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## Health services and territorial hierarchies in Brazil

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## **HEALTH SERVICES AND TERRITORIAL HIERARCHIES IN BRAZIL**

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This paper deals with the different territorial hierarchies established by the consumption of health services in Brazil. Flows are classified in two groups, one for general services (general hospitals, laboratory analysis and dental services), another for specialised, higher level attention (specialist consultations and exams, major surgery, organ transplants). Urban centers are classified in terms of the level of equipment they are endowed with.

The traditional approach to analysis of polarisation in terms of dominant flows between centers has been extended by Rabino to deal with other types of flows, such as counter-hierarchical and transversal flows (see Rabino and Occelli, 1997, and Berroir et al., 2001). The research reported here shows that in Rio Grande do Sul, a southern State selected for a preliminary analysis, the two networks identified illustrate different types of organisation. Both the higher level and the general services network are strongly hierarchical, with well defined, nested levels. The general services network, however, is far less dependent on the hierarchy of the centres, exhibiting a larger proportion of both transversal and shorter distance flows.

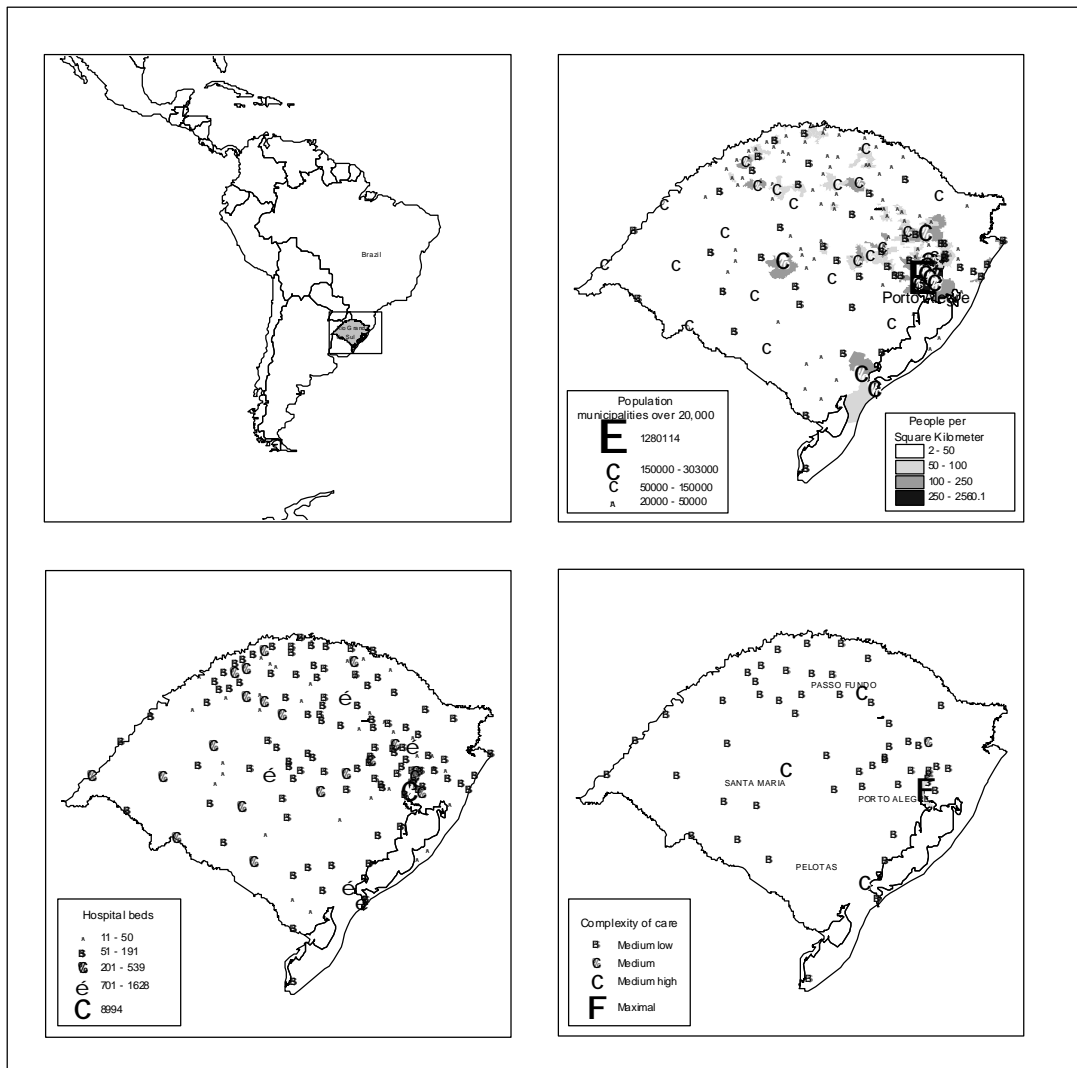
## ***Introduction***

The Brazilian Constitution (1988) established the Unified Health Care System (SUS), based on universal access to health care services, and from 1990, when the system was implemented, several policies were designed to promote the “hierarchical regionalization” of services. Geographical equity is a necessary – though not a sufficient – condition for achieving social equity in health services utilisation, equity being understood to mean equal access opportunities for equal needs (Travassos et al., 2000). Per capita measures of availability of health care resources should be based on areas which reflect travel patterns for health care, not on arbitrary