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THE USE OF QUANTITATIVE TECHNIQUES IN THE ANALYSIS OF GEOGRAPHICAL FEATURES REGARDING PATIENTS WITH ACUTE CORONARY SYNDROMES

Abstract*: This paper mainly intends to pursue the manner in which spatial distribution of the medical infrastructure is correlated to the hospitalized patients' flow having as diagnosis Acute Myocardial Infarction. In this context, we will describe territorial distribution elements for the hospital beds by various medical specialties as well as the way in which this distribution is according to specific morbidity elements. Focusing on the Acute Myocardial Infarction diagnosis will also imply some comparisons between Romania and other countries. The statistical information we used is supplied either by the National Institute of Statistics or by the analyses of some patient samples.*

Key words*: Quantitative Methods, Acute Coronary Syndromes, Romania, Spatial Analysis.*

JEL Classifications: I10, I14, I12, I19

1. Introduction

The efficiency of using medical spaces can determine an increase in the material benefit by reducing allocated costs or by reducing losses, as well as an increase of benefits related to the quality of the services and, implicitly, an increase in the efficiency of the results obtained by the patients. The request for medical services in private as well as public institutions is determined by economic and social factors: the increase in the level of the incomes, the increase in the level of education of the citizens, access to information, the change of the health system, etc. In Greece, for instance, in the period 1997-2004, the market share of the private system increased from 52.3% to 61.4^and the dynamic of the incomes in the same period was 134% (Boutsioli, Z., 2007). Meanwhile, the number of hospital beds remained, according to the same author, almost constant. In the public health system, the number of beds decreased by only 3% in the period 1996-2000 and in the private system, it decreased by only 1%.

A massive decrease in the number of hospital beds per 1000 inhabitants has registered not only in Romani. According to the OECD (2010) data, in most of the EU member states, the number of hospital beds to 1000 inhabitants decreased in 2008 versus 1995. In the top offered by OECD, Romania is following the trend of the majority, registering an average decrease of 1 pat per 1000 inhabitants in the 14 years. Extreme evolutions are registered in Lithuania, Latvia, Estonia, Bulgaria and even Italy, where decreases are of over 3 beds per 1000 inhabitants.

Descentralization of the public system has, in many cases, direct and strong effects on system efficiency. In Romaina, in particular case, the benefits of system descentralizations on the health system efficiency are not visible yet, mainly because therelated projets developped after EU integration are still running (Andrei, T. et. al.,2009)

Economic efficiency in a medical system, and sometimes in the entire economy, is also given by the number of sick people as well as their structure by different types of diseases. Many international studies show the impact of diseases on the size of the GDP, on the development of the work force or on human capital. Most of the studies referring to the impact of the diseases, especially AIDS, on economic indicators, are performed in African countries, where AIDS is a stringent problem for any decisional level. Bell et al. (2003) specify a model for South Africa in which it is estimated an average decrease of the GDP by 1.2% per year in the period 1990-2050 due to HIV infestations. The same negative effects mentioned here, as well as other positive collateral, such as the increase in agricultural output at a higher rate than the increase in salaries in the hypothesis of HIV/AIDS in rapport to the case of the inexistence of this disease, are highlighted by Roe, T.L. and Smith, R.B.W.(2008).

Knowing the diseases and the structure of the population by disease type is useful not only in elaborating economic policies. Information on diseases creates the premises of developing an analysis which targets the reduction of death rates in the population. For instance in France, following a comparative analysis in the period 1968-79 and 1988-99 there could be observed strong correlation between death causes from both periods. After structuring them on age groups it could be seen that the main causes of death in the age group 15-24 were accidents and poisoning, in the age group 25-64, for men, HIV infections, and in the age group 45-84 cardiovascular, digestive and neoplasms diseases (Coste, J. et al, 2006).

2. Methodology

In this article we intend to reach three main objectives: determining some characteristics of the Romanian medial system, from the perspective of the number of beds in hospitals by medical specialties depending on the diseases that affect the population; highlighting the influence of geographical factors on the patients hospitalized due to acute myocardial infarction; comparing the results registered in Romania for acute myocardial infarction with results registered in other countries.

