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Geographic distribution of physicians in Portugal

Isabel Correia · Paula Veiga

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Abstract The main goals of this paper are to (1) analyse the inequality in geographic distribution of physicians and its evolution, (2) estimate the determinants of physician density, and (3) assess the importance of competitive and agglomerative forces in location decisions. The analysis of the geographic distribution of physicians is based on the ratio of general practitioners (GPs) and specialists to 1,000 inhabitants. The inequality is measured using Gini indices, coefficients of variation, and physician-to-population ratios. The econometric models were estimated by ordinary least squares. The data used refer to 1996 and 2007. The impact of the growing number of physicians, and therefore potential increased competition, on geographic distribution during the period studied was small. Nonetheless, there is evidence of competitive forces acting on the dynamics of doctor localisation. Geographic disparities in physician density are still high, and appear to be due mainly to geographic income inequality.

Keywords Physicians · Location choice · Geographic inequality · Health resources · Portugal

I. Correia
European, International and Industrial Economics Research Unit (NEEII), Economics Department, University of Minho, Braga, Portugal
e-mail: icorreia@eeg.uminho.pt

P. Veiga
Applied Microeconomics Research Unit (NIMA), Economics Department, University of Minho, Braga, Portugal

P. Veiga (✉)
Applied Microeconomics Research Group (NIMA), Escola de Economia e Gestão, Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal
e-mail: paulav@eeg.uminho.pt

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Introduction

In spite of universal access to health care being constitutionally enshrined, and fairness being stated as a major objective of the National Health System (NHS), Portugal still presents inadequate results in terms of health care equity [3, 10, 12]. The uneven geographic distribution of health care human resources has been identified as a factor contributing to these persistent inequities [3, 11]. The problem is not exclusively Portuguese; virtually all OECD countries face an uneven geographical distribution of physicians [16, 17, 28, 37].

The number of physicians has been increasing and the number of physicians per inhabitant in Portugal is around the OECD average [37]. Nonetheless, the geographic distribution of health care human resources is still highly asymmetrical. The concentration of physicians in the coastal areas, particularly in the Coimbra, Lisbon, and Porto regions, contrasts with the shortage of professionals in more remote areas where the population is poorer and older. The absence of incentive policies to encourage medical doctors to work in rural and less populated regions is identified as one of the main weaknesses of the NHS [3].

Despite intense debate, there is no consensus on the optimal geographic concentration or distribution of physicians. Studies have suggested that a higher density of physicians tends to be associated with better health outcomes even in the presence of other unfavourable socioeconomic factors. In terms of equity, the distribution of physicians should meet the population's needs and provide sufficient accessibility of health care services. Nonetheless, other issues such as the efficiency and safety of procedures are also considered important and may result in distributions different from those that arise under the rule of fairness. Overall, the issue of trade-off between equity and efficiency in the distribution of health care resources still attracts lively debate in the field of health economics.

The purpose of this study was to assess the existing imbalances in the geographic distribution of physicians and to investigate the determinants of physician location—mainly whether decisions are affected by market mechanisms. From the public policy perspective, knowing the determinants of physician location is important, insofar as the evidence suggests that market mechanisms are insufficient to ensure an optimum geographical distribution. Knowing the determinants of the location of physicians, public policies can promote a more balanced geographical distribution of physicians and the growth of social welfare. Moreover, from the regional economic perspective, the distribution of physicians gives important information about the ability of regions to attract qualified human capital.

The article is organised as follows: a brief Review of the literature is followed by a description of Data and methods. The Results section presents and discusses the results, followed by a Conclusion and a discussion of the Limitations of the analysis and further research.