geographic units (Makuc, 1991). Delineating functional regions – which also provide a way to compare the average distances that patients have to travel – is thus the first requirement. This paper is part of a larger ongoing research project, and its major thrust is the test of a methodology to establish the initial benchmark, in the early 90's, against which to compare developments to date, in order to evaluate how far the stated equity aims have been reached as regards the reduction of geographical inequalities. The dominant-flow approach to the identification of nodal regions extracts the tree of the graph associated with the matrix of flows between places to define the organisation of networks of cities and the position of each city within the network (Nystuen and Dacey, 1961). In this paper two networks were identified for Rio Grande do Sul, a Brazilian state, for specialised, and general, health care services. Within the two nodal regions defined by these networks, the flows between centers have been analysed following Rabino's classification, which considers, besides hierarchical, counter-hierarchical and transversal flows (see Rabino and Occelli, 1997, and Berroir et al., 2001), to investigate whether the global trend towards increasing interdependence and complementarity between medium-sized urban centers (Castells, 1996) could be discerned in this area of Brazil.

## ***The Region***

One reason for selecting Rio Grande do Sul for the preliminary analysis of the different territorial hierarchies established by the consumption of health services in Brazil was its peripheral location in the extreme south of Brazil (Figure 1). The definition of an arbitrary cut-off for flows – both incoming and outgoing – at the state's limits is thus less of a problem than would be the case with otherwise centrally located states.

Population densities are low in most of the area, with a marked north-south divide in settlement patterns. The sparsely populated lowlands to the South are traditional cattle-raising and rice growing areas, the North-western area is a major grain producer (soy, corn and wheat), and in the Northeast the metropolitan area of Porto Alegre, the state