In order to make the study we used three categories of statistical data and information for medical and geographical areas:

- In order to establish to what extent the allocation of medical resources was made in accordance to the major medical issues of the population, we used statistical data provided by the National Institute of Statistics for the period 1990-2010. The statistical data were reported at national level. For the processing of the statistical data we used the statistic and econometric resources provided by Eviews;
- In order to meet the second objective we used statistical data registered at the level of patient samples. In this case, we registered medical information for the patients admitted in hospitals, residents of various regions in Romania. To build the database we considered the following variables: patient identification information, demographical data, risk factors for ischemic coronary disease, EKG localization of the myocardial infarction, patient addressability in the hospital, symptomatology, the period of time from the first symptoms until the patient presented them at the hospital, the period of time from going to a hospital until starting the treatment, intra-hospital treatment, evolution, complications, mortality. For the inclusion of the patients in the sample, we defined three criteria: (i) clinical (retrosternal or precordial pain, longer than 20 minutes, unresponsive to nitroglycerin, left superior member, base neck level irradiation); (ii) electrocardiographic (overdenivelation of ST segment higher than or equal to 0,2 mV in V2-V6 and/or higher than or equal to 0,1 mV in DII, DIII, aVF); biological (the increase in troponin T or I or/and in myoglobin and/or in CK-Mb to values according to current guidelines). The statistic data was stored in a SPSS database. In processing the data we used statistic-mathematical methods.
- In order to compare the results registered at Romanian level for acute myocardial infarction with the ones at the level of other countries, we used information provided by various medical publications.

3. The analysis of the number of patients discharged from hospitals

Based on the statistical data from the period 1993-2011 regarding the Number of patients discharged from the hospitals, by disease categories, we determined for each year the distribution of patients by disease category. The results are presented in table 1[1]. They allow us to identify characteristics of the evolution of the number of patients discharged from the hospital (N_P) and their distribution by disease category.

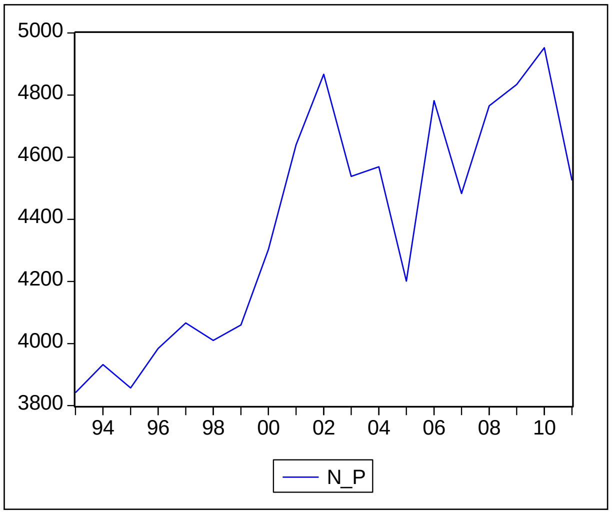


Figure 1. The evolution of the number of patients discharged from hospital in 1993-2011

The results allow us to formulate the following notable conclusions:

- The number of patients discharged from the hospital in the period under analysis has increase by 17.8%. According to Figure 1, the increase was significant in the period 1993-2002, reaching the level of 26.7%. In the following three years, there was a significant decrease of the number of patients discharged from the hospital. In the period 2005-2011 we note an important variation, from one year to the next, of the number of patients discharged from the hospital.
- The disease categories with the highest number of patients leaving the hospital are: the diseases and disorders of the respiratory system (with an annual average for the number of patients discharged from the hospital which varies in 1993-2011 between 16.65% and 12.80%); diseases of the circulatory system (values between 11.11% and 14.46%); diseases of the digestive system (values between 9.81% and 12.78%).

[1] Due to the large amount of information, tables 1, 2 and 7 are available only in electronic form at the following address: http://www.hertz.ase.ro/html/cyb/ec_cyb_01_13.htm

- Throughout the period 1993-2011, the number of patients hospitalized due to respiratory system diseases continuously increased. Starting with 2008, this disease category holds the highest weight of the patients discharged from the hospital. Starting with 2009, the annual value of the indicator surpasses 14%. In graph 2 we illustrate the evolution of the number of patients discharged from the hospital affected by diseases of the circulatory system (n_c) and the evolution of the weight of these patients in the total number of discharged patients;