Review of the literature

There is a growing literature that aims at understanding physician location patterns. The empirical literature is eclectic in terms of econometric approach. The majority of studies use cross-sectional data [18–21, 26, 33]. Foster and Gorr [14] and Nocera and Wanzenried [28] estimate dynamic models using panel data methods and data from the United States and Switzerland, respectively. Póvoa and Andrade [29] estimate a fixed effect model using data from Brazil. Bolduc et al. [4] estimate a spatial autoregressive multinomial probit model of the choice of initial location of general practitioners (GPs) in Canada. Using data from Germany, Kuhn and Oschen [23] applied spatial econometric techniques to control for cross-regional correlations.

According to economic theory, if the market for medical care was competitive, a concentration of physicians, and hence increased competition, would reduce earnings and make less densely covered areas more attractive. Overall, there is consensus around the idea that the market for medical care is far from perfectly competitive. Many have asserted that the physician's market is not competitive because physicians are able to generate their own demand [13, 31]. The argument is that if the physicians induce demand and ensure that their incomes do not decrease as a result of increased competition, they may continue practicing in very competitive and saturated areas. In this sense, the market does not lead to the socially desirable distribution of physicians. This market failure argument has aroused political intervention and incentives in countries such as Canada and the United States [4, 28]. The literature disagrees on the importance of the phenomenon of induced demand, as well as its effects [8, 26].

Second, the market is not competitive owing to the prevalence of a large employer. In Portugal, around 73% of physicians work for the publicly funded health care system, the National Health System (NHS), and approximately 70% of medical consultations occur at public health care facilities [1]. Assuming that decisions regarding location of NHS services are exogenous relative to the physicians' preferences, and if those services are disproportionately concentrated in relation to population size, this can lead to a disproportional number of physicians in those regions. The association between the availability of NHS services and the density of physicians can possibly justify an uneven distribution of physicians but does not reveal market failures, only potential government failures.

Several studies find evidence of some competitive market forces in the location of physicians [26–28, 33, 35]. Contrary to the presumed market failure, Newhouse et al. [26] argue that an unequal distribution of physicians may be consistent with the proper functioning of the market and standard economic literature. Newhouse et al. [26] study the geographic pattern of United States physicians as a function of town size. As expected, larger towns are more likely to attract doctors within each speciality. This finding is confirmed eventually in every study. Moreover, the high growth in the number of specialists translates into a faster diffusion in small towns at the same time that small towns lose GPs more rapidly. Rosenthal et al. [33] revisited the model of Newhouse et al. [26] and, with more recent data, confirmed their main findings. Newhouse et al. [27] show that, as the supply of physicians grew, medical and surgical specialists diffused into smaller communities in the United States. Other evidence suggests that increasing the number of physicians has had only a small impact on reducing the disparities seen in their geographical distribution [4, 5]. Foster and Gorr [14] found that increasing the supply of doctors impacted on locational trends of GPs but not specialists.

An important factor appears to be the geographic concentration of income. The traditional theory assumes that physicians seek to maximise their profit and therefore tend to practice in regions with high income. The existence of a positive relationship between the number of physicians and the level of income has been proven empirically [2, 4, 34]. Benham et al. [2] show that the ratio of physicians per capita increases with the level of income in the region and, therefore, with a more equitable distribution of income among regions, the imbalances observed in the geographical distribution of physicians would be reduced. Assuming that physicians seek to maximise their utility [9, 14, 18] and not only their profits, it is important to consider other factors such as a municipality's quality of life and availability of non-cash benefits (cultural, sports, and recreational facilities, accessibility of knowledge, etc.). Several studies have suggested that physicians tend to practice near universities, especially those where they studied themselves [7, 22, 29, 36]. The authors explain this trend as due to sentimental reasons as well as social and professional relationships that have formed in that period and are important in a medical career. The evidence of association between the location of physicians and the presence of the university may also be explained by the fact that university hospitals are attractive to physicians, particularly due to the availability of technology and faster diffusion of knowledge and innovation. Because of this trend, in some developed countries (the United States, Norway, Sweden, and England) the opening of new courses in medicine takes into account the needs of physicians in the region [26]. One implication of the relationship between the physician's choice of location and these economic and non-economic factors is that an increase in the supply of physicians does not necessarily lead to a more even geographic distribution [32].