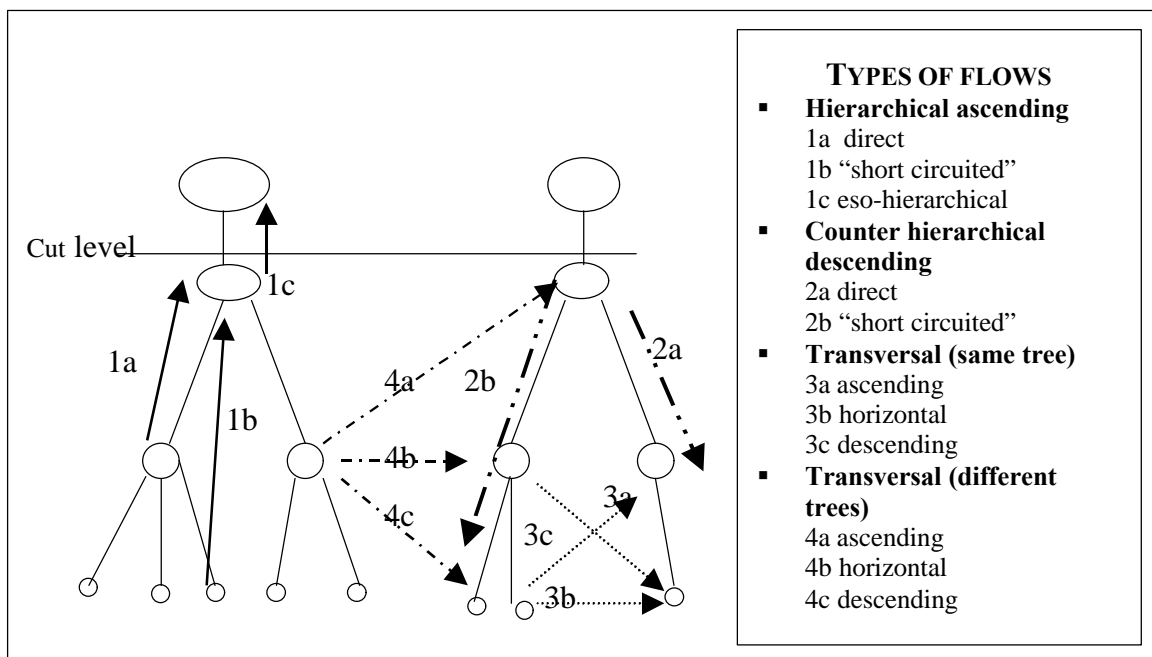
**Figure 1. Rio Grande do Sul, Brazil, population and services, 1992-1993.**

capital, is the hub of a nationally significant industrial region. The three largest regional centers are Passo Fundo in the North, Santa Maria in the Central region, and Pelotas in the Southeast.

### ***Method and data***

A method for the identification of nodal regions was developed by Nystuen and Dacey (1961) “on the basis of the single strongest flow emanating from or moving to each of

the unit areas in the vicinity of a central place”. Their method entails a prior ranking of the cities, as “a city is ‘independent’ if its largest flow is to a smaller city” (idem). On the other hand, if the dominant flow goes to a larger city, the smaller city is subordinate to the larger. Once the hierarchy of centers has been established, and the network structure has been identified, Rabino extended this approach in order to deal with the diversity of flows through which the internal and external relations of a region are structured. The classification of flows requires a definition of “significant areas”, the set of nodes of a given hierarchical level which are over a threshold, both in terms of size and of number of subordinate units. The graph is thus partitioned at a specified “cut level”, and the resulting upper level identifies “that part of the hierarchical structure which falls outside the areas themselves.” (Rabino and Occelli, 1997). The typology of flows comprises hierarchical ascending, counter hierarchical descending, and transversal, and is presented in Figure 2, adapted from Rabino and Occelli (1997) and Berroir et al. (2001). The classification of flows used the software developed by L.



**Figure 2. Types of flows**

Mabini and G. Rabino.

For the identification of nodal regions, then, two elements are required: a measure of size for the centers, and of the linkages between them. Here, municipalities are ranked by a composite measure, combining number of hospital beds (IBGE, 1992) and an index of complexity of hospital care available (Oliveira, 2001). This index is based on a

classification of medical (clinical and surgical) procedures appearing on 1993 microdata files from the in-patient information system – SIH-SUS – with information on hospital costs charged to the Unified Health System (DATASUS, 1993). For the linkages, a national study delineating nodal regions – Regiões de Influência das Cidades, 1993 – collected information for all cities with population over 20,000 on preferred locations for provision of various kinds of goods and services (IBGE, 2000). For higher level services the original questionnaire listed the cities providing those services, for general services the question was where people came from to get the services provided. This second item was not investigated for nine of the major cities in the country, Porto Alegre, the state capital, among them.

A subset of the original database, comprising flows relating to health services was selected for this study. The flows for general services refer to general hospitals, laboratory analysis and dental services, those for specialised attention comprise specialist consultations and exams, major surgery, and organ transplants.