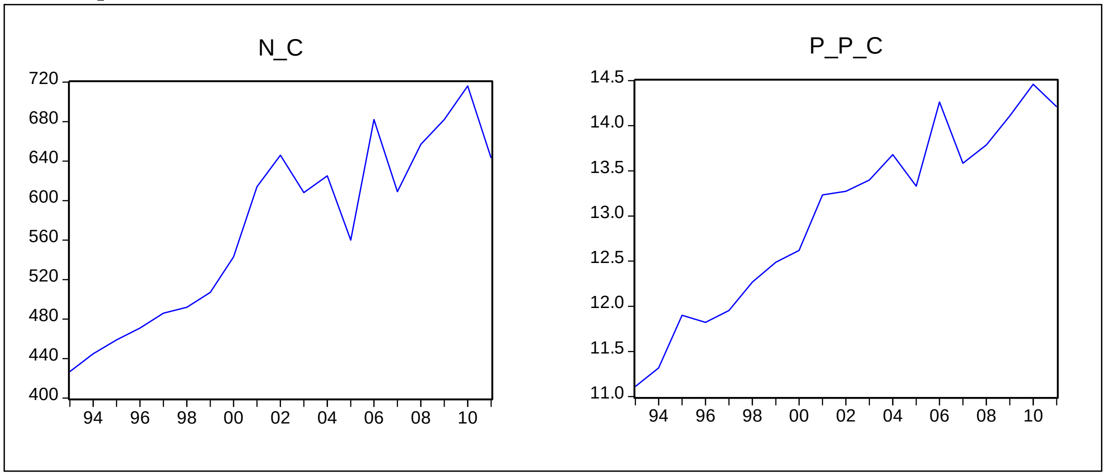


Figure 2. Characteristics of the number of patients discharged from hospital, having circulatory system diseases

- In the period 1993-2011 the number of patients discharged from the hospital, having circulatory system diseases (N_C) increased in an annual average rate of 2.30%
- In the followings, we shall study the stationarity of the series (N_C) using ADF. In this regard, we apply the methodology in Heij (2004).

Thus, we define three models:

M1: $\Delta N\_C_t = \phi N\_C_{t-1} + \sum_{j=1}^{p} \phi_j \Delta N\_C_{t-j} + \varepsilon_t$

M2: $\Delta N\_C_t = c + \phi N\_C_{t-1} + \sum_{j=1}^{p} \phi_j \Delta N\_C_{t-j} + \varepsilon_t$,

M3: $\Delta N\_C_t = c + at + \phi N\_C_{t-1} + \sum_{j=1}^{p} \phi_j \Delta N\_C_{t-j} + \varepsilon_t$

In table 3, we present the results obtained after applying the two statistical tests.

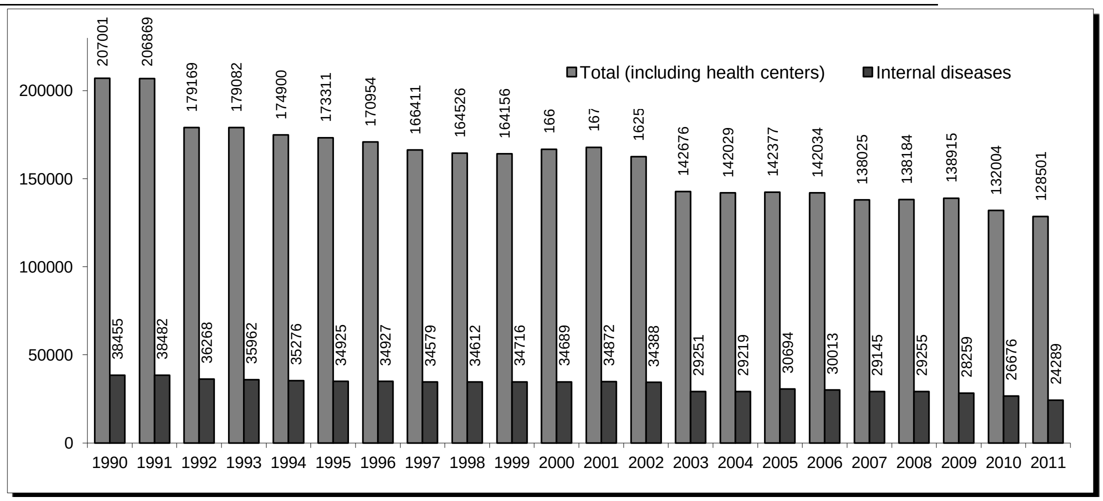
	Coefficient value	$t-Stat$ value
ϕ	-0.9962	-3.427
a	14.596	2.915
c	439.468	3.596
Critical value for 10%	-3.286909	
Integration degree	I(0)	
Model type for stationary series	M_3	
Lags of differences (p)	0	

Table 3. Applying the ADF test in order to analyze the stationarity of series N_C