Data and methods

Data

We use data published by the National Institute of Statistics (INE), from the Census and Statistics of Health, for 1996 and 2007. The data include information about the number of physicians per municipality of residence, by specialty, and other relevant information concerning the provision of healthcare in the municipality.

The main limitation of the data stems from the fact that it does not include data about the municipalities where physicians carry out their activities. According to location theories, suppliers of goods and services tend to be close to their customers, especially in those cases where the place of production of goods or services coincides with the location of its consumption. Therefore, we admit that the majority of physicians tend to locate in the municipality where the activity is carried out. A more appropriate unit of analysis of physician services would be "physician market area".

These data were supplemented with statistical information on the purchasing power of 278 municipalities, published by the INE.

Variable(s) of interest

The most common variable used to study the pattern of spatial distribution of physicians is the number of physicians per 1,000 inhabitants. This variable contains information relevant to understanding the inequality of the distribution. Moreover, it is easy to build and has the advantage of being able to be compared with the reference set by the World Health Organization (WHO) of at least one physician per 1,000 inhabitants in each community.

The literature converges on the understanding that health care services are not homogeneous and accordingly it is desirable to distinguish between GPs and specialists. In general, we can assume that the GPs regard both other GPs and specialists as competitors. In contrast, for specialists the competitor tends to be a physician in the same specialty. These differences suggest that we should examine the determinants of the locations of the two types of physician separately [14, 28]. These differences must also be taken into account when judging inequality in physician distribution. Indeed, in the case of specialists, a higher concentration is considered more acceptable, or even desirable, than in the case of GPs.

Measurement of inequality

Gini index

The Gini coefficient is the most widely used single measure of health care geographic inequality [6, 15–17, 21, 25]. The Gini coefficient measures departure from a uniform distribution, indicating whether physicians are distributed equally or not across all municipalities relative to their population size. With perfect equality in the distribution, the Gini coefficient takes the value 0; as inequality increases it approaches the value of 1.

An important property of the Gini index is that it can be decomposed. We decompose Portuguese inequality by groups of municipalities (grouped by population size) in an effort to distinguish "between-group inequality" and "within-group inequality" among groups. That approach allows us to establish how homogeneous or heterogeneous the groups are, assessing the extent to which imbalances are greatest among the different groups—which indicates that the population size is a strong determinant of the location of physicians—or whether there are differences mainly within the groups. Following the methodology proposed by Pyatt [30], the overall Gini estimate can be decomposed as:

$$G = B + W + R$$

where B is a measure of the degree of convergence in the average number of physicians per 1,000 inhabitants per group of municipalities, and W is a weighted sum of the Gini index of each group. The term of interaction (R) is a little more difficult to interpret; it depends on the frequency and amount of overlap in the ratios of different groups of municipalities, and can be thought of as a comparison of the distributions of the number of physicians per 1,000 inhabitants of the various groups.

Coefficient of variation

The coefficient of variation (CV) describes the dispersion of the variable in a way that does not depend on the variable's measurement unit. The standard formulation of the CV is the ratio of the standard deviation to the mean of the variable. The higher the CV, the greater the dispersion in the variable.

Unserved municipalities and population

Inequality may be also measured against a benchmark. The percentage of municipalities below the WHO threshold gives important information about the inequality of geographic distribution.

Econometric models

We use different models and specifications for studying the determinants of the location of physicians in mainland Portugal: (1) a static model to understand the distribution of physicians in 2007, and (2) a so-called "dynamic" model that examines changes over the period 1996–2007.

The models were estimated by ordinary least squares (OLS). Cook-Weinberg diagnostic tests revealed heteroskedasticity. Therefore, the standard errors (SEs) were corrected using the Huber-White method. Multicollinearity was explored using the regression diagnostic measure variance inflation factor. Collinearity does not present a threat to the interpretability of the presented models.

