procedures analyzed, and according to data facilitated by Guidant (personal communication), Extremadura and Castilla-La Mancha send patients to Madrid for ICD implantation (although from 2004 Extremadura began to implant ICD), and La Rioja sends patients to Cantabria. Furthermore, a little over half the implantations in Navarra are done in patients from other regions. The absence of PCI in La Rioja is also misleading, since these patients are looked after in other autonomous regions. In the case of CRT, information on patient transfer between Spanish regions is not available. These limitations are due to the fact that there are no data available on transfers between regions for specific procedures, but only for general hospital care. Thus, a transfer rate between autonomous regions could only be calculated based on discharges following ischemic heart disease from the Spanish hospital morbidity survey of 2003, which was used to adjust the disease burden. Obviously, not all ischemic heart disease patients receive the procedures analyzed and, furthermore, these are not the only ones used in this disease. However, despite its limitations, the use of this indicator permits an indirect approach to the effect of patient transfers between regions.

All the limitations mentioned underline the need to improve existing information systems on clinical cardiology practice, thus enabling advances in knowledge on the relationship between use of and need for specific technologies. Nevertheless, while recognizing the limitations indicated, this analysis has been done with the best data available in Spain.

CONCLUSIONS

Although the results of this work should be interpreted with caution, they indicate that there is strong interregional variability in the use of these technologies which is basically explained by regional wealth, but not by disease burden. Healthcare resources should be more oriented to need if we want to use them more efficiently (wherever they produce better health) and more equitably (more accessible to those who need them more).

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