4. The analysis of hospital beds dynamics

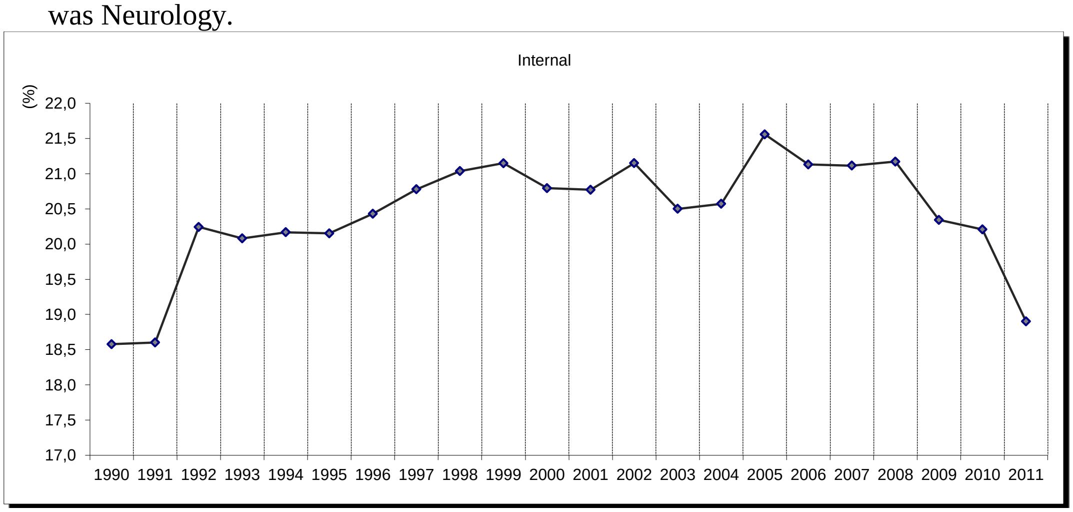
The results presented in table 4 allow us to formulate the following comments:

- Throughout the period we notice a significant decrease of the number of hospital beds. In 2011, the number of hospital beds decreased versus 1990 by 37.9%. Graph 3 highlights four important periods in the evolution of this indicator:
    - In the first two years after the 1989 revolution the number of hospital beds was maintained at the same level;
    - 1992 was the year with the first significant decrease of the number of hospital beds. The decrease was 13.4%. In the period 1992-2002 the value remained relatively constant.
    - In 2003, we notice another significant drop. The decrease was 12.3% versus 2002. In the period 2003 – 2009 the indicator was reduced by only 2.6%.
    - In 2010, we register the third significant drop in the transition period. The decrease in this year amount to 5% versus the previous year.
- The specialty “internal medicine” had, in 2011, the highest number of beds. This specialty held 18.9% of the total number of beds an weight relatively close to the one in 1990 (18.58%). The maximum level of the weight regarding the number of beds in this specialty was reached in 2005, with 21.5%. Starting with 2006, the weight of this medical specialty was continuously reduced down to 18.9%, in 2011. Graph 4 presents the evolution of the weight of the number of beds in “Internal Medicine” in the total number of beds in 1993-2011.



Graph 3. The evolution of the total number of hospital beds versus hospital beds in Internal Medicine between 1993 and 2011

- The most important decrease registered throughout the period under analysis regarding the number of beds, by almost 70%, was for the Pediatrics specialty.
- The only specialty which registered an increase in hospital beds, by 14.3%, was Neurology.



Graph 4. The evolution of the weight of hospital beds for Internal medicine in the total number of beds between 1993 and 2011

In order to analyze stationarity for the series, we apply ADF. The results are presented in table 5. The series integration degree is I(0).

	Coefficient value	$t-Stat$ value
ϕ	-0.018236	-2.459359
Critical value for 5%	-1.961409	
Integration degree	I(0)	
Model type for stationary series	M_1	
Lags of differences (*p*)	0	

Table 5. Applying the ADF test for the stationarity analysis of the series number of beds

5. The evolution of the number of deaths

In the context of the population decreasing, due to a drop in the rate of births, the number of deaths registered a moderate increase. Thus, in 2011, the number of deaths was 1.8% higher than 1990. The number of deaths in the feminine population was 3.5% higher in 2011 than in 1990, while in the masculine population, 0.2%.

The annual structure of the deaths by gender is illustrated in figure 5. The stationarity analysis is accomplished using ADF and the results obtained for the weight of deaths in the masculine population are presented in Table 6. Similar results are obtained for the weight of deaths in the feminine population. Differences can be spotted when it comes to the signs of parameters a and c.

