

Hospital Demand: Using Gis and spatial analysis for estimation

Hospitalizations of the Minas Gerais municipal districts in Belo Horizonte Region – Brazil

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The search for tools for helping in the demand quantification and physic dimension of investment in public health is an issue that still needing answers. Governmental sectors and private business, related to planning, are studying and searching for tools and technical systems that help in the demand quantification and physical dimension of health establishments.² Many studies foresee the public health units dimension in connection to the needs of a given population, taking into account parameters previously established by the Pan American Health Organization, by the World Health Organization or other governmental institutions.³ By considering the idea forming regional systems of public health, we know that the proposition of forming reference centers of medical specialties in cities strategically located, keeping only the basic services in the great majority of the locations, is an economically advantageous solution.

In the Minas Gerais, it is well known that most of the patients use to transpose great distances in order to be assisted in hospitals located in the states' capital, Belo Horizonte, instead of trying to go to a hospital nearby their districts of residence. Intuitively, this information would be confirmed by the relevant presence of patients coming from areas other than Belo Horizonte to get assisted in the capital or even by the great number of ambulances in the capital's streets. However, this affirmative needs empirical studies.

A simple analysis of the hospital resources installed in the Minas Gerais' public health system brings to light signs of an unequal distribution of these resources. In this first analysis, the total of beds, weighted by the population, in medical specialties such as

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² NERO, 1995; MEDICI, 1995; FJP, 1999, GOSSMAN, 1972

³ BRASIL, 1982;

Surgery, Pediatrics, General Clinic and Obstetrics, is used as a proxy for hospital resources for assisting population's basic needs.

It is possible to observe that the states' capital concentrates around 13% of the population and 22% of the existent beds (see Table 1). On the other hand, small districts, with less than 50.000 inhabitants concentrates 46,1% of the state's population and 32,7% of the hospital beds in these specialties.

Table 1
Population, Total Number of Districts and relative participation in beds and population according to municipal district's population size category - Minas Gerais, Brazil - 1999-2000

Municipal District's Category	Population	Total Districts	Beds	Relative Participation	
				Population	Beds
To 50.000 inhabitants	8.214.860	793	8.230	46,1%	32,7%
50.000 to 100.000 inhabitants	2.619.424	37	4.220	14,7%	16,8%
100.000 to 300.000 inhabitants	2.678.017	17	4.290	15,0%	17,1%
300.000 to 600.000 inhabitants	2.093.490	5	2.770	11,7%	11,0%
Belo Horizonte	2.229.697	1	5.640	12,5%	22,4%
Total	17.835.488	853	25.150	100,0%	100,0%

Source: IBGE, 2001; SIH-MS-DATASUS, 1999

Although the use of districts as the unity of analysis may be a good representation of the Brazilian health system's physical function, it may lead to incomplete analysis, since the small districts present economically impracticable hospitals. However, by aggregating the districts' data in IBGE (Brazilian Geographical and Statistical Institute) Geographical Micro Region, it is possible to observe a less unequal division. Even though, the Belo Horizonte Micro Region, the more populated in the state, concentrates 23,8% of the state's population and 28,2% of the total beds, while small Micro Regions (until 200.000 inhabitants) have 27,8% of the population and only 23,1% of the state's beds. In a more deep analysis NASCIMENTO (2001) confirm these facts:

“Only three From the state's health agglomerations (Belo Horizonte, Juiz de Fora e Montes Claros), that concentrate 48,5% of the state's population, concentrate more than half (54%) of the hospital's beds, 48,2% of the doctors' offices and 44,1% of the ambulatory services related to the Public Health System (Sistema Único de Saúde), besides 64,0% of high complexity services”.

Tabela 2

Population, Total Number of Micro Region and relative participation in beds and population according to micro region's population size category - Minas Gerais, Brazil - 1999-2000

Categoria da Micro Região	População	Total de Micro Regiões	Participação relativa	
			População	Leitos
To 200.000 inhabitants	4.962.450	38	27,8%	23,1%
200.000 to 300.000 inhabitants	4.066.883	17	22,8%	24,2%
300.000 to 500.000 inhabitants	2.672.801	7	15,0%	14,0%
500.000 to 750.000 inhabitants	1.892.284	3	10,6%	10,5%
Belo Horizonte	4.241.070	1	23,8%	28,2%
Total	17.835.488	66	100,0%	100,0%

Fonte: IBGE, 2001; SIH-MS-DATASUS, 1999

It would be expected that Belo Horizonte, given its dimensions, connect specialty diversification and medical services. And the higher concentration of medical services and hospitals in larger cities becomes an acceptable situation. In this sense, it is expected that the state's capital attract patients from the state's inland to its hospital's system, bigger and more equipped. However, to quantify in which measure a health system installed in a city or region does not have the right dimension to receive the patients in general still an issue being studied.⁴ This reality leads to a concentration of investments in physical structure in only a few regions of the state and these investments are usually based in subjective and or political criteria. They, normally, do not take into account technical aspects.

This study does not intend to suggest the kind of health establishment is more appropriated to one region or town. It also does not mean to indicate where a given service must be installed. Furthermore, it also does not intend to conclude the possible analysis that the topic allows, since it is a very complex subject. It actually intends to observe whether or not the cities are using in an efficient way the resources available in the district itself and in locations nearby it. To evaluate the way that the population uses its resources is also exemplified by the districts situated in the state's borders' areas, where the populations move to neighbors States instead of moving to places in the same State. Moreover, in the case of districts situated close to larger cities, such as Belo Horizonte, it is even possible to observe that the population is unaware of the existence of some sorts of services located in nearby cities and ends up moving to more known establishments. It may happen because of trust in the known or just because some services are not available.

The aim of this study is to explore if some districts send patients to Belo Horizonte in higher rates than what is observed in the rest of the state. It will be done taking into account the distance crossed by the patient. These districts or regions distinctions would lead us to suppose the existence of an insufficient health system, offering low quality or little trustful services in the origin areas. It is our intention, in this work, to evaluate if the patients who live in Minas Gerais submit themselves to great distances' journeys in order to get assistance in the Belo Horizonte region or they prefer to trust in the local health system.

Methodology and Data Set

The methodology used in this study is based in linear regression model structure that explores the significance of the distances traveled by a patient hospitalized in the Belo Horizonte's micro region (BHMR), the larger and better equipped in the state, from its district of origin. This model uses data from patient's hospitalization in this micro region along with data about the distances between the districts and Belo Horizonte's micro region, the population and the hospital's infra structure existents in the patient's origin district or region. This hospital infra structure is represented by the total number of beds in the following specialties: General surgery, General clinic, Pediatrics, Obstetrics and the total of these specialties. In a further study, other specialties, ambulatory service, installed and high costs specialized services may be included as estimators of the hospital's complexity and capacity.

The State of Minas Gerais is located in the Brazilian Southeast Region, that is the area economically more dynamics of the country. The Metropolitan area of the capital of the State, Belo Horizonte, is the third urban center of the country in economic and demographic importance. But, even with this relative importance, the state presents a great diversification of its social and cultural characteristics. Its territory is influenced strongly by other urban centers of the country, besides its capital (Brasília, Rio de Janeiro and São Paulo) - see Illustration 1.

⁴ FJP 2001, NASCIMENTO 2001

Illustration 1

Minas Gerais State, Brazil – 1999-2000



Source: PRODEMGE, 1996

The BHMR choice is due its greater diversification and installed capacity. Furthermore, the option by the BHMR, rather than the Belo Horizonte district, is justified by the existence of important hospitals in other cities, belonging to the same Metropolitan Area that would have some effect in the study. The districts existent in the micro region of Belo Horizonte were excluded of the study.

