

# Characterization of the variation of health care taking into account the costs of hospital admissions for acute myocardial infarction in Brazilian Unified Health System

*Caracterização dos padrões de variação dos cuidados de saúde a partir dos gastos com internações por infarto agudo do miocárdio no Sistema Único de Saúde*

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**ABSTRACT:** *Introduction:* The global epidemiologic scenario indicates an increase in cardiovascular disease rates, with special emphasis on acute myocardial infarction (AMI), owing to its large magnitude and severity. In Brazil, coronary diseases now account for about 5% of hospital admission expenditures. *Objective:* To characterize the admissions in the Brazilian Unified Health System of patients with AMI, by identifying clusters suggested by a traditional cluster analysis and by a multiple correspondence analysis (MCA). *Methods:* The records of the Hospital Information System/ Brazilian Unified Health System with a primary diagnosis of AMI in the State of Rio de Janeiro, Brazil, 2002, were selected and subsequently related to the records of the Mortality Information System. Next, an MCA and a metric called the tolerance distance were used for cluster identification. The variable of interest was “hospital expenditures”, classified into two categories (above and below BRL 905). *Results:* “Higher costs” were associated with “use of the Intensive Care Unit (ICU)” and “moderate severity of the case” and “lower costs” with “low severity” and “nonuse of the ICU”. On the other hand, high severity cases, with no apparent association with “use of ICU” or other categories. Other associations identified were “lower costs” and “no displacement of the patient,” “female,” “age between 56 and 75 years,” “death within 30 days,” and “death within 1 year”. *Conclusions:* The nonclustered characteristic of the most serious cases and the association between “deaths” and “lower costs” suggests that the technological resources available during hospitalization for AMI are not being properly used.

**Keywords:** Health services accessibility. Myocardial infarction. Delivery of health care. Hospital mortality. Risk factors. Multifactor dimensionality reduction.

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**Conflict of interests:** nothing to declare – **Financial support:** Study partially financed by *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)*, *Programa PROEx*, and *Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)*.

**RESUMO: Introdução:** O cenário epidemiológico mundial revela um crescimento das doenças cardiovasculares, no qual se destaca o infarto agudo do miocárdio (IAM), devido à sua grande magnitude e severidade. No Brasil, doenças coronarianas representam já cerca de 5% dos gastos com internação hospitalar. **Objetivo:** Caracterizar as internações dos pacientes do Sistema Único de Saúde (SUS) por IAM por meio da identificação de agrupamentos sugeridos por uma análise de agrupamentos tradicional e por uma análise de correspondência múltipla (ACM). **Métodos:** Registros do Sistema de Internações Hospitalares (SIH/SUS) com diagnóstico principal de IAM, no Estado do Rio de Janeiro, 2002, foram selecionados e posteriormente relacionados aos do Sistema de Informações sobre Mortalidade (SIM/SUS). A seguir, uma ACM e uma métrica chamada distância de tolerância foram utilizadas para a identificação de *clusters*, sendo a variável de interesse “gastos com internação” classificada em duas categorias (acima e abaixo de R\$ 905,00). **Resultados:** Foi possível associar “maiores gastos” com “utilização de Centro de Tratamento Intensivo (CTI)” e com “gravidade moderada do caso”, e “menores gastos” com “gravidade leve” e “não utilização de CTI”. Por outro lado, casos de alta gravidade apresentaram-se isolados, sem associação com CTI ou outras variáveis. Também foi detectada associação entre a categoria “menores gastos” e as categorias: “não deslocamento do paciente”, “sexo feminino”, “idade entre 56 e 75 anos”, “óbito até 30 dias” e “óbito até 1 ano”. **Conclusão:** o aspecto isolado dos casos de maior gravidade e a associação entre “óbitos” e “menores gastos” sugere que os recursos tecnológicos disponíveis durante a internação por IAM não estão sendo adequadamente empregados.

**Palavras-chave:** Acesso aos serviços de saúde. Infarto do miocárdio. Assistência à Saúde. Mortalidade hospitalar. Fatores de risco. Redução dimensional com múltiplos fatores.