## Results

Two networks were derived, one for specialised services, the other for general services. For the former, Porto Alegre, with size more than 9 times that of the second largest

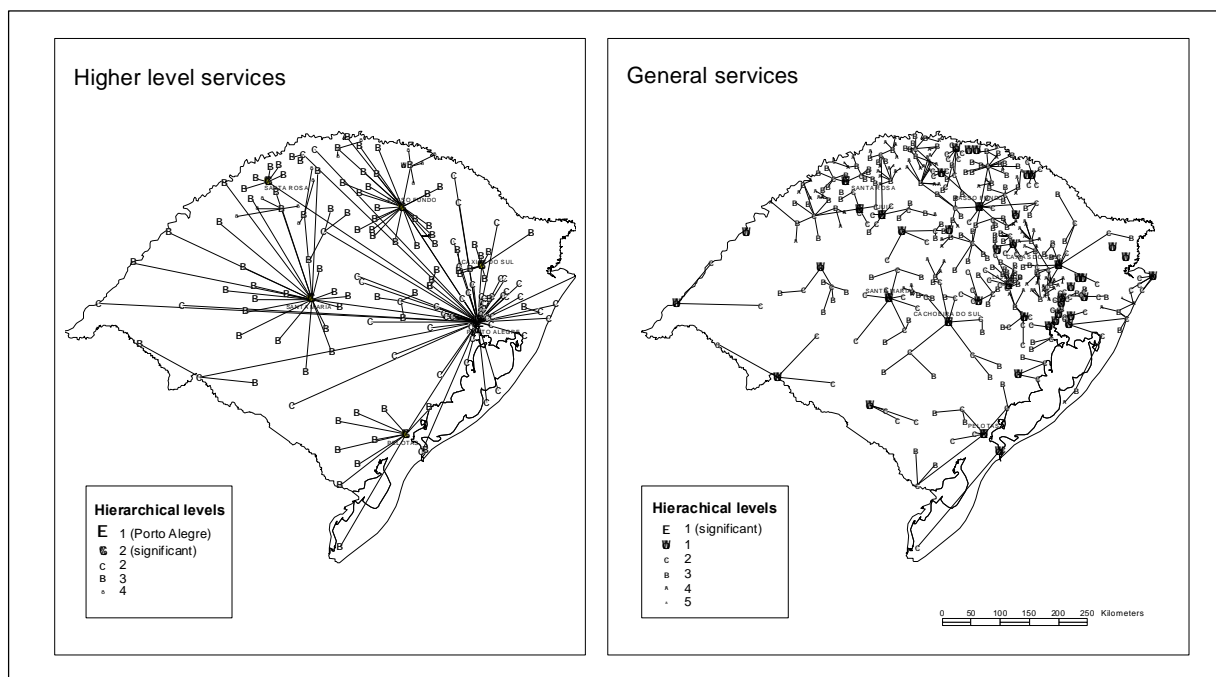


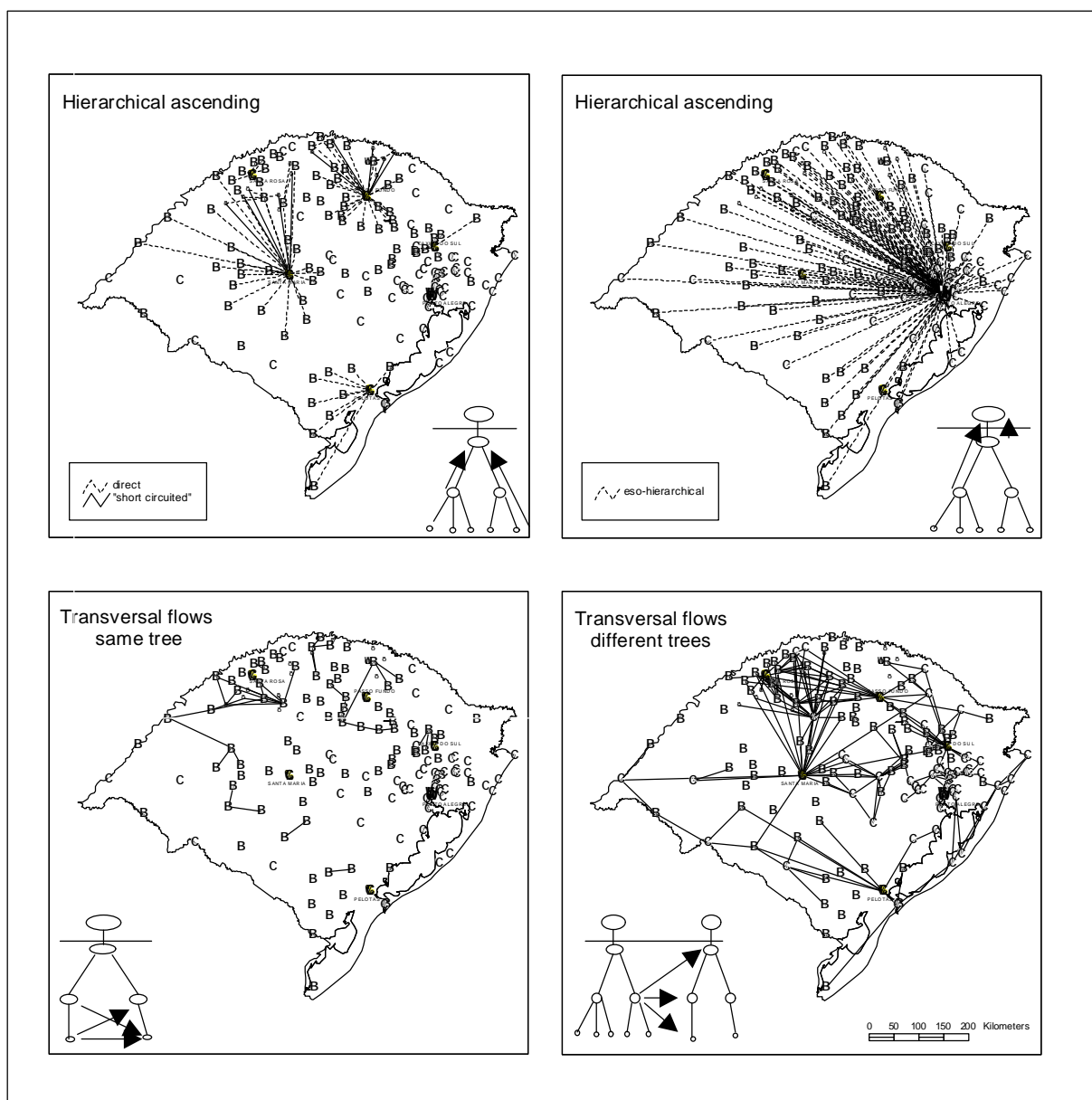
Figure 3. Health care services networks in Rio Grande do Sul – 1993 -

center (Pelotas), and receiving 31.3% of the flows (9.7% for the second placed in terms of incoming flows, Santa Maria), is the head of the network. There is another city classified as first level, because its dominant flow is directed to a smaller city, but it is quite small, and does not have any subordinate cities of its own. In the same way, only 14 of the 62 second level centers have tributaries, as do four of the 86 third level. There are also 13 cities on the fourth and last rung of the hierarchy. The first map in Figure 3 shows the spatial distribution of the network. The dominance of Porto Alegre ranges over the whole state, with second level centers clustered around its immediate vicinity, spaced along the international frontier and, in the more densely peopled areas, providing foci for their own tributary networks. For the classification of flows, significant areas were defined as those of second level centers with size over 1,000,000 and more than five subordinate cities. The reason for focusing on the second level was to simplify comparison with the other network, in which Porto Alegre does not figure. Five out of the 14 second level regions met the stated criteria, Santa Maria, Passo Fundo, Pelotas, Caxias do Sul and Santa Rosa. The first three, as already mentioned, are the largest regional centers in the state. Passo Fundo, with 30 centers in its region, and Santa Maria, with 32, are the largest regions, standing, as they do, in densely occupied areas. On the other hand, having far fewer neighbours, Pelotas is a pole for 10 municipalities. With only nine centers, Caxias do Sul is very close to Porto Alegre, and the outlying Santa Rosa commands six municipalities.