Examinations in other state's regions would bring more precise and detailed information about specific regions deficiencies. Other regions were evaluated in a similar way during the study's period, being considered as areas of regional hospital's concentration by a João Pinheiro Foundation (Fundação João Pinheiro - FJP, 2000) research. This study showed insignificant regression results and, in this way, it can be deduced that a study in smaller and less specialized regions needs, apparently, evaluations in smaller geographical units.

Alpha numeric data set

From the 1999 Hospital Information System (Sistema de Informações Hospitalares - SIH - DATASUS) information related to hospitalizations were acquired. The medical specialties included in this study are restricted to those considered, apparently, as being basic for the population (Clinics, Obstetrics, Pediatrics and Surgery). It is believed that these specialties, at first, would be closer, as possible, to the patients. Other specialties considered by the DATASUS (Tisology, psychiatrics, rehabilitation, chronicle patients and high cost services) are located, theoretically, in regional centers and the patient's movement to the state's capital would be an expected and natural phenomenon. In this sense, whenever we make mention to data related to hospitalization in the Belo Horizonte's micro region, we will be considering only the four previously mentioned specialties. We cannot assure that these specialties' subdivision is faithful to the population's primary needs. However, it is possible the closest one.

From the preliminary Demographic Census data (IBGE, 2.001) information about the districts' population was obtained. The difference between the 1999 and the 2000 the populations' hospital data information does not seems to bring notable differences in the population's distribution.

Spatial data set

For information related to the distances between the state's districts and the BHMR, Cartesian distances were adopted based on digitized maps processed by PRODEMGE (PRODEMGE, 1996a, 1996b, 1996c e 1996d).

Information related to the hospitals is limited to the total of beds in each one of the specialties included in this study. It was also considered that the hospitals' locations were coincident with the municipal headquarter location. From this, we can calculate the mean location of beds within a micro region. The mean location of beds was weighted by the number of beds hired by the Public Health System (SUS) in each micro region's district

under study. The assumption that the hospital is located in the same geographical position that the municipal headquarters it is surely liable to mistakes, mainly in the Belo Horizonte micro region, where nor all the hospitals are not located in Belo Horizonte Center Area. The geographical positions were weighted by the specialties previously mentioned and related to the total of these for all the micro regions in the State.

One example of the center mass beds was suggested in Illustration 2 and in the Formulas 1 to 4. The formulas exemplify the “weighted centroid from the headquarters districts” and “weighted centroid from the hospitals’ beds” calculus.

The UTM (Córrego Novo) coordinate systems were adopted because they work with metrical coordinates and, for this reason, make easier the reading of the distances. This system of coordinates generates projection mistakes areas located far away from the terrestrial equator and, for this reason, they are expected deformations in the distances esteemed in the highest latitudes. Futhermore, the union of the zones 22 and 23, of Coordinate UTM's System (Córrego Novo), it also produces mistakes in the estimates of the distances. These deformations were considered as not very significant for the result found in this work because of the relative proximity of the state with the terrestrial equator - the State of Minas Gerais is located among the parallel 14th and 23rd South of the equator.

District headquarters weighted Centroid

$$X_j = \frac{\sum X_i}{n} \qquad Y_j = \frac{\sum Y_i}{n} \qquad (1 e 2)$$

Onde:

X_i e Y_i	Spatial Coordinates, X e Y, of the Municipal Districts’ Headquarter
X_j e Y_j	Spatial Coordinates, X e Y, of <u>i</u> th Municipal District headquarters weighted Centroid belongs to <u>j</u> th micro region
N	Total of Municipal districts belong to <u>j</u> th micro region

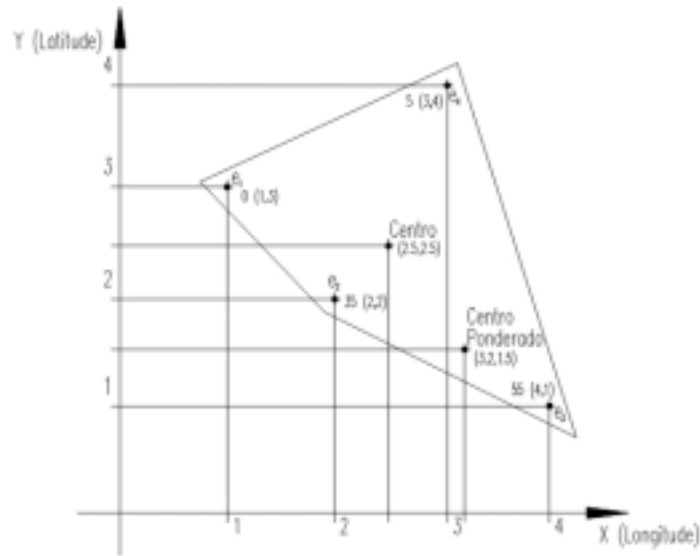
Weighted centroid from the hospitals' beds (or hospitals bed's regional center):

$$X_j = \frac{\sum X_i * LeitosMun_j}{LeitosMicro_j} \qquad Y_j = \frac{\sum Y_i * LeitosMun_j}{LeitosMicro_j} \qquad (3 \text{ e } 4)$$

Onde:

$LeitosMun_i$:	Total of hospitals beds in i th municipal district, belongs to j th micro region
$LeitosMicro_j$:	Total of hospitals beds, belongs to j th micro region
X_i e Y_i	Spatial Coordinates, X e Y, of the i th Municipal District headquarters
X_j e Y_j	Spatial Coordinates, X e Y, of the weighted centroid from the hospitals' beds, belongs to j th micro region

Illustration 2
Weighted beds mean calculus model



From the weighted centroids information of the districts' beds for each micro region of the districts headquarters, the Cartesian distances between the state's districts and the regional centers were estimated according to Formula 5.

$$Dist\acute{a}ncia_i = \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2} \quad (5)$$

Onde:

$Dist\acute{a}ncia_i :$	Distance between the <u><i>i</i></u> th district headquarter and the weighted centroid from the hospitals' beds of the <u><i>j</i></u> th micro region
X_i e Y_i	Spatial Coordinates, X e Y, of the <u><i>i</i></u> th Municipal Districts' Headquarter
X_j e Y_j	Spatial Coordinates, X e Y, of the weighted centroid from the hospitals' beds, belongs to <u><i>j</i></u> th micro region

As an example, the map in Illustration 2 stresses the regions of Belo Horizonte and Ouro Preto. It is possible to observe that in the BHMR, the regional center of beds for all specialties in issue, is close to the capital's district headquarter. The same does not happen to the Ouro Preto micro region, where it is possible to observe that the regional center is some point situated between Itabirito and Ouro Preto. It is due to the relative weight of Belo Horizonte district, that has more beds than all the other districts in the Belo Horizonte micro region together, bringing the regional center to its headquarter. In the Ouro Preto micro region case, the Ouro Preto and Itabirito districts share the micro region's beds. For this reason, this regional center is located in one point in the line between the Ouro Preto and Itabirito's districts headquarters.

Illustration 3

Belo Horizonte Micro Region and Ouro Preto Micro Region, Minas Gerais, Brazil - 1996

Districts Headquarter, hospitals bed's regional center e border districts.



Source: PRODEMGE, 1996.

Table 3 presents the processed data used in the next models. This table shows both the alpha numerical and spatial data. Moreover, this table also shows data produced from the previously mentioned data set (alpha numerical and spatial data).