## INTRODUCTION

In recent decades, the global epidemiological scenario shows an increase in cardiovascular disease, with special emphasis on acute myocardial infarction (AMI) owing to its large magnitude and severity<sup>1</sup>. In 2011, about 20 million people were suffering from cardiovascular diseases worldwide, of which approximately 12 million were victims of fatal AMI<sup>1</sup>.

Similarly to what has been happening worldwide, Brazil has showed changes in its population's morbidity and mortality profile. The number of deaths from cardiovascular diseases has been growing, although accompanied by a progressive decrease in mortality rates<sup>2</sup>. However, cardiovascular diseases are currently the leading cause of death in Brazil<sup>3,4</sup>, being responsible for about 29% of deaths in 2009<sup>5</sup>. This year, they represented the third leading cause of hospitalization in the Brazilian Unified Health System (SUS), with more than 1 million hospitalizations and total spending of about 1.9 billion reais<sup>6</sup>. Values of this magnitude have a huge financial impact on the health system. They constituted about 5% of expenditures with hospital admissions in the early 2000s<sup>7</sup>, and this percentage was reiterated in the current decade<sup>8</sup>.

On the other hand, the ease of access to databases on the use of health services has promoted an increase in the number of studies on the allocation of health resources in Brazil. Thus, various statistical techniques have been proposed for the analysis of such data and to aid decision-making processes in health care. One of these techniques, multiple

correspondence analysis (MCA), which basically consists in representing the relative position of variables in a Euclidean space, although of great potential, still has not been widely employed<sup>9</sup>. The MCA has the advantage of not requiring the assumptions of the gaussianity and linearity of the data, and, by enabling the visualization of categories of variables, also suggests associations based on the distance between these categories (the closer they are, the more likely they are associated)<sup>10,11</sup>. The MCA can be used not only as an exploratory technique but also to suggest associations between categories of variables<sup>12-14</sup>.

In this context, it is particularly important to identify variables that can better characterize or predict such high costs, and studies conducted in the country with patients hospitalized for AMI, based on medical records or secondary data, have used multivariate methodologies<sup>15-17</sup>. However, we did not identify the use of the statistical techniques MCA and hierarchical cluster for this purpose. Therefore, this study aimed to characterize hospital admissions of patients in the Brazilian Unified Health System for AMI in municipalities in the state of Rio de Janeiro, by identifying clusters suggested by the MCA. In addition, in order to make it a more objective technique, allowing for the control of confounding factors and eliminating the possibility of presenting and discussing false associations, we used a heuristic proximity index, the tolerance distance<sup>12</sup>.

## MULTIPLE CORRESPONDENCE ANALYSIS AND TOLERANCE DISTANCE

For the application of this method, the data must be adjusted in the form of a rectangular matrix in which rows ( $n$ ) represent, e.g., patients, and columns ( $p$ ) represent the categories of the variables analyzed, thus creating an indicator matrix  $Z$ . Through the standardization of each element ( $z_{ij}$ ) of this matrix by the corresponding row ( $r_i$ ) and column ( $c_j$ ) profiles, given by the marginal relative frequencies (masses) of rows and columns, a standardized matrix  $G$  with  $g_{ij}$  elements is obtained, according to Equation 1.

$$g_{ij} = \frac{z_{ij}}{\sqrt{r_i \cdot c_j}} \text{ to } 1 \leq i \leq n \text{ and } 1 \leq j \leq p. \quad (1)$$

In which:

$$r_i = \sum_{j=1}^p Z_{ij} \text{ (mass of rows);}$$

$$c_j = \sum_{i=1}^n Z_{ij} \text{ (mass of columns).}$$

The matrix  $G$  is then factored by an algorithm called singular value decomposition (SVD), from which Equation 2 is obtained.

$$G = U.D.V^T \tag{2}$$

above, U and V are matrices of singular vectors; the first corresponding to the rows and the second to the columns. D is a diagonal and square matrix, composed of the singular values associated with each one of the rows or columns. Thus, the main coordinates of the rows and columns can be estimated from the product of the standard coordinates and their respective singular values.