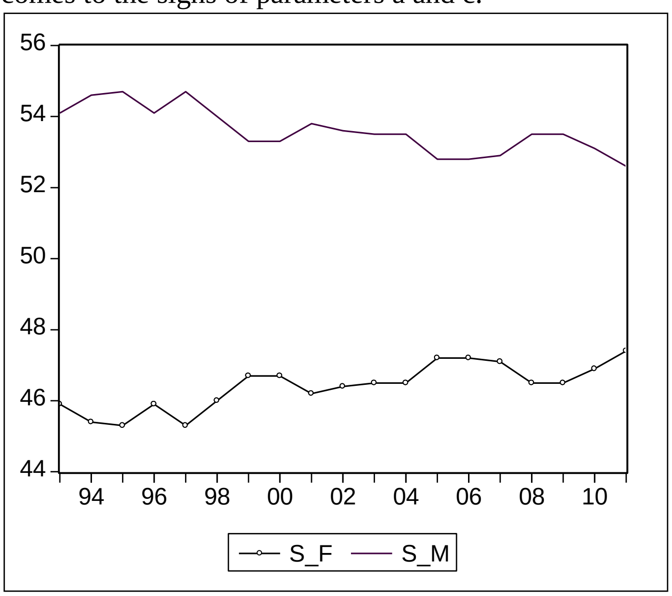


Figure 5. The evolution of the structure of deaths by genders, in the period 1993-2011

	Coefficient value	$t-Stat$ value
ϕ	-2.844025	-4.446570
a	0.048542	1.872216
c	-0.859070	-2.574737
Criticla value for 5%	-3.791172	
Integration degree	I(1)	
Model type for the stationary series	M_3	
Lags of differences (p)	2	

Table 6. Applying the ADF test for the stationarity analysis of series N_C

The results obtained above regarding the structure of deaths by genders allow us to formulate the following comments:

- For each year, the weight of male deaths is higher than the female deaths. The largest difference is between the two weights, of 9.4% which was registered in 1995 and 1997. The smallest difference of 5.1% was registered in 2011;
- For a longer period, we notice a convergence of the two data series towards 50%.

In table 7, we present the structure of deaths by death cause for each year. For all the year, the most important cause is circulatory system diseases. For the entire period 1990-2011 their weight is higher than 60%. Another important cause is represented by tumors. The weight of deaths having tumors as cause increased from 13.35% in 1990 to 19.23% in 2011.

6. Degree of concentration degree

The analysis of concentration is made based on three important characteristics:

- The number of patients discharged from the hospital, by disease category
- The number of hospital beds by medical specialty
- The number of deaths, in total, by causes and by gender

In order to analyze the concentration of the values by classes for each of the variables above, we will use the Herfindahl index.

For each variable we compute the value of the index at the level of each year in the analyzed period. At the level of each year, for each variable we compute the values of the structure vector $\mathrm{y_i} = [y_{i1}, y_{i2}, ..., y_{in}]$, where $y_{ti} = n_{ti} / \sum_i n_{ti}$. In the last expression we noted the absolute frequency of class *i* by n_{ti}.

The Herfindahl index is computed for each year based on the expression below:

$$H_t = \sum_{i=1}^{n} (y_{ti})^2. \quad [1]$$

For the period 1990-2011 we compute the series of Herfindahl indices represented by $H_{1990},...,H_{2011}$. For this series we compute the medium level, standard square deviation and homogenity coefficient for the analysis of the variation degree of the specialization index in time.

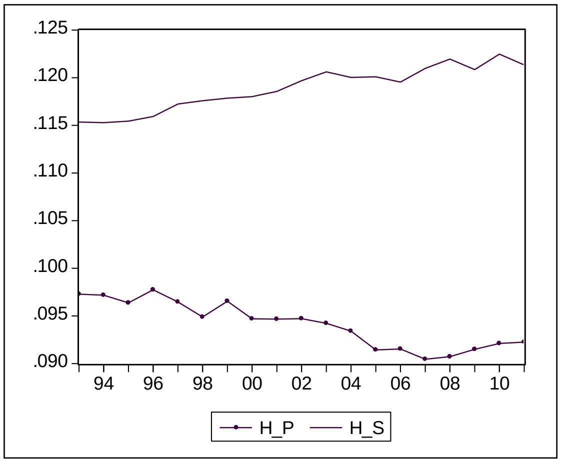
The values of the Herfindahl index for “The number of patients discharged, by disease category (H_S)”at the level of the 1993-2011 period are computed based on the values in table 1.