Table 3
 Descriptions, means, Standard error, maximum e minimum of variables Minas Gerais, Brasil

Descrição	Variável	Média	Desvio Padrão	Máximo	Mínimo
District Code	MunicRes				
Micro Region Code	MicroRes				
District distance between headquarter districts and hospitals bed's regional (General surgery, General clinic, Pediatrics, Obstetrics and the total)	Dist30_Cir	308,729	156,983	787,573	45,474
	Dist30_Clin	308,736	156,817	786,936	45,718
	Dist30_Ped	308,755	157,287	784,035	45,965
	Dist30_Obst	308,752	156,454	785,991	45,819
	Dist30_Tot	308,733	156,916	787,073	45,819
Hospitalizations in Belo Horizonte Micro region by 1000 inhabitants (General surgery, General clinic, Pediatrics, Obstetrics and the total)	Int30_Cir	1,693	2,291	18,962	0,011
	Int30_Clin	0,916	1,622	18,791	0,004
	Int30_Ped	0,418	0,630	5,927	0,002
	Int30_Obst	0,675	2,058	14,738	0,003
	Int30_Tot	2,678	4,450	44,952	0,021
Hositals Beds Resident Micro region by 1000 inhabitants (General surgery, General clinic, Pediatrics, Obstetrics and the total).	Mic_Cir	0,214	0,153	0,794	0,000
	Mic_Clin	0,705	0,298	1,537	0,000
	Mic_Ped	0,161	0,113	0,449	0,000
	Mic_Obst	0,257	0,149	1,296	0,000
	Mic_Tot	1,337	0,513	2,916	0,317

Source: PRODEMGE, 1996; IBGE, 2001; e SIH-DATASUS-MS, 1999

The use of additional data, such as deaths and age groups didn't show significance in the regressions. The low significance of age variables or death frequencies by hospitalization would be connected with the weak relationship between age or deaths and the distance crossed by the patient. It would also suggest that the transference for hospitalization would not be selective by patient's age or health condition.

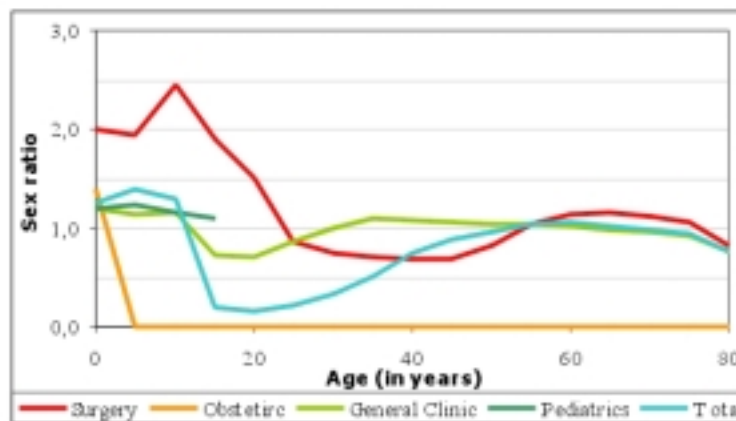
For studies desegregated by medical specialties the population's age distribution is surely significant. Graphs from 2 to 4 display the patient's age pyramids, according to medical specialties. Graph 1 shows the Sex ratios for each medical specialty. These data demonstrate the need for weighting the medical specialty hospitalizations such as Pediatrics and Obstetrics by the age group adequate.

The analysis of the Graph 1 demonstrates a tendency of the women of 20 to 50 years if they intern in surgery and clinic more than the men. This tendency perhaps is justified for the women's fact to seek more for medical services than men. In inferior ages that 15 years old and in the pediatrics internments we didn't notice this tendency of more internments of women, possibly for the fact that in these ages the decision of going into or

it is not the individual's decision, but of their parents or other responsible adult, doing with that the tendency of the sex reasons to accompany the real population. In the most advanced ages we have a distribution of sexes practically equal for the surgery specialties and clinic. Finally, in obstetrics, the internments are larger for men in the first group of age (newly born) and zero for the other ages, for obvious reasons.

Graph 1

Sex Ratio for patients, by age and medical specialty, Minas Gerais – Brazil, 1999



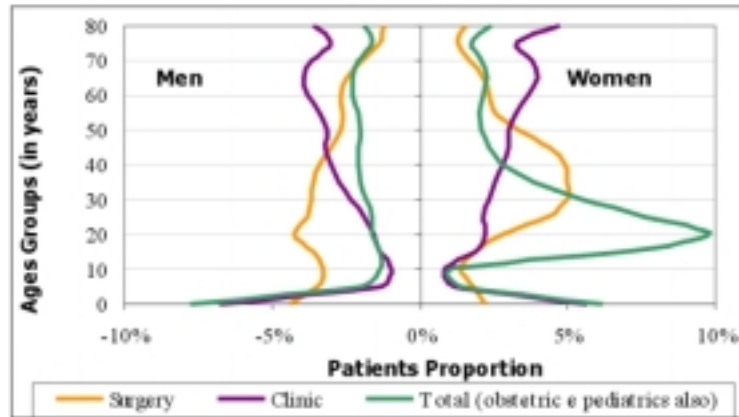
Source: SIH-MS-DATASUS, 1999;

The analysis of the Graph 2 demonstrates that the total internments in to Belo Horizonte Micro Region have a tendency strongly influenced by the largest number of women in the obstetrics internments and surgery. This fact justifies the use of the patients' internments separately in the four specialties and not for the total internments. But, the regressions using the totals of internments could detect cities not detected by the studies using all the specialties.

Still observing the Graph 2, we noticed that there is a larger amount of women interned in the surgery specialty in the age groups of 20 to 50 years, approximately, already showed in the analysis of the Graph 1. The reasons for this tendency still need others studies, but, initially, it could be that the most of these internments is obstetric surgeries and the women's largest tendency in seeking for medical attendances.

Graph 2

The patients' age pyramid in the specialties of General Clinic, Surgery and Total, Minas Gerais - Brazil, 1999

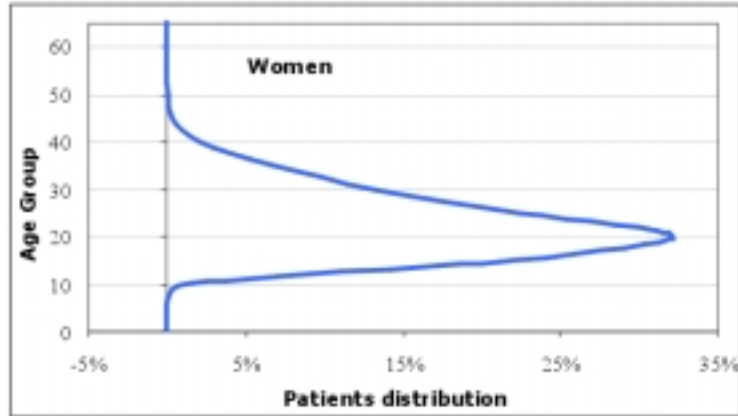


Source: SIH-MS-DATASUS, 1999;

The Graph 3 demonstrates that the internments in obstetrics is similar with the function of the fecundity of the population, taking us to believe that most of the obstetrics hospitalizations is linked to services of the childbirths. Finally, the Graph 4, about Pediatrics hospitalizations, demonstrates that most of the pediatrics internments happens in the first year of life decreasing progressively to the 15 years of age. These graphs justify that the denominator of the ratio between internments and the population should be pondered by specific groups of age. Seemingly the age group of 0 to 15 years could be the denominator indicated for the pediatrics specialty, and the women of 10 to 50 years old could be the denominator indicated for obstetrics services.