The following sections (Static models and Dynamic models) describe the variables considered in the models. Table 1 presents the descriptive statistics for the variables.

Static models

In the static models, the dependent variables are the logarithm of the ratio of the number of GPs and specialists per 1,000 inhabitants per municipality [LN (GPs) and LN (specialists)]. The size of the resident population is a measure of the size of the market and the volume of demand in that municipality. We expect the (logarithm of) population size (LNPOP) to be associated positively with the location of physicians, particularly for specialists. The general economic environment of the municipalities is mirrored in their (logarithm) purchasing power (LNPP). In addition to measuring the response of physicians to higher demand and higher ability to pay, the variable is also a proxy for quality of life as well as the cultural and social environment. We expect the sign to be positive and its impact to be greater for specialists.

Table 1 Descriptive variables

Variable	Mean (SD)	Min–Max
LN(GPs)1996	−0.847 (0.718)	−3.046–1.835
LN(SPECIALISTS)1996	−0.591 (0.878)	−3.118–2.647
LN(GPs)2007	−0.552 (0.727)	−2.398–2.093
LN(SPECIALISTS)2007	−0.847 (0.881)	−2.681–2.890
LNPOP1996	9.804 (1.033)	7.534–13.258
LNPOP2007	9.825 (1.101)	7.456–13.122
LNBEDS1996	−1.957 (3.695)	−6.908–3.554
LNBEDS2007	−4.598 (3.596)	−6.908–3.025
LNPP1995	4.001 (0.446)	3.125–5.750
LNPP2007	4.282 (0.287)	3.855–5.375
DCENTRAL1996	0.018	0–1
DCENTRAL2007	0.025	0–1
VARCENTRAL	0.007	0–1
AGEING1996	130.892 (63.449)	34.1–417.2
AGEING2007	175.718 (88.428)	51–560.9
DDISTRICT	0.058	1–18
VARPOP	0.024 (0.183)	−0.434–1.114
VARBEDS	−0.331 (0.560)	−1–2.410
AVERAGEPP	68.297 (28.750)	35.760–265.067
DENSITY1996	1.319 (1.802)	0–19.2
DENSITY1996 SQUARED	4.976 (25.954)	0.000–368.64

The (logarithm) provision of beds per 1,000 inhabitants in public health facilities (LNBEDS), and the presence of a central general hospital[1] (DCENTRAL) reflect the scale of public health care resources in the municipality. We expect the estimated coefficients of these variables to be positive. In Portugal, the majority of municipalities with one or more central hospitals also have one or more medical schools, so in practice it is not possible to separate the two effects. Thus, a variable to control for the presence of a medical school in the municipality was not included. Moreover, the central hospital variable is also correlated strongly with the variables for the number of health care centres without hospitalisation as well as with the number of private hospitals. Therefore, DCENTRAL may capture the attractiveness of the municipality in terms of access to knowledge, technology, and primary care, as well as private medicine.

There is a discussion surrounding the question of the correlation between the demand for health care and the need for health care. The need for health care tends to be higher in areas of aging population. In contrast, the demand for health care tends to be greater in areas of higher per

[1] Two central specialized hospitals were not classified as central general hospitals: the psychiatric hospital of Source and the orthopaedic hospital of Setubal.

capita income and more educated people—typically urban areas where the population is younger. The model controls for the index of the ageing rate of the population in the municipalities (AGEING). The expected sign of the variable is ambiguous, denoting the possible conflict between need and demand. AGEING is associated strongly with morbidity variables, such as the incidence of cancer and cardiovascular diseases. To reduce multicollinearity problems we do not include morbidity variables in the model.

There are specific characteristics of districts that may affect decisions regarding location of physicians and which were not considered in the model. Some institutional features of the NHS, for example, are best captured in terms of districts, which coincide with sub-regions of health. These specific characteristics (omitted) should be captured by dummy variables that identify the district of residence (DDISTRITO).