The general services network (Figure 3) is made up of several unconnected trees: there are 43 first level centers, 30 of which subordinate other cities. This contrasting pattern is basically due to not having Porto Alegre investigated, as already mentioned. Of the 124 second level centers, 52 have tributaries, as do 33 of the 148 third level, and five of the 96 on the fourth level. In the fifth and last level in the hierarchy, there are seven cities. In the South and South-western sparsely peopled areas, the main centers have few levels, and the increased density and local articulation of the network in the rest of the state is striking. The definition of significant areas used the same criteria as before: centers with size over 1,000,000 and more than five subordinate cities. Nine out of the 30 first level regions met these criteria: the five previously identified for the higher level, i.e. Santa Maria, Passo Fundo, Pelotas, Caxias do Sul and Santa Rosa, plus Ijuí, Santo Angelo, Lajeado and Cachoeira do Sul.

The arrangement of this network leads to a reduction of the region of Santa Maria, both in number of cities, now only 12, and in range. The other regions have increased their number of cities, in line with the larger number of centers investigated in this level: Passo Fundo with 86 cities, Caxias do Sul with 52, Santa Rosa with 18. Only Pelotas, constrained by its position, is stable, now with 11 cities.

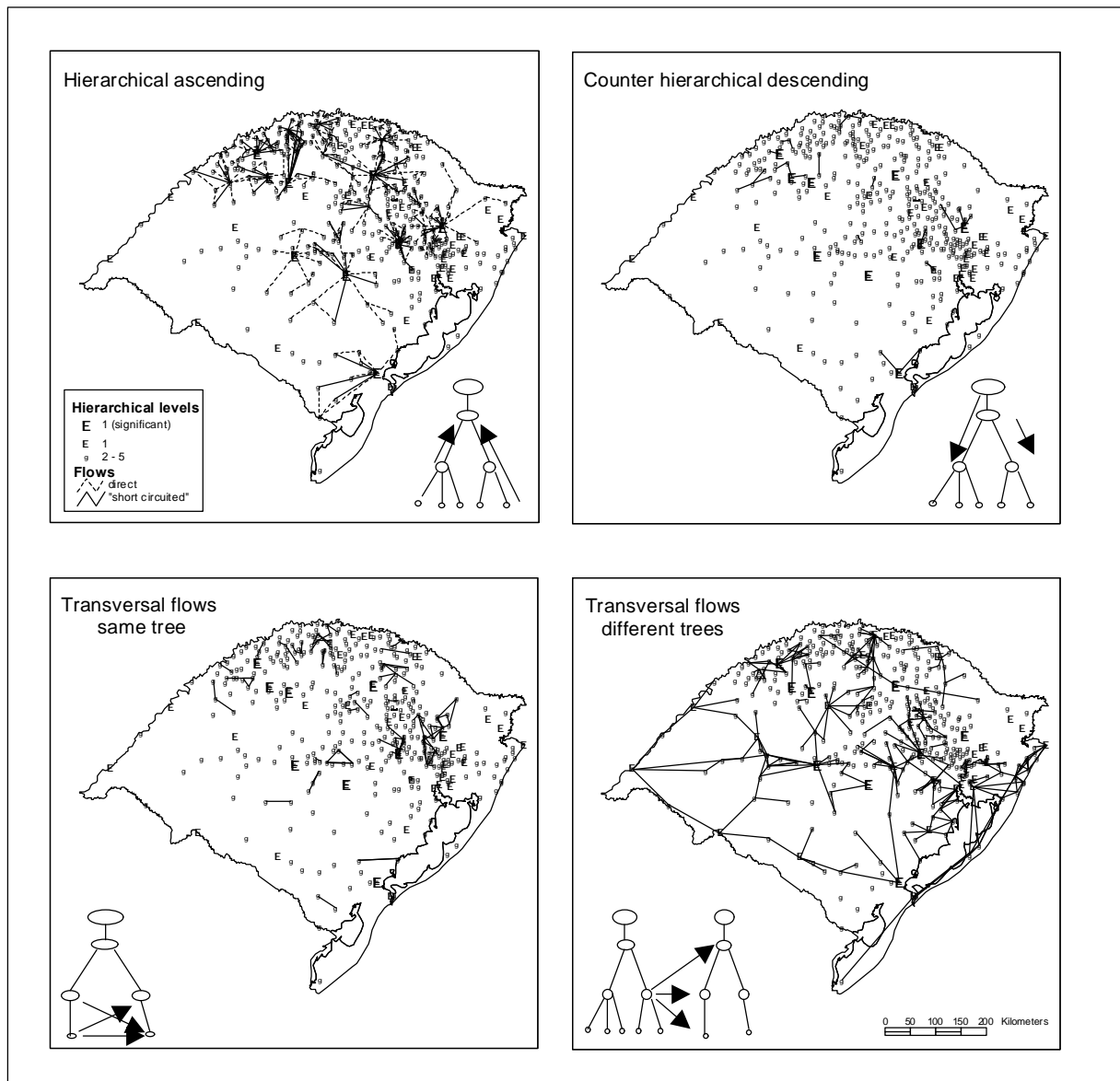
Besides size and concentration, the two networks also differ in the way their flows are structured. Although both are strongly hierarchical (Table 1), the flows demanding specialised services are more dependent on larger central places, witness the convergence of flows to Porto Alegre coming from all over the state (Figure 4). The pattern of transversal flows between different trees also suggests that city size is more of