Similarly to the known techniques of principal component analysis and factor analysis, the MCA works with the concept of explained variance, here called Inertia, according to Equation 3.

$$\tilde{\lambda}_j^2 = \left( \frac{Q}{Q-1} \right)^2 \cdot \left( \lambda_j^2 - \frac{1}{Q} \right)^2 \tag{3}$$

In which:

- Q = number of active variables;
- $\lambda_j$  = singular values related to the indicator matrix;
- $\tilde{\lambda}_j$  = adjusted value.

The graphical representation of the coordinates of the categories is called the correspondence map, which is formed by the projection of the main line and/or column coordinates in the two or three dimensions (axes) of greater inertia (higher contribution to the variability of the data). The usual interpretation of this map is based on the spatial proximity between the categories of variables. However, this proximity depends on, among other factors, the inertia of the dimensions considered, the scale of the graph, and even on user experience. An alternative to the evaluation of the association between categories is the use of a heuristic index, called tolerance distance<sup>12-14</sup>, expressed by Equation 4.

$$dist = \sqrt{(X - Y) \cdot \Lambda \cdot (X - Y)^T} \tag{4}$$

In which:

X and Y = main coordinates of the categories;

X = (x<sub>1</sub>, x<sub>2</sub>, ..., x<sub>s</sub>), Y = (y<sub>1</sub>, y<sub>2</sub>, ..., y<sub>s</sub>), in which s is the maximum dimension, obtained through a scree plot, and Λ is the diagonal matrix, which α<sub>j</sub> elements are given by Equation 5.

$$\alpha_j = \frac{\tilde{\lambda}_j^2}{\tilde{\lambda}_1^2} \text{ to } 0 \leq j \leq p. \tag{5}$$

Therefore, the tolerance distance is a weighted Euclidian distance, in which the weights are given by the ratio between the adjusted inertia and the inertia of the first dimension<sup>12-14</sup>. This distance provides an objective interpretation of the concept of proximity between categories, allowing inferences about the relationship between variables.

Another important concept in the MCA is the supplementary variable: when there is a need to establish associations between explanatory variables and one response variable; as in a regression, the response variable can be inserted in the correspondence analysis graph by means of a transition formula<sup>10,11</sup>. Thus, this variable does not influence the calculations of the main coordinates nor of the variability.

## **METHODS**

### **DATABASE**

First, the Hospital Information System (SIH/SUS) was surveyed, and we selected hospitalizations with a primary diagnosis of AMI (International Classification of Diseases 10<sup>th</sup> Revision: I21 or I22), from hospitals affiliated with the Brazilian Unified Health System (SUS) in the state of Rio de Janeiro in 2002. Records of children under 18 years (only three incomplete records) were excluded. On the other hand, the records of a first hospitalization for AMI in 2002 were kept, and a passive follow-up of patients was conducted in the Mortality Information System (SIM) in 2002 and 2003 by means of a probabilistic linkage of the records using the software RecLink<sup>18,19</sup>.

Thus, the study was population-based, with patients receiving care in the SUS network (cross-sectional design), of both sexes, aged between 18 and 100 years in the municipalities of Rio de Janeiro. The records of hospitalization by AMI in 2002 (SIH/SUS) were used for the analysis, along with information on mortality for the years 2002 and 2003 owing to the availability of the data compiled.

The variables “place of hospitalization” and “place of origin” were merged into a single variable, called “intermunicipal displacement” (two variables became one). Similarly, the variables “revascularization,” “angioplasty,” “transplants,” “orthotics and prosthetics,” “diagnoses and therapies,” “blood transfusion,” and “CT and MRI” were merged to form the variable “use of technology” (seven variables became one). After these procedures, only those variables with categories showing a variability percentage higher than 5% were maintained, resulting in 10 variables.

### **STATISTICAL ANALYSIS**

In this study, the MCA was used to characterize associations between categories of variables. MCA is a statistical technique that allows the presentation of variables in a

Euclidean space, so that the proximity between the categories of these variables reflects their associations<sup>14</sup>.

In the application of MCA, the outcome (response) variable used was the expenditure with patients hospitalized for AMI (MCA output), because, as mentioned, coronary diseases, especially AMI, have a major financial impact on the health system<sup>7,20</sup>, and the others were considered as inputs, that is, possibly related to that expenditure. Initially, the “standardization of the indicator matrix” was performed. Next, those data were represented in a Euclidean space through a “correspondence map”. The maximum dimension  $s$  was selected through a scree plot, a graph criterion often used in factor analysis<sup>12,14</sup>.