Graph 3

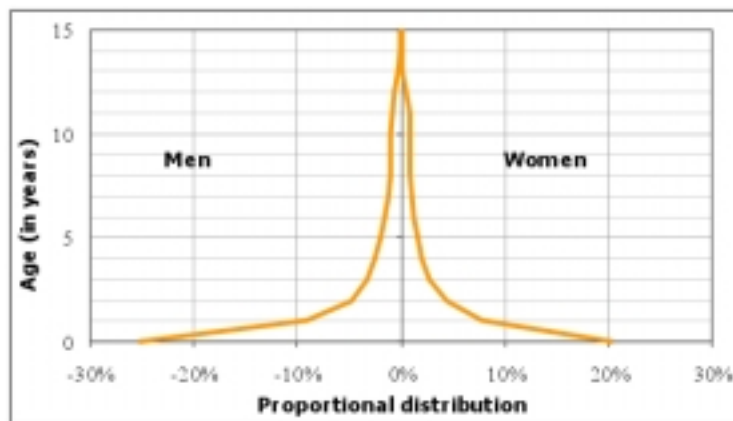
The patients' age pyramid interned in the specialty of Obstetrics, Minas Gerais - Brazil, 1999



Fonte: SIH-MS-DATASUS, 1999;

Gráfico 4

The patients' age pyramid interned in the specialty of Pediatrics, Minas Gerais - Brazil, 1999



Fonte: SIH-MS-DATASUS, 1999;

Model development

In the beginning of this study, became obvious that the use of a data set including the districts from the BHMR would lead to mistaken results. Districts located in this area and that have hospitals, would be configured as districts receiving patients who would need to travel to get medical assistance, while, in fact, they would be getting assistance in their district hospitals. For this reason we disregard the cities belonging to the Belo Horizonte's micro region.

The first model (Model 1) tested, assumes that the hospitalization in the BHMR would be explained by the distances crossed by the patient and by the infrastructure installed in the patient's micro region of origin. The formula presenting this situation is the number 6. The districts' population weights the number of hospitalizations and the micro region's population weights the micro region's beds.

$$Int_i = \beta_0 + \beta_1 Dist_i + \beta_4 Leitos_i \quad (6)$$

Onde:

int_i :	Hospitalizations by 1000 inhabitants by <u>i</u> th district (origin) in Belo Horizonte Micro Region (destine).
$Dist_i$:	Distance between <u>i</u> th district (origin) and Belo Horizonte Micro Region (destine).
$Leitos_i$:	Hospitals beds by 1000 inhabitants in <u>i</u> th Micro Region (origin).

In spite of the difference among the distributions for sex and the interned patients' age, the total population of each municipal district was used as weight of the data. It was believed, initially, that the results would be not very distorted by the use of the total population. Ally to that, the difficulty of obtaining data for age and sex in all of 853 municipal districts of the State of Minas Gerais took to the adoption that the total population would be the weight of the data that will be used in the linear regression developed.

A second model (Model 2) was proposed including distance dummy variables. The coefficients β_0, β_1 e β_2 correspond to the districts that are less than 75 Km away from the micro region i. The coefficients β_3 e β_4 correspond to additional values in the intercepts to districts that are from 75 to 150 km distant from the micro region and to those more than 150 Km distant, respectively.

$$Int_i = \beta_0 + \beta_1 Dist_i + \beta_2 .Leitos_i + \beta_3 .Dist_i_{-75150} + \beta_4 Dist_i_{-150} \quad (7)$$

Onde:

int_i :	Hospitalizations by 1000 inhabitants by i th district (origin) in Belo Horizonte Micro Region (destine).
$Dist_i$:	Distance between i th district (origin) and Belo Horizonte Micro Region (destine).
$Dist_i_{-75150}$:	Dummie variable for distances between residencial district i th (origin) and BHMR (destine) between 75 and 150 km
$Dist_i_{-150}$:	Dummie variable for distances between residencial district i th (origin) and BHMR (destine) more than 150 km
$Leitos_i$:	Hospitals beds by 1000 inhabitants in i th Micro Region (origin).

Scatter Plot

The graph 5 shows the scatter plot for the patients' total internments in MRBH cross by of the distance traveled by the patient. The graphs of the analyzed other specialties are presented in the appendix. Analyzing the graphs quickly, seemingly, we could believe that a linear adjustment for this dispersion would be unacceptable, because of the outliers observed in the diagram. For this reason the models were tested in two ways: one without the municipal districts that had more than a specific number of hospitalizations and another with all the municipal districts of the state.

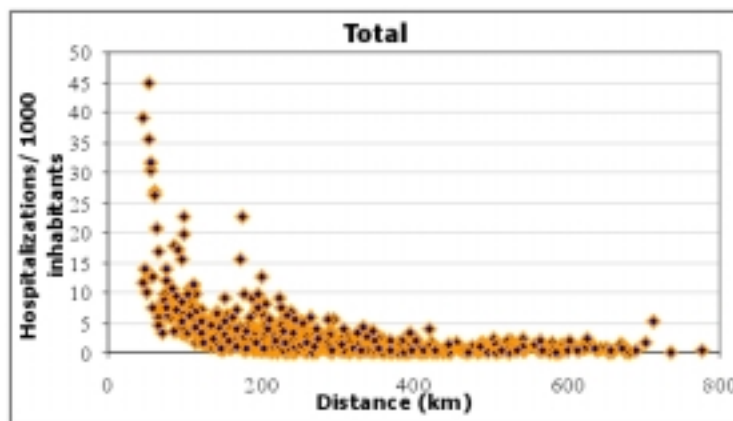
The idea of the model was detect the municipal districts that sent patient above the average of the state, and then if we eliminate municipal districts that sent more patient than the others we are excluding the largest exporters of patients, disabling the detection of these. Although, these municipal districts that export patient above the average could elevate the general average and the detection of municipal districts with significant patient export, but not so big. In descriptive analyses of data it was highlight municipal districts, placed at the same distance of Belo Horizonte, and that export numbers of patients significantly different, justifying like this the adoption of this cut line in the data. Finally, the Table 5 summarizes the variables used in the models and the cut line adopted for each specialty.

Table 5
Variables used in regression models and cuts lines of data

Variable Data	Model 1	Model 2	Total	Cut line for the dependent variable			
				Cirurgia	Clínica	Pediatria	Obstetrícia
	Mic_TotMil	Mic_TotMil					
	Dist30_Tot	Dist30_Tot					
Independent		D30_150_Tot	More than 10 hospitalizations for 100 inhabitants	More than 6 hospitalizations for 100 inhabitants	More than 3 hospitalizations for 100 inhabitants	More than 1 hospitalizations for 100 inhabitants	More than 1 hospitalizations for 100 inhabitants
Dependent	Hospitalizations by 1000 inhabitants, by speciality						

Graph 5

Scatter plot of total hospitalizations by 1000 inhabitants cross by distance between residential district and Belo Horizonte Micro region, Minas Gerais, Brazil – 1999



Source: DATASUS, 1999; PRODEMGE, 1996 e IBGE, 2000.

Results

Total of Hospitalizations

The two models presented satisfactory results, whether or not with the elimination of the possible outliers. Table 6 presents the regression coefficients of the produced models, including, or not, the districts with a great number of hospitalizations.

The results show that the hospitalizations in Belo Horizonte have relationship with the distance traveled by the patient. Analyzing the map presented in the

Illustration 4, it's possible to see that the patients, who traveled to Belo Horizonte Region, in its great majority, come from close cities. But, the model doesn't detect that all municipal districts located close the Capital send patients above the mean. It could be possible to suppose that the resources in the patient's origins influences the patients' emigration or not to the capital. The results demonstrate that the hospitals beds, in the patient's origin, and the hospitalizations were connected. It is still detected a great amount of hospitalizations from the Northeast region of the State, coincidentally one of the more poor of the state.

Table 6

Linear Model of the total hospitalizations, by 1000 inhabitants, from origin district, in Belo Horizonte Micro Region, Minas Gerais - 1999

Variable	All districts				Whithout districts with six or more hospitalizations by 1000 inhabitants			
	Model 1		Model 2		Model 1		Model 2	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	7,6333	0,5026	18,3643	0,7415	5,1960	0,2333	7,9260	0,5696
Mic_TotMil	-0,7737	0,2887	-0,5129	0,2339	-0,6932	0,1308	-0,5543	0,1224
Dist30_Tot	-0,0137	0,0010	-0,0061	0,0010	-0,0078	0,0005	-0,0051	0,0005
D30_150_Tot			-14,0995	0,7364			-3,9871	0,5664
D30_75150_Tot			-11,3748	0,7491			-2,1278	0,5744

Observações: Statistical significant in $p < 0,05$
n = 853 observations

Fonte: Demographic Census 2000, IBGE; SIH/DATASUS/MS, 1999; PRODEMGE; 1996.