**Figure 4. Types of flows for the specialised services network.**



a determinant for complex services than for less complex needs. The maps in Figures 4 and 5 suggest that transversal flows between trees are more likely to be directed to cities at the top of the hierarchy in the specialised services network. The pattern for general services evidences a more general dependency on the internal hierarchy, with a larger share of hierarchical ascending flows, even though there are some instances of short distance descending flows.



**Figure 5. Types of flows for the general services network.**

The evidence of the maps is that distances travelled for less complex services are smaller, and distance effects are also related to flow type: both descending and

transversal flows in the same tree are consistently shorter than either ascending, or transversal flows between different trees (Table 2).

**Table 1. Types of flows in the two networks between origins and destinations in the state of Rio Grande do Sul (Brazil), 1993**

TYPES OF FLOWS	SPECIALISED SERVICES		GENERAL SERVICES	
	Number	%	Number	%
<b>Hierarchical ascending</b>	<b>254</b>	<b>49.0</b>	<b>360</b>	<b>44.5</b>
direct	82	15.8	272	33.6
"short circuited"	12	2.3	88	10.9
eso-hierarchical	160	30.9	-	-
<b>Counter hierarchical descending</b>	<b>2</b>	<b>0.4</b>	<b>31</b>	<b>3.9</b>
direct	2	0.4	28	3.5
"short circuited"	-	-	3	0.4
<b>Transversal (same tree)</b>	<b>43</b>	<b>8.3</b>	<b>107</b>	<b>13.2</b>
<b>Transversal (different trees)</b>	<b>219</b>	<b>42.3</b>	<b>310</b>	<b>38.4</b>
Total	518	100.0	808	100.0

**Table 2. Straight line distances (km) between origins and destinations in the state of Rio Grande do Sul (Brazil), by type of flow, 1993.**

TYPES OF FLOWS	Mean	Minimum	Percentile		Median	Percentile	Maximum
			25	75			
SPECIALISED NETWORK							
<b>Hierarchical ascending</b>							
direct	82.2	12.7	39.2	67.8	110.3	296.3	
"short circuited"	123.7	27.4	82.3	130.6	178.6	193.3	
eso-hierarchical	227.1	11.7	95.3	227.4	349.6	618.4	
<b>Counter hierarchical descending</b>							
direct	26.9	19.0	19.0	26.9		34.7	
"short circuited"							
<b>Transversal (same tree)</b>	51.3	8.7	30.1	40.2	60.0	138.4	
<b>Transversal (different trees)</b>	76.2	1.5	30.0	56.0	99.9	346.4	
GENERAL SERVICES NETWORK							
<b>Hierarchical ascending</b>							
direct	27.6	3.3	15.0	22.0	35.2	142.2	
"short circuited"	40.4	9.1	25.2	34.9	46.8	114.0	
eso-hierarchical							
<b>Counter hierarchical descending</b>							
direct	25.2	4.2	15.0	22.8	33.6	58.3	
"short circuited"	27.6	26.3	23.6	24.6		34.5	
<b>Transversal (same tree)</b>	24.5	5.3	14.2	21.2	32.9	74.0	
<b>Transversal (different trees)</b>	39.1	1.5	16.1	29.9	51.5	207.0	