The tolerance distance was estimated from the fifth percentile (5%) of all the distances between pairs of categories. This distance was considered to be an association threshold, that is, two categories were considered to be linked when their distance was below that threshold<sup>12-14</sup>. To check whether the associations found were stable, we used the bootstrap simulation method (construction of sampling distributions through resampling, having as a methodological basis the same population sample that originated the data, as described by Costa et al.<sup>12</sup>. Thus, about half of the records was randomly selected ( $n = 2,200$ ), repeating the MCA and the calculation of the tolerance distance. This procedure was repeated 1,000 times, the number of common clusters was determined, and those that showed more than 75% of repeatability were considered stable<sup>12</sup>.

In order to compare the methodology used (MCA + tolerance distance) to a widely used statistical technique, a dendrogram (a graphical representation of clusters of variables) was also constructed from a hierarchical cluster analysis. In general, the horizontal axis of a dendrogram represents the categories of the variables analyzed and the vertical axis represents their similarity. The number of clusters in a hierarchical analysis can be determined by a metric that indicates the proximity of the clusters, called “fusion level”<sup>21</sup>. Next, the groups formed by each methodology were compared empirically.

For the statistical treatment of the database, we used the statistical software R, version 2.11.1<sup>22</sup>, also using the *ca* package. This software is the result of an international collaboration, is distributed free of charge, is user-friendly, and allows for comprehensive statistical analysis. The study was approved by the Research Ethics Committee of the School of Nursing Anna Nery of *Universidade Federal do Rio de Janeiro* (EEAN/UFRJ).

## RESULTS

The original database had 4,435 records with 48 variables, from which 10 were selected for this study. The percentage of deaths identified in the study population was approximately 29%, that is, from 4,435 records of patients hospitalized for AMI, 1,272 died during the follow-up period. The remaining percentages of the variables with their respective categories in the sample cluster are shown in Table 1.

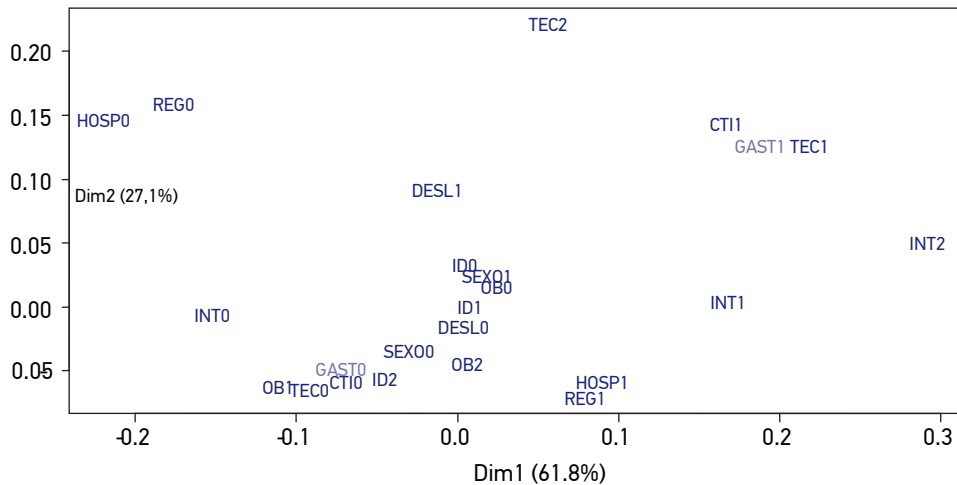
Table 1. Absolute and relative frequencies of the variables used to characterize the variation of health-care standards from the costs on admissions for acute myocardial infarction. A total of 4,435 patients were admitted to hospitals in the Brazilian Unified Health System, Rio de Janeiro, in 2002.