The results obtained are presented in table 8 and in graph 8. The values obtained at the level of the period are homogenous: the rapport between the highest value and the smallest is 1.08l variation coefficient in 2.5%.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Patients				0.097	0.097	0.096	0.098	0.096	0.095	0.097	0.095
Specialties	0.113	0.113	0.116	0.115	0.115	0.115	0.116	0.117	0.118	0.118	0.118
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Patients	0.095	0.095	0.094	0.093	0.091	0.092	0.090	0.091	0.092	0.092	0.092
Specialties	0.119	0.120	0.121	0.120	0.120	0.120	0.121	0.122	0.121	0.122	0.121

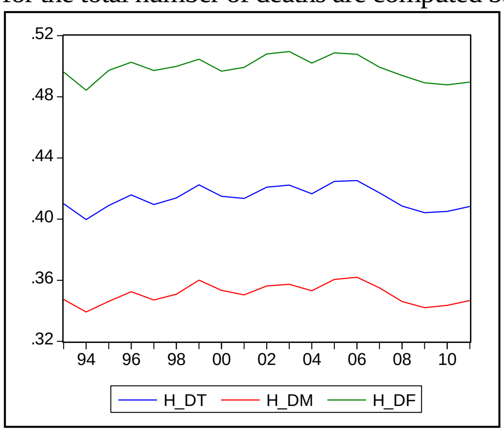
Table 8. Concentration indices

The values of the Herfindahl index for “Number of hospital beds (H_P)”, by medical specialties, for the period 1990 – 2011 are presented in table 8 and in figure 6. Medical specialties and the statistical data used for the years 1990 and 2011 are presented in table 3. The values obtained are placed in an interval from 0.1125 and 1.1225. This is a homogeneous series: the rapport between the highest value and the smallest one is 1.09; variation coefficient is 2.4%.



Graph 6. The evolution of the concentration index for "The number of patients discharged, by disease category" and "the number of hospital beds by medical specialty"

The values of the Herfindahl index for "the number of deaths, in total, by causes (H_DT)" and by genders (H_dm, H_df) for the period 1990 – 2011 are presented in graph 6. Indices for the total number of deaths are computed based on the data in table 9.



Graph 7. The evolution of the concentration index for the number of deaths by causes at the level of the total population, and by gender

In table 6, we present characteristics of the series of the Herfindahl indices for the number of deaths (by causes, in total, and by genders). In all three cases, the series are homogeneous, the rapport between the highest value and the smallest being less than 1.07.

	Female	Male	Total
Mean	0.4986	0.3510	0.4137
Median	0.4992	0.3508	0.4138
Maximum	0.5095	0.3619	0.4251
Minimum	0.4843	0.3392	0.3996
Std. Dev.	0.0074	0.0064	0.0072
Skewness	-0.2312	0.0274	-0.0615
Kurtosis	2.1835	2.0736	2.1242

Table 9. The characteristics of the series of Herfindahl indices for the number of deaths, by causes, in total and by genders

The results above highlight a series of remarkable characteristics related to the evolution of the three important characteristics of the public health system:

- The degree of concentration for the Number of hospital beds, by medical specialties for the period under analysis, has increased. The increase index for the value of the indicator in 2011 versus 1990 is 107.8%.
- In exchange, the degree of concentration of the Number of patients discharged from the hospital by disease category has decreased. The rapport between the value of the indicator in 2011 and the value in 1993 is 0.95 (a decrease by 5%).
- The degree of concentration of the Number of deaths, by causes, in total and by gender, was relatively constant in the period under analysis;
- The correlation between the series of the concentration indices regarding the number of patients discharged from the hospital, by disease category and the series of the concentration indices regarding the number of hospital beds by medical specialty is significantly negative. The value of the linear coefficient of the correlation computed for the two series is -0.89. In graph 8 we present the linear dependence between the two data series. The graph above suggests the estimation of the parameters of the regression linear model below:

  $$H\_s_t = b + aH\_p_t + \varepsilon_t \quad [2]$$

  where ε_t is a variable $N(0, \sigma_\varepsilon^2)$.

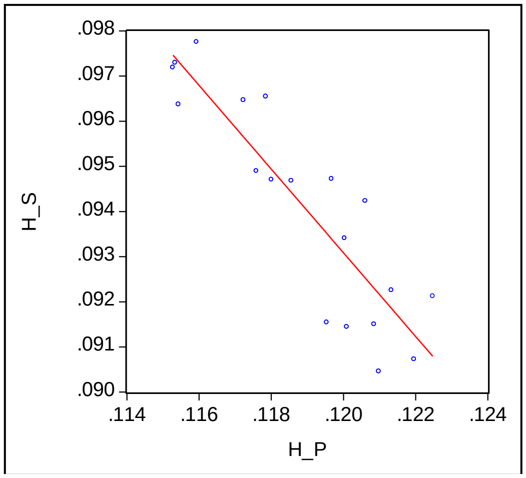


Figure 8. Linear dependence between H_S and H_P

The estimation of the parameters was made using the OLS method and the results obtained are presented in table 19, model M_1. In the same table, in the column corresponding to M_2, we have estimated the parameters of the regression model:

$$\log(H\_s_t) = b + a\log\cdot(H\_p_t) + \varepsilon_t \quad [3]$$

	M_1	M_2
b	0.204^{*} (0.01377)	-3.724^{*} (0.20137)
a	-0.927^{*} (0.11587)	-0.675^{*} (0.0852)
R^2	0.79	0.79

Table 10. The characteristics of models [2] and [3]

The estimations for the two models highlight a negative dependence between the evolution of the concentration degree for the number of patients discharged from the hospital, by disease category and the concentration degree for the number of hospital beds, by medical specialties. We can thus say,, that in fact, increasing the concentration of the patients by various specialties/by hospital beds decreases the concentration of the patients discharged by various disease category (more specifically, the disease range is diversified).