Comparing the five major regions across the two networks one finds some differences in their patterns. In the region of Passo Fundo a proportion of hierarchical ascending flows of 58% in the specialised network, and 70% in the general, point to a tighter

control of its area, especially for the less complex levels of care. External transversal flows are proportionally less than the state average: 20% for the specialised and 7.9% for the general services networks. Even so, for the specialised services, Passo Fundo makes large inroads to the west, attracting centers directly linked to Porto Alegre such as Três Passos and Tenente Portela and cutting into the area of Santa Rosa. Being the smallest, Santa Rosa is the only region to have a share of external transversal flows (50%) larger than that of ascending flows (42.3%) for the more complex network; for the general health care services, however, its closure is quite high: 70% of the flows ascending, and only 10% external transversal. Pelotas exhibits traits of a closed, isolated region: 79% and 70% for ascending flows in each network, but external transversal flows extend its linkages to the neighbouring areas of Rio Grande and, to the west, Bagé. The regions of Santa Maria and Caxias do Sul, exhibit patterns closer to the state average. Even so, their “control” seems to be tighter: 56% and 52.4% (for specialised and general health care services, respectively) of ascending flows in the Santa Maria area, 51.5% and 54.2% in the second. This last – Caxias do Sul – is similar to Pelotas as regards the significance of external transversal flows (33.3%) in the specialised network flows.

### ***Discussion***

The application of the methodology to Rio Grande do Sul provide a first picture of the different types of organisation established by the consumption of health services. Two networks were derived, according to level of services, and both of them exhibit markedly nested hierarchies. The fact that the range of the services is smaller for those of lesser complexity, and larger for the higher level group is something that, as Hagget (1965) says, has been well established in central place literature for decades, and in everyday experience since time was. The interesting question, as usual, is the way in which these networks deviate from the norm. For the specialised network, interregional flows tend to be directed to larger centers, and the primacy of Porto Alegre is the dominant key, though there are also cases of links between centers on the same level, and flows to smaller neighbouring centers. In this instance, the weakening of the hierarchical principle is primarily due to centers "leapfrogging" the hierarchical level, going straight to the top. For the general services, the instances of descending flows, together with a large proportion of transversal flows in the same tree possibly reflect the policy of municipal consortiums, whereby neighbouring municipalities pool their

resources and divide medical facilities between members, for shared use. The Santa Maria University, with its leading teaching hospital may cause the link between Caxias do Sul and Santa Maria, and the interconnections established in the general services network, reflect more traditional elements of accessibility and neighbourhood. There is no real evidence, in either case, of the process of increasing interdependence and complementarity between medium-sized urban centers posited by Castells (1996). This may be merely an expression of the inadequacy of the regional scale (limited to the state of Rio Grande do Sul), and this question will be considered again at the national level.

As regards the test of the methodology for establishing functional regions for evaluating per capita measures of availability of health care resources, this paper has established the method's capacity for defining the "skeleton" of the regions. The major contribution of the analysis of flows within and between regions in this context has been to establish the relative "closure" of the regions, validating their use as basic units of analysis. The next step will be to aggregate the areas, probably nesting the general services regions as a second level, and to extend the analysis to the whole country.

A final comment refers to the importance of using purpose built regions for specific analysis, whenever possible, as already suggested in the national definition of nodal regions (IBGE, 2000). This study was based on the complete questionnaire, which includes a diversity of other service and commercial central functions, and it also ranks Pelotas, Passo Fundo and Santa Maria, on the second level. As for the other centers here identified, Caxias do Sul is on the third level, directly linked to Porto Alegre, and Santa Rosa is a fourth level center in the Santa Maria region. Ijuí is also assigned to Santa Maria, as a third level center subordinating – among others – Santa Rosa and Santo Angelo. Lajeado and Cachoeira do Sul are both directly linked to Porto Alegre, as fourth and fifth level centers, respectively. These results illustrate that similarities in the general delineation of regions do not mean identity of flows for different purposes.

### ***Acknowledgements***

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