Variables/categories	Absolute frequency	Relative frequency (%)
<b>Type of hospital (HOSP)</b>		
Contracted (0)	1,276	29
Self-owned (1)	3,159	71
<b>Intermunicipal displacement (DESL)</b>		
No displacement (0)	3,781	85
With displacement (1)	654	15
<b>Place of admission (REG)</b>		
Nonmetropolitan (0)	1,374	31
Metropolitan (1)	3,061	69
<b>Age (ID) (years)</b>		
18–55 (0)	1,591	36
56–75 (1)	2,256	51
≥ 76 (2)	588	13
<b>Sex (SEXO)</b>		
Females (0)	1,669	38
Males (1)	2,766	62
<b>Use of technologies (TEC)</b>		
Low complexity (0)	3,025	68
Moderate complexity (1)	1,219	27
High complexity (2)	191	5
<b>Time of admission (INT)</b>		
Up to 7 days (0)	2,393	54
8–30 days (1)	1,864	42
Over 30 days (2)	178	4
<b>Use of Intensive Care Unit (CTI)</b>		
No (0)	3,145	71
Yes (1)	1,290	29
<b>Death (OB)</b>		
No (0)	3,163	71
Within 30 days (1)	722	16
Within 1 year (2)	550	13
<b>Costs (GAST)</b>		
Lower than BRL 905,00 (0)	3,212	72
Higher than BRL 905,00 (1)	1,223	28

The application of the MCA resulted in the correlation map shown in Figure 1, where dimension 1 explains approximately 61.8% of the variability in the data (the considered “inertia”), which is more related to the structure of hospital care. On the other hand, dimension 2 explains approximately 27.1% of the variability and is more closely associated with processes applied to AMI patients. Thus, the total inertia of the MCA, taking into account only the first two dimensions, is approximately 0.89.

Taking the outcome variable as reference, the correlation map suggests an association between the “costs lower than BRL 905.00 (GAST0)” and “death within 30 days (OB1),” “use of low complexity technologies (TEC0),” “nonuse of Intensive Care Unit (CTI0),” “age equal or higher than 76 years (ID2),” and “female (SEX00).” Moreover, regarding the “costs higher than BRL 905.00 (GAST1),” the map suggests an association with: “use of ICU (CTI1)” and “use of moderate complexity technologies (TEC1)”.

The tolerance distance obtained (calculated up to the second dimension) was 0.024. Considering that tolerance distance and the nine groups in pairs that include the outcome variable, we obtained seven associations between categories of



HOSP: contracted hospital; HOSP: self-owned hospital; DESL0: no displacement; DESL1: with displacement; REG0: nonmetropolitan region; REG1: metropolitan region; ID0: age 18–55 years; ID1: age 56–75 years; ID2: age  $\geq$  76 years; GAST0: cost lower than BRL 905.00; GAST1: cost higher than BRL 905.00; OB0: no death; OB1: death within 30 days; OB2: death over 30 days; TEC0: use of low complexity technologies; TEC1: use of moderate complexity technologies; TEC2: use of high complexity technologies; CTI0: nonuse of Intensive Care Unit; CTI1: use of Intensive Care Unit; SEX00: females; SEX01: males; INT0: less than 7 days of hospitalization; INT1: between 7 and 30 days of hospitalization; INT2: over 30 days of hospitalization.