The results show that the hospitalizations in Belo Horizonte can be strongly related with the distance between the residence city and the patients' destiny. The great majority of the variables obtained values of smaller p than 0,0001 in the regressions.

Analyzing the results starting from the Model 1, with all the municipal districts, the data are inferred that there is the hospitalizations decrease about of 13.7, for each a thousand inhabitants interned, for each 100 km that we moved away from Belo Horizonte Micro Region (Coefficient of the Variable Dist30_Mic*100). The relative coefficients to the existent beds in origin micro region can still demonstrate that, on the average, for each bed for a thousand inhabitants installed in the origin region there is the decrease about 77 patients for each a thousand inhabitants!

The use of cut lines in the analysis of the data; decrease the medium values with it were already waited. But coefficients still highlights the significant for the variables: on the average, it has less 69 patient for each bed installed in the origin area and it decreases about 7.8 patients interned for each 100 km that we moved away of Belo Horizonte.

The uses of variable dummies for the distances add other consideration to the study. Cities that are located the less than 75 km of Belo Horizonte could have increased about 6,08 hospitalizations, for each a thousand inhabitants in the origin municipal district.

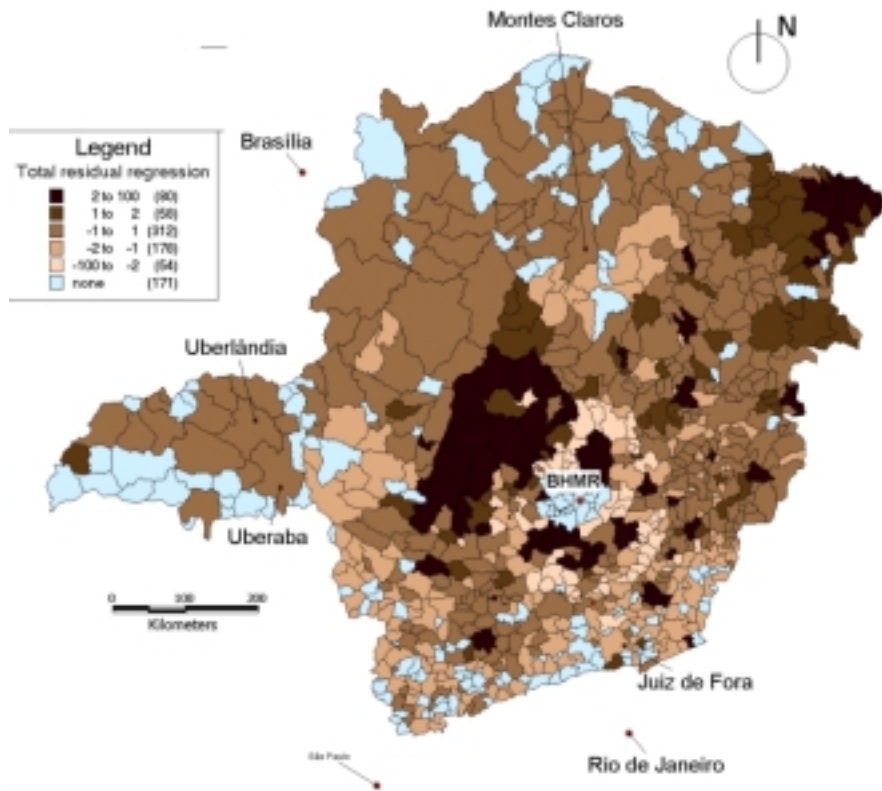
The map presented in the Illustration 4 presents the residues of the regressions. The most of the patients hospitalized in Belo Horizonte comes from the cities closer than the BHMR, mainly in the central area of the state, in the west of the capital. Surprisingly the model doesn't detect that all the close municipal districts send patient and it could be possible to suppose that the resources in the patient's origins influences the patients' flow to the capital, how it already inferred from the evaluation of the coefficients of the regressions.

It is detected, in the Illustration 4, a great amount of hospitalizations from of the Northeast area of the State, that coincides with the poorest areas of the state. The regions located near the City of Montes Claros, seemingly, send patient below the average of the State. Previous studies already observed the high complexity and good infrastructure installed in the municipal district of Montes Claros, taking us to suppose that this region, in spite of its population are poor, uses the resources installed in the region satisfactorily.

Finally, regions located in the South of the State and in the vicinity of the Cities of Uberlândia, Uberaba and Juiz de Fora, seemingly, send their patient to BHMR below the average of the state. This confirms hypotheses that these areas suffer strong influence of the cities Rio de Janeiro and São Paulo, respectively. The same case is observed in the northwest area of the State of Minas Gerais, where the patients probably moved to Brasília, the capital of the Country.

Illustration 4

Residuals of Linear Regression from Total Hospitalizations, from model 2, with all observations, Minas Gerais – Brasil, 1999



Source: Prodemge, 1996, SIH, DATASUS, 1999; and Demographic Census, 2000

Surgery Hospitalizations

In the general surgery specialty could be observed, from the coefficients of the regression, that there is significant influence of the beds placed in the patients' origin as well as of the traveled distance. Of the four analyzed specialties in this work, Surgery obtained the largest coefficients for the beds in the origin was, as well as for the distance. This result is coherent with observations that this specialty is reference in the state by the capital. But, nevertheless, the evaluation of the variables dummies noticed that the cities located near the capital have the bigger flows to the BHM for each a thousand inhabitants.

Table 7

Linear Model of the surgery hospitalizations, by 1000 inhabitants, from origin district, in Belo Horizonte Micro Region, Minas Gerais - 1999

Variable	All districts				Without districts with six or more hospitalizations by 1000 inhabitants			
	Model 1		Model 2		Model 1		Model 2	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	4,6291	0,1907	8,0030	0,3607	3,1901	0,1160	4,6027	0,3652
Mic_TotMil	-3,5314	0,5248	-2,6092	0,4643	-2,2155	0,2989	-1,7452	0,2722
Dist30_Tot	-0,0080	0,0005	-0,0041	0,0005	-0,0050	0,0003	-0,0031	0,0003
D30_150_Tot			-5,0812	0,3886			-2,3028	0,3743
D30_75150_Tot			-3,2616	0,3925			-0,8628	0,3775

Observations: statistical significant in p < 0,05
n = 853 observations

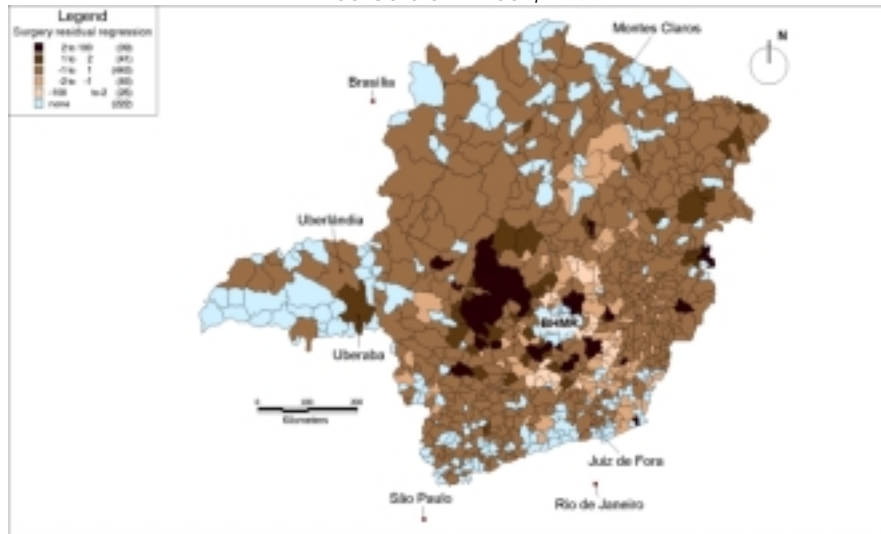
Fonte: Demographic Census 2000, IBGE; SIH/DATASUS/MS, 1999; PRODEMGE; 1996.