7. Evaluations based on clinical data

In this part of the paper we identify the differences between the geographical regions in Romania regarding the clinical - therapeutical approach for acute myocardial infarction. In the sample we included 1257 patients from the four geographies of Romania. In figure 9 we present the distribution of the patients by regions.

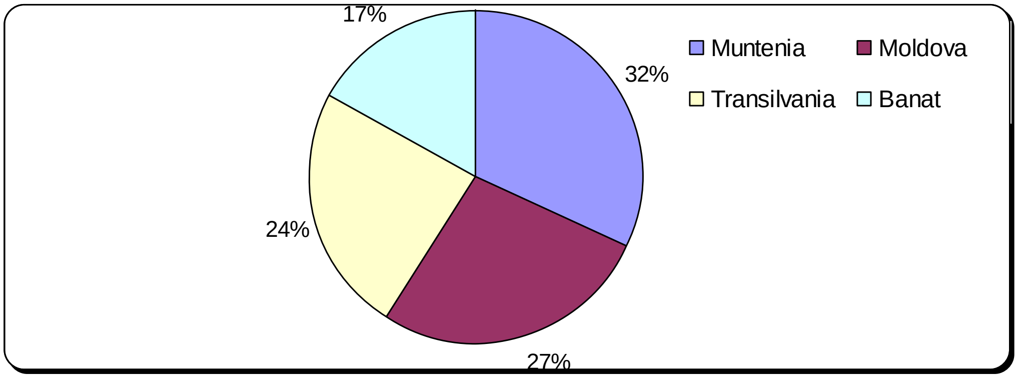


Figure 9. The distribution of the patients by regions

The first aspect we must follow regards the analysis of the correlation between the age of occurrence for acute myocardial infarction (AMI) and the degree of socio-economic development of the county of residence of the patients. In order to assess the level of development of the county we used the value of the GDP by inhabitant. The value of the linear correlation coefficient ((r_{i/PIB_L}) between the two variables is 0.6. This value is significant for a significance threshold of $\alpha < 0.01$. The lowest average age in the appearance of the AMI was registered in Moldova. This value is followed by Muntenia, Transylvania and Banat.

Table 11 presents a few relevant descriptive results obtained after processing the database

Indicator	Geographical region				National level
	Muntenia	Moldova	Transilvania	Banat	
Average age (years)	66.4± 8.1	60.4± 7.5	66.1± 7.8	64.4± 7	65.4± 8
(r_{i/PIB_L})	0.63^{*}	0.58^{*}	0.66^{*}	0.58^{*}	0.60^{*}
AMI incidence for patients with arterial hypertension	55.2%	60.1%	56.7%	57.9%	57.2%

Table 11. Descriptive statistics at sample level and by geographical regions
$\alpha < 0.01$

According to the data registered at the level of the sample, AMI is more frequent in men than in women (61% versus 39%).

One of the risk factors for the incidence of AMI is represented by arterial hypertension. As geographical feature, we notice that arterial hypertension has the same incidence in patients in all geographical regions.

Another important risk factor in the incidence of AMI is smoking. This factor was registered at sample level, for 43,2% of the patients. The values registered in the four geographical regions are not significantly different, being placed in the interval 42 and 44%. Smoking is more frequent until the age of 65 in all regions, except for Muntenia, where it has the same incidence after the age of 65.

Based on empirical results obtained after processing the database we have identified other important risk factors relative to the incidence of acute myocardial infarction:

- Dyslipidemia (37.6% of the patients); this is more frequent in Muntenia and Banat;
- Type 2 diabetes (27.4% of the patients); this risk factor is more frequent in Muntenia and Banat. In the case of these regions the value of the indicator is higher than 35%.
- Obesity (23.7% of the patients), more frequent in Muntenia (30.2%);
- Track record of other AMIs (8.3% of the patients).