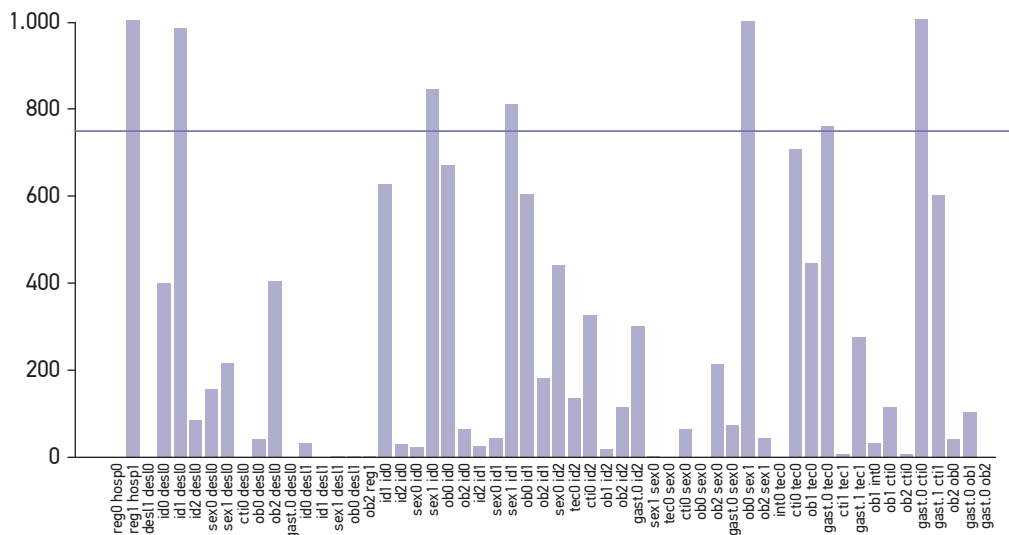
Figure 1. Correspondence map generated by a Multiple Correspondence Analysis based on variables used to characterize costs of admissions for acute myocardial infarction. A total of 4,435 patients were admitted to hospitals in the Brazilian Unified Health System, Rio de Janeiro, in 2002.



variables with “cost lower than BRL 905.00 (GAST0):” “no displacement (DESL0),” “Aged 76 years or older (ID2),” “females (SEX00),” “use of low complexity technologies (TEC0),” “death within 30 days (OB1),” “death within 1 year (OB2),” and “nonuse of ICU (CTI0)”. However, two other associations, with “cost higher than BRL 905.00 (GAST1)” were identified: “use of moderate complexity technologies (TEC1)” and “use of ICU (CTI1)”.

After validation by the bootstrap method, only seven associations could be considered stable, two of which included the outcome variable (Figure 2). In this figure, the bars represent the number of occurrences found in the validation process while the continuous line indicates the limit set for stability (75%). Table 2 shows the categories associated with the outcome variable.

The cluster analysis (hierarchical cluster) enabled the construction of the dendrogram shown in Figure 3. Associated with “cost lower than BRL 905.00” are the following: “nonuse of ICU (CTI0),” “use of low complexity technologies (TEC0),” “up to 7 days of hospitalization (INT0),” “death within 30 days (OB1),” and “aged 76 years or older (ID2)”. Four associations with “cost higher than BRL 905.00” were suggested: “use of ICU (CTI1),” “use of moderately complex technologies (TEC1),” “more than 30 days of hospitalization (INT2),” and “use of highly complex technologies (TEC2).”



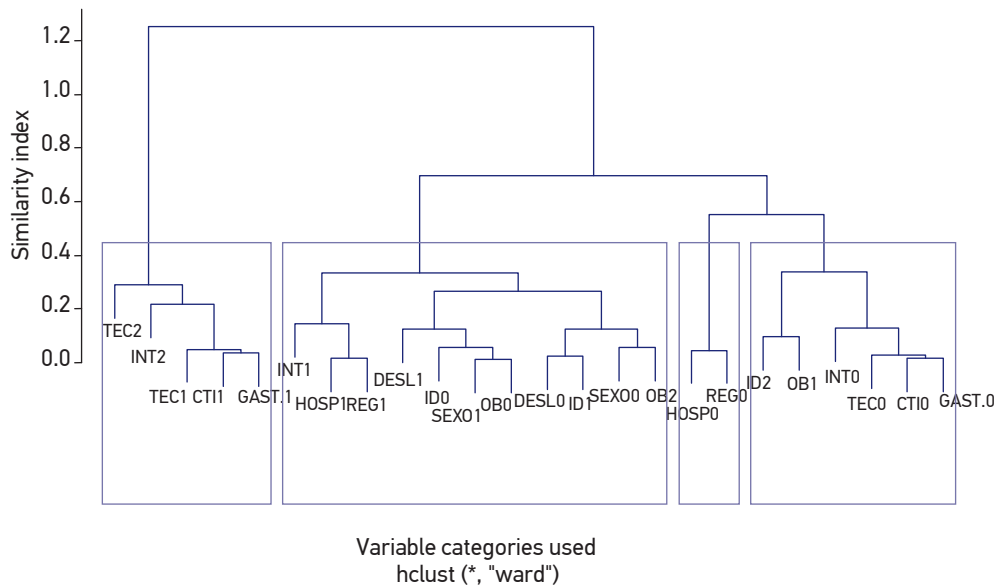
The variables' codes are described in Figure 1

Figure 2. Bar graph showing the associations found by a multiple correspondence analysis based on variables used to characterize the costs of admissions for acute myocardial infarction. A total of 4,435 patients were admitted to hospitals in the Brazilian Unified Health System, Rio de Janeiro, in 2002.