The map presented in the Illustration 5 shows a similar pattern demonstrated by the total internments. It is important to notice that the surgery hospitalizations are the one of larger absolute value, and it is probable that the results of the total hospitalizations are being influenced by the values of surgery. The characteristic behavior of the municipal districts placed in the northeast of the state, on the average, is different than the total hospitalizations. The municipal districts located in the central area of the state, in the west of the capital, have the largest flow of patients to the capital. Resident patients in the South and in the region of Uberlândia and Uberaba cities, seemingly they send its patients for São Paulo. Already the areas near to Juiz de Fora district, seemingly send its patients for Rio de Janeiro and the areas near to Brasília could send their patients to the Brazilian Capital.

Furthermore, the areas located in the to Northeast and in the North of the State have a bad road system, and it, perhaps, explains the patients' flow to Belo Horizonte: the municipal districts seemingly were close to themselves, but the precarious roads could make the patient prefer travels where the ways are better (Belo Horizonte or Montes Claros have the better road access).

Illustration 5

Residuals of Linear Regression from Surgery Hospitalizations, from Model 2 with all districts, Minas Gerais – Brasil, 1999



Source: Prodemge, 1996, SIH, DATASUS, 1999; and Demographic Census, 2000

General Clinic Hospitalizations

In this specialty the data didn't show significant results for the beds located in the patients' origin. This result could take us to suppose that the technical capacity installed in MRBH is significantly superior that the remaining of the state: the patients moved to capital to find specific services. In this hypothesis is supposed that the patient is going to Belo Horizonte in search of specific services, because the services only exist in the capital of the State. The distance traveled by the patient still maintain the significant statistical, decreasing of 0.2 to 0.37 hospitalized patients, for each a thousand inhabitants, for each 100 km that stands back of Belo Horizonte. The smaller proximity than 75 km of the capital of the state still demonstrates that, in the great majority, the patient were interned in BHMR comes from the closer municipal districts.

Table 8

Linear Model of the general clinic hospitalizations, by 1000 inhabitants, from origin district, in Belo Horizonte Micro Region, Minas Gerais - 1999

Variable	Todas as observações				Whithout districts with three or more hospitalizations by 1000 inhabitants			
	Model 1		Model 2		Model 1		Model 2	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	1,7619	0,2009	5,0396	0,3122	1,1717	0,0681	1,5471	0,1536
Mic_TotMil	0,2056*	0,2198*	0,2639*	0,1920*	-0,0535*	0,0733*	-0,0454*	0,0706*
Dist30_Tot	-0,0037	0,0004	-0,0016	0,0005	-0,0018	0,0002	-0,0012	0,0002
D30_150_Tot			-4,1079	0,3163			-0,6336	0,1541
D30_75150_Tot			-3,7146	0,3172			-0,2517*	0,1547*

Observations: Statistical significant at $p < 0,05$
 (*) Not significant at $p \geq 0,05$
 n = 853 observations

Source Demographic Census 2000, IBGE; SIH/DATASUS/MS, 1999; PRODEMGE; 1996.

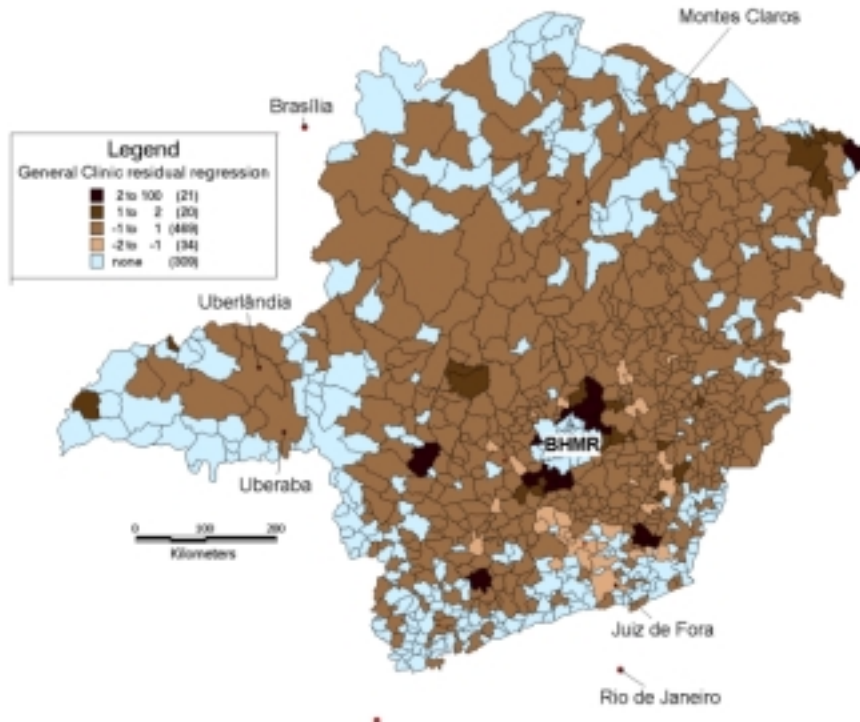
The analysis of the thematic map presented in the Illustration 6 has a standard the results found previously. Most of the state has values close to the general average, and the districts that differentiate a lot of this average don't form a characteristic group and highlighted in the state.

Cities located in the Northeast of the state maintain the tendency of patients' flow, for a thousand inhabitants, above the general average, even if slightly. The areas that presented the tendency of not maintaining flows, be above or below the average, it also maintains this softened tendency.

Most of the state didn't present the tendency of patients' emigration above or below the average. This observation justifying the hypothesis that the patients would go Belo Horizonte in search of specific specialists: the hospitalizations, seemingly happen in the origin area. Seemingly the patients' exportation could happen in complicated cases, where depends on specialized staff or of more complex equipments, that would only be found in the capital.

Illustration 6

Residuals of Linear Regression from General Clinic Hospitalizations, from Model 2, with all districts, Minas Gerais – Brasil, 1999



Source: Prodemge, 1996, SIH, DATASUS, 1999; and Demographic Census, 2000

Pediatric Hospitalizations

The evaluation of the results of the pediatrics hospitalizations brings strange results because of the relative weight of the municipal districts of the hospitalizations for each one thousand inhabitants in the origin area. The outliers took all the municipal districts to the general average of the state and the non-retreat of the outliers obtained non-significant values for the relative variable to the beds in to the patient's origin. The hypotheses are similar the those deduced for General Clinic: the hospitalizations in pediatrics are marked for the medical cases that don't find in the origin specialists' area and services capable to solve the problems of the children's health. This can be confirmed by certain observations: (1). The low significant value of the relative variables to the beds in the patient's origin denotes that these beds don't influence in the decision of hospitalizing in

Belo Horizonte; (2). The coefficients of the traveled distances are low, denoting that the traveled distance is not an impediment to the internments; and (3). The fact of the variables distance dummies present not significant values in the Model 2 (without the districts with an or more hospitalizations in BHMR), denotes in the great proximity of Belo Horizonte the patients don't move to the capital, only in some cases.

These considerations maintain a certain relationship with the reality: the installation of pediatrics hospital beds already depends on a demand. These beds could be more easily observed in the largest urban centers.