An important indicator in treating acute myocardial infarction is the length of time between the symptoms' debut and the patient's hospitalization. Graph 10 presents the distribution of the patients based on this characteristic. The 60% of the patients who arrived at the hospital in the first 6 hours from the first symptoms benefitted from treatment according to the current European Guidelines. The distribution of the patients by this characteristic does not significantly differ from one region to another. In all regions, the amount of time from the first symptoms to hospitalization is smaller with patients who live in cities where there are university hospitals. The significant difference regarding this indicator is registered at rural – urban level. This situation is mainly due to the following factors: the lack of an appropriate infrastructure between satellite localities and the city where the patient can be hospitalized, the absence of telemedicine systems between rural and urban levels, ignoring the symptomatology, deficient medical resources in rural sanitation.

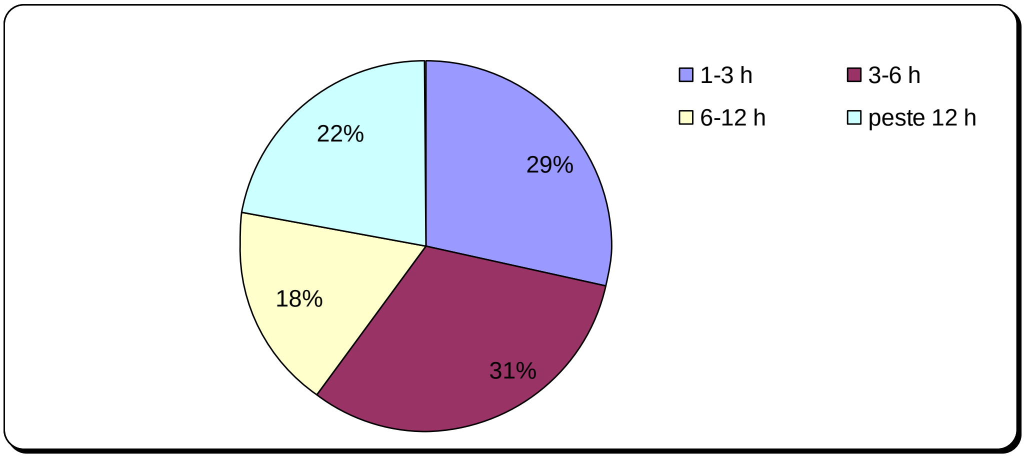


Figure 10. The distribution of the patients by the amount of time between the first symptoms and their hospitalization

The evolution and complications have been determined mostly by the type of treatment administered rather than the geographical region of origin.

Global in-hospital mortality was 12.3%. There are no significant differences between geographical regions relative to in-hospital mortality. Mortality was reduced among young patients and among patients who benefitted faster, from adequate treatment.

8. Conclusions

The decrease of the number of beds per 1000 inhabitants in Romania is a phenomenon which characterizes most of the EU countries. The issue of hospital beds reduction is complex, and it is the effect of a range of socio-economic measures specific to each country. For instance, in Estonia, the main reason which led to the decrease of the number of hospital beds was the introduction of a hospital accreditation system, thus small hospital as well as precarious ones were closed (Mc.Kee, M., 2004). Other causes, besides strictly economic ones, are the ones determined by the system efficiency changes by transforming some treatments in ambulatory or house care. We should also consider the transformation of some hospitals in social care centers. In Romania, the evolution of the number of beds per 1000 inhabitants is a results of all the factors mentioned above. Still, the dramatic reduction measure regarding the number of hospital beds in Romania can have more serious effects in time considering at least two aspects extremely important to the evolution of the potential beneficiaries: i) the increase in the number of patients especially in disease categories which require extended treatment and ii) the phenomenon of demographic aging caused by the increase of the number of patients with chronic diseases.

Knowing the distribution by region and cause of dissease, particular systems of treatement could be developped in order to increase efficiency of system reatement.For example one of the most efficeint treatement of ventricular based pacing (VVIR) is pacemaker therapy (Dina O. et al., 2008) could generate the treatement of patient from medical centers into homecare assistance, increasing thus both economic efficenciy and therapy efficiency.

The structure of causes of death remains quasi unchanged in the past 20 tears. In general, temporal series built on each cause of death are stationary or have a reduced slope trend. A single category of death cause tends to be more visible – tumors; their weight in the total deaths increased by approximately 6% in the period under analysis.

The results we obtained in this study were compared to those presented by various international studies. These comparisons have allowed the identification of risk factors with higher incidence at the level of the Romanian population, such as: smoking, dyslipidemia (even if the percentage of obese patients or type 2 diabetes is similar) and the age of the patients.

The number of women with acute myocardial infarction is lower than the males', at the level of Romania as well as in other countries mentioned by other studies.

Global mortality resulted from this study remains twice as higher for Romania as compared to other developed European countries.

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