Table 2. Associations for the outcome variable (hospital expenses with hospitalization) detected by multiple correspondence analysis. A total of 4,435 patients were admitted to hospitals in the Brazilian Unified Health System, Rio de Janeiro, in 2002.

Costs	Categories
Lower than BRL 905,00 (GAST0)	No displacement (DESL0)
	Age equal or over 76 years (ID2)
	Females (SEX00)
	Use of low complexity technologies (TEC0)*
	Death within 30 days (OB1)
	Death within 1 year (OB2)
	Nonuse of Intensive Care Unit (CTI0)*
Higher than BRL 905,00 (GAST1)	Use of moderate complexity technologies (TEC1)
	Use of Intensive Care Unit (CTI1)

\*Stable associations by bootstrap analysis.



The variables' codes are described in Figure 1.

Figure 3. Dendrogram developed from a cluster analysis with data used to characterize the costs of admissions for acute myocardial infarction. A total of 4,435 patients were admitted to hospitals in the Brazilian Unified Health System, Rio de Janeiro, in 2002.

## DISCUSSION

AMI is an acute event, which always requires emergency care followed by hospital admission. Owing to its magnitude, impact on mortality, lethality, volume of admissions, and sensitivity to technological intervention, it has been especially pointed as an important disease for the development of standards and indicators for the monitoring of medical care<sup>23</sup>.

Data with follow-up between admission and death, such as those used in this study, are virtually nonexistent in the country. However, analysis of this type of data is crucial, owing to the unique insights that can be obtained from them. In this database, using MCA enabled the visual and simple analysis of a large number of variables, also indicating associations of variable categories. Thus, it was possible to establish the profile of admissions for AMI in the municipalities of the State of Rio de Janeiro, and underlying structures were detected, by reducing data dimensionality.

The correlation map generated from the MCA had a total inertia, considering the first two dimensions, of 0.89, with the first dimension explaining about 61.8% of the variability of the data and dimension 2, approximately 27.1%. Dimension 1 more directly represents the structure of hospital care, highlighting the variables “type of hospital” and “place of hospitalization”. On the other hand, dimension 2 is more related to the procedures adopted in the care to patients with AMI, pointing to the “use of technology.” Therefore, from the analyzed variables, which did not include detailed clinical information about the patient, it was found that those related to the structure of hospital care (type of hospital; area of service) were far from the centroid, with a high percentage of explanation of the variability of cases (in MCA, the greater the distance from one category to the centroid, the higher its explanatory power)<sup>11</sup>.

The MCA, together with the tolerance distance, suggested 56 associations, of which 9 refer to the outcome variable: 7 were associated with “cost lower than BRL 905.00” (“no displacement,” “age ≥ 76 years,” “female,” “use of low complexity technologies,” “death within 30 days,” “death within 1 year,” and “nonuse of ICU”); and 2 were related to “cost higher than BRL 905.00” (“use of moderate complexity technologies” and “use of ICU”). As mentioned, two were considered stable by the validation method used (bootstrap). These associated the “cost lower than BRL 905.00 (GAST0)” to the “use of low complexity technologies (TEC0)” and “non-use of ICU (CTI0).”

Therefore, the correspondence map, along with the tolerance distance, showed that, as expected, the cases that use low complexity technologies are associated with nonuse of ICU, and both are associated with lower costs. In contrast, higher expenses are more associated with the use of moderate complexity technologies and the use of the highly specialized unit (ICU). Although the use of ICUs involves high complexity treatment, with the use of expensive equipment and technologies, the cases with use of highly complex technologies (TEC2 category in Figure 1), were “isolated,” showing no association with the use of ICU (in spite of being located in the same quadrant of the category “use of moderately complex technologies”). This finding suggests that the facilities available in the ICU

are not being adequately used in patient care, thus resulting in negative outcomes, which would be reflected in the correspondence maps as a lower association between these cases and the use of technologies.