Table 9

Linear Model of the pediatric hospitalizations, by 1000 inhabitants, from origin district, in Belo Horizonte Micro Region, Minas Gerais – 1999

Variable	All Observations				Whithout districts with one or more hospitalizations by 1000 inhabitants			
	Model 1		Model 2		Model 1		Model 2	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	0,8567	0,0789	1,3812	0,1220	0,4506	0,0273	0,4885	0,0567
Mic_TotMil	-0,4129*	0,3111*	-0,3233*	0,3000*	-0,3385	0,1025	-0,3333	0,1035
Dist30_Tot	-0,0015	0,0002	-0,0009	0,0003	-0,0005	0,0001	-0,0005	0,0001
D30_150_Tot			-0,7471	0,1370			-0,0482*	0,0603*
D30_75150_Tot			-0,6858	0,1333			-0,0427*	0,0599*

Observations: Statistical significant at $p < 0,05$
 (*) Not significant at $p \geq 0,05$
 n = 853 observations

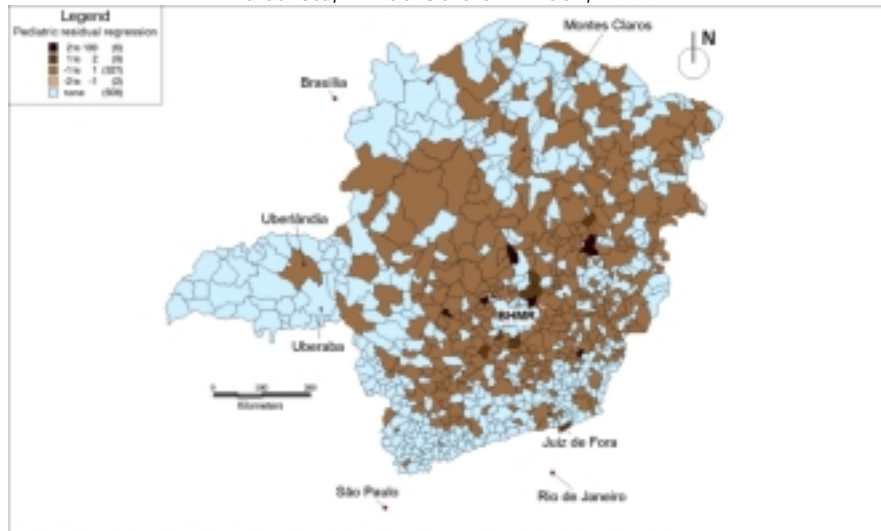
Source Demographic Census 2000, IBGE; SIH/DATASUS/MS, 1999; PRODEMGE; 1996.

The thematic map presented in the illustration 7 demonstrates that there isn't a big variation among the several municipal districts of the state. Practically all the municipal districts have values of hospitalizations in the average of the whole state. The use of the residues of the Model 1, without the superior hospitalizations to one for each thousand inhabitants, brought all the municipal districts of the state for the interval between -1 and 1 standard error, demonstrating an uniform behavior for all them municipal district of the state of Minas Gerais that sent some patient for the area of the Capital. Seemingly, the municipal districts tended to send patient according to the hypothesis of a similar pattern observed previously, with relationship to the areas that send or retains more patient than the average of the state. But, a fact should be highlighted: the use of the whole population of

the municipal district as the weight of the pediatrics internments is probably distorting the values found for this specialty. Posterior studies should contemplate the age groups of the population more indicated for these hospitalizations, because the age distribution is extremely variable for the several municipal districts of the state.

Illustration 7

Residuals of Linear Regression from Pediatric Hospitalizations, from Model 1 with all districts, Minas Gerais – Brasil, 1999



Source: Prodemge, 1996, SIH, DATASUS, 1999; and Demographic Census, 2000

Obstetric Hospitalizations

The results of the hospitalizations in obstetrics were not very significant to the formulation of hypotheses. But, from the data presented in the Table 10, it can be supposed that the patients were hospitalized, more commonly, in these origin area: the beds in the origin area were significant in at least one of the models. However, the distances it don't influence the patients' internments: the use of the dummies variables of distance removes the significant statistical of the other variables, taking us to suppose that most of the internments happens in the closest municipal districts of the capital of the state. This result certainly is the expected, because, as most of the hospitalizations in obstetrics seemingly were from childbirths, and travel long distances is an unviable attitude in the moment of the childbirth. Long displacements to the capital, in the obstetrics specialty, possibly are rare cases and could happen for the doctors' personal preferences and patient or due of the social nets between the capital of the state and the origin municipal district.

Table 10

Linear Model of the obstetric hospitalizations, by 1000 inhabitants, from origin district, in Belo Horizonte Micro Region, Minas Gerais – 1999

Variable	Todas as observações				Whithout districts with one or more hospitalizations by 1000 inhabitants			
	Model 1		Model 2		Model 1		Model 2	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Intercept	1,1023	0,3405	3,6441	0,4468	0,2801	0,0335	0,4334	0,0585
Mic_TotMil	1,6792	0,8444	0,5597*	0,7585*	0,0195*	0,0870*	-0,0287*	0,0856*
Dist30_Tot	-0,0044	0,0012	-0,0007*	0,0015*	-0,0004	0,0001	-0,0001*	0,0002*
D30_150_Tot			-3,4433	0,5341			-0,2497	0,0662
D30_75150_Tot			-3,3219	0,4486			-0,1699	0,0599

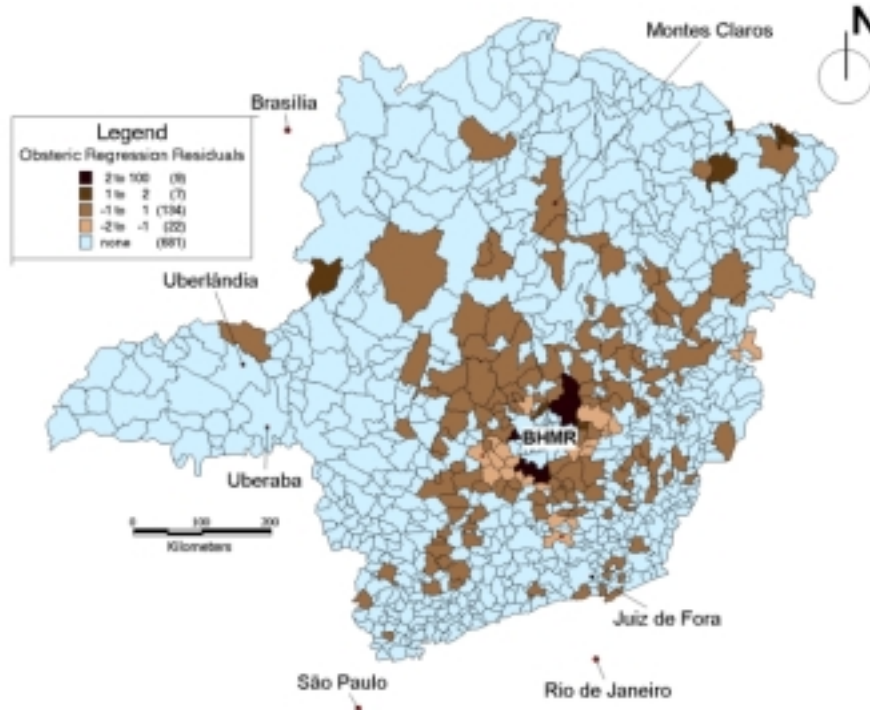
Observations: statistical significant in $p < 0,05$
 (*) not significant in $p \geq 0,05$
 n = 853 observations

Source Demographic Census 2000, IBGE; SIH/DATASUS/MS, 1999; PRODEMGE; 1996.

The thematic map presented in the Illustration 7 also highlights the northeast area of the state as a great exporter of patient. This fact perhaps can reaffirm the hypothesis of the social nets mentioned previously. But, the largest part of the hospitalizations is belonging to the close cities of BHMR. The obstetrics hospitalizations be less influenced by the age distribution than pediatric hospitalizations, and the results suffered less with the use of the total population in the municipal district with weight of the data.

Illustration 8

Residuals of Linear Regression from Obstetric Hospitalizations, from Model 1, with all districts, Minas Gerais – Brasil, 1999



Source: Prodemge, 1996, SIH, DATASUS, 1999; and Demographic Census, 2000

Concluding Remarks

It is possible that there could have been some significant factor and not contemplated above in the study. The conclusions on where and how the investments in health could be made demand studies of political, cultural and social needs that they cannot be reduced to numeric information. We believed that other information could be added to other studies, like costs of the hospitalizations, average of interned days, for example. The results found that the models of the pediatrics specialties and obstetrics can still be strongly influenced by the use of the total population as weight of the hospitalizations.

But, some considerations on the pattern of patients' flow from the State of Minas Gerais to the Belo Horizonte Micro Region can be inferred: (1). The region of Juiz

de Fora, probably sends its patients to Rio de Janeiro, instead of you send them for Belo Horizonte; (2). The regions close to the cities of Uberlândia and Uberaba, and the South of the state, could be sending their patients to São Paulo; (3). The regions near to Brasília, placed in the northwest, could be sending its patients to the capital of the country; (4). The northeast area of the state sends its patients to the Belo Horizonte in spite of the long distances; (5). The regions near to Montes Claros' City seemingly absorbs demand of its region in a satisfactory way; and finally (6). The central area of the state, in the west of the capital, is the largest exporter of patients to the capital of Minas Gerais state.

Besides these suppositions, it is observed that certain cities, detected by the models as great exporters of patient, don't really possess, in its municipal district, a satisfactory system of health. This way, it is believed that the model could help the understood of the behavior of the public system of health.

This study could be useful to complement to the analysis of the hospitals resources installed, as well as, to evaluate as the population of the state it uses these resources. Other analyses can complement these evaluations as origin and destiny matrix; evaluations of the system of health in the origin municipal district; and studies about the technical capacity of the staff in the cities or regions. The analysis of the road infrastructures installed in the state, could allow the evaluation of the causes of the observed pattern.

It is notorious that this study needs complements. One possibility could be analysis of the behavior other micro regions on the state, like Juiz de Fora, Uberaba, Montes Claros or in other states in the country in the same ways of this study. The study these other regions was begun but the results were not statically significant, what takes to the supposition that the geographical unit of analysis should be smaller. The increment of another variables, like epidemic, the causes of the hospitalization, the real distances among the cities, or the cost of the traveled could find better results in posterior works. However, look for deficiencies in the health public system in the municipal districts they presented here could already be a good beginning for the researches.

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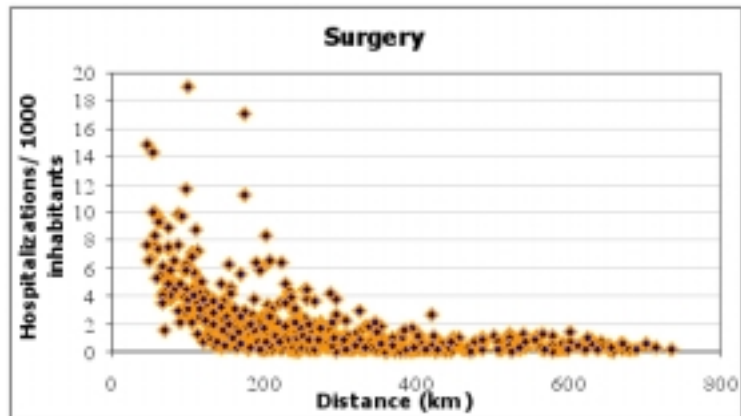
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Appendix

Graph 1

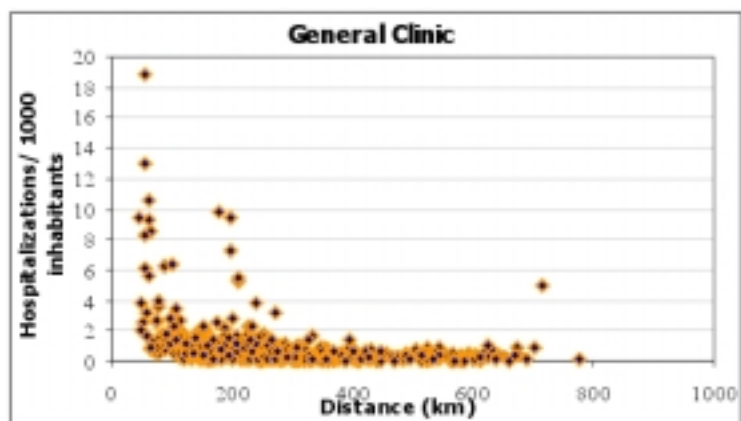
Scatter plot of Surgery hospitalizations by 1000 inhabitants cross by distance between residential district and Belo Horizonte Micro region, Minas Gerais, Brazil – 1999



Source: DATASUS, 1999; PRODEMGE, 1996 e IBGE, 2000.

Graph 2

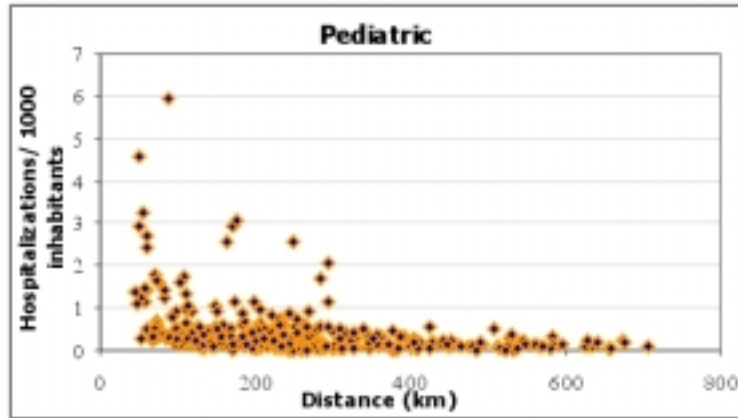
Scatter plot of General Clinic hospitalizations by 1000 inhabitants cross by distance between residential district and Belo Horizonte Micro region, Minas Gerais, Brazil – 1999



Source: DATASUS, 1999; PRODEMGE, 1996 e IBGE, 2000.

Graph 3

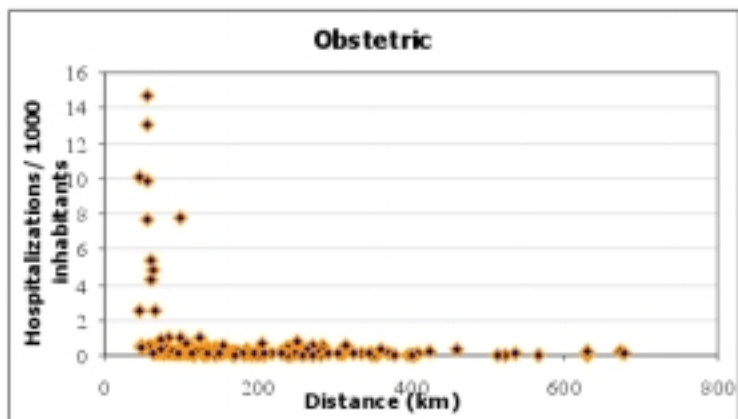
Scatter plot of pediatric hospitalizations by 1000 inhabitants cross by distance between residential district and Belo Horizonte Micro region, Minas Gerais, Brazil – 1999



Source: DATASUS, 1999; PRODEMGE, 1996 e IBGE, 2000.

Graph 4

Scatter plot of Obstetric hospitalizations by 1000 inhabitants cross by distance between residential district and Belo Horizonte Micro region, Minas Gerais, Brazil – 1999



Source: DATASUS, 1999; PRODEMGE, 1996 e IBGE, 2000.