The methodology also suggested an association between cases that used less complex technologies and patients aged over 75 years. Individuals in this age group already have collateral circulation (arteriogenesis)<sup>24</sup>, which decreases the intensity of the stroke, making the AMI less severe, with less need for highly complex interventions. On the other hand, younger persons, owing to not having an auxiliary mechanism when the partial or total occlusion of a vessel occurs; and older people, with debilitated and weakened heart muscles, are victims of the most serious AMI cases, with medium and high complexity. However, the association of cases using less complex technology with death and with no use of ICU indicates differences between diagnoses (directly influencing the type of treatment, owing to the actual severity of the case), and possibly early hospital discharges. In addition, the low percentage of use of ICU (Table 1) can also be explained by its underreporting<sup>17</sup>, or even by “barriers to access” (nonavailability of beds).

The methodology of the MCA + tolerance distance showed no significant differences relating to the hierarchical cluster method. The clusters represented by the dendrogram are similar to the findings of the tolerance distance methodology. Note, however, that the clusters formed by the hierarchical clustering methodology include categories that are apparently more distant. These associations were not detected by the tolerance distance, which is more rigorous, formalized, and systematic in defining associations<sup>12</sup>. Furthermore, the tolerance distance enables subsequent validation processes, such as stability analysis, used in this study.

The percentage of deaths by AMI in the study is similar to that estimated by the Brazilian Ministry of Health<sup>8</sup>, through the data for hospital deaths from SIM. Overall, the profile of expenditures follows the national standard, with lower expenses related to cases using low complexity technologies and nonuse of ICU, and vice-versa. Two issues, however, stand out: the first is related to the use of ICU, which, in both sexes (29%), is well below that seen in developed countries<sup>25</sup>. This low use can also help explaining the mentioned lack of association between cases with use of highly complex technologies and the use of ICU observed in this study. The second relates to the fact that, in the correspondence map, the category “males (SEXO1)” is close to “no death,” and that the category “females (SEXO0)” is close to “death within 30 days (OB1)” and “death within 1 year (OB2).” Table 1 shows that the proportion of AMI cases was higher among men (SEXO1), but the mortality rate was higher among women (SEXO0), which causes the proximity between “no death” and males and “death” and females, relationships that have been identified in the scientific literature in recent years<sup>26</sup>.

As stated, the MCA is a technique that has not been used before to obtain the profile of admissions for AMI and its relations to the use of financial resources. Thus, some limitations to this study should be considered. The use of a secondary database can cause problems, such as, for example, underreporting or errors in the filling of forms. In addition, a limitation on the SIH database refers to insufficient data to distinguish patients with different levels

of severity, complicating comparisons between patients and hospitals. Moreover, another obstacle is that information not investigated may be involved in the admission profile, such as time interval from the onset of symptoms to admission, size of infarct, and hemodynamic situation at the time of initial evaluation. The lack of registration of these variables makes it difficult to perform predictive analyses for clinical outcomes or the adjustment of risk factors.

In terms of future research, it would be interesting to build databases with linkage to more updated data, allowing for studies contemplating the use of bases with patient records in their structure, that is, variables related to clinical and physical aspects of the individuals. It would also be important to use these bases for longer follow up periods, which would allow the collection of more accurate information, allowing more efficient use of financial resources by the managers.

## CONCLUSION

In conclusion, the study indicates that lower costs are more associated with not using ICU and cases with use low complexity technology. In contrast, higher expenses are more associated with the use of ICU and the use of moderately complex technologies, and this effect is not observed in cases with use of highly complex technologies. This last aspect suggests that technological facilities available in ICUs were not being adequately used in the care of hospitalized patients, thus not stopping them from dying. Such an interpretation is also supported in studies reported in the literature, which found that the use of ICU is much lower than that observed in developed countries

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Received on: 03/20/2015

Final version presented on: 08/27/2015

Accepted on: 09/24/2015