"Dynamic" models

In the "dynamic" models the dependent variable is the percentage change in the number of physicians per 1,000 inhabitants in each municipality. The growth rate of the resident population in the municipality between 1996 and 2007 (VARPOP) addresses the importance of a growing demand in location decisions. The effect of resident population growth on encouraging the growth of physicians per 1,000 inhabitants is theoretically ambiguous. Nonetheless, we expect it to be positive in the specialists' regressions and negative for GPs, reflecting the competition/substitution between them [26, 28]: specialists tend to locate in growing and larger municipalities while GPs may avoid settling in growth areas because of increasing competition from specialists. The number of physicians per 1,000 in 1996 (DENSITY1996; as well as the square of this variable to allow for non-linearity) enters the model as a variable for the degree of competition. The estimated coefficient is thought to capture two opposite mechanisms. Agglomeration effects are expected to exert a positive influence on the location decision. On the other hand, increased competition may encourage spread. The relative sizes of the effects and determination of the sign of the estimated coefficient are empirical questions. We anticipate different impacts of the density of doctors on GPs' and specialists' location decisions, since the ability of specialists to provide a wider range of services makes them less susceptible to competition than GPs.

Preliminary analysis of the data suggested that variations in purchasing power between 1995 and 2005 are small, so we consider the hypothesis that physicians tend to remain in the most prosperous regions and we control the regression for the average purchasing power during the period (AVERAGEPP).

VARBEDS stands for the percentage of the variation in the number of beds per 1,000 inhabitants in the municipality between 1996 and 2007. VARCENTRAL is a dummy variable indicating whether the municipality acquired a new central hospital during the time span. These variables are thought to capture the effects of changes in availability of the NHS. We expect these variables to have positive signs, since the majority of Portuguese physicians work for the NHS and therefore the availability of resources should attract doctors.

Results

Trends in the number of practitioners in Portugal

Despite the prevalence of restrictive human resources training policy—through the imposition of "numerous clauses" and lack of private provision—the number of physicians has been increasing continuously since the creation of the NHS in 1978. Overall, the number of practitioners in Portugal increased by approximately 365% during the period 1970–2007 (Table 2), which corresponds

Table 2 Evolution of the number of practitioners and population size in Portugal

Year	Number of physicians	Annual growth rate (%)	Population	Annual growth rate (%)	Physicians per 1,000 Inhabitants	Annual growth rate (%)
1970	8,156		8,663,250		0.94	
1975	11,101	6.36	9,307,810	1.45	1.19	4.84
1980	19,332	11.73	9,818,980	1.08	1.97	10.55
1985	24,629	4.96	10,014,300	0.39	2.46	4.55
1990	28,016	2.61	9,877,480	−0.27	2.84	2.89
1995	29,353	0.94	10,043,180	0.33	2.92	0.60
2000	32,498	2.06	10,256,660	0.42	3.17	1.63
2005	36,138	2.15	10,569,592	0.60	3.42	1.53
2007	37,904	2.41	10,617575	0.23	3.57	2.17

to a variation of 280% in the number of physicians per 1,000 inhabitants. In recent years, a moderate but continuous growth in the "numerous clauses", as well as the inflow of a significant number of foreign physicians [24], has sustained this growth.

Table 3 shows that the greatest increase in the size of the physicians' workforce during 1996–2007 occurred among specialists. The number of specialists per 1,000 inhabitants grew by 30%, compared to 28% growth in the number of GPs per 1,000 inhabitants during the observed period. As a result of the increase in medical education towards specialisation, in 2008, specialists accounted for more than 72% of the total number of physicians.

Inequalities in distribution of physicians

Figure 1 illustrates the dimensions of the inequality problem. In the figure each dot represents one doctor per 1,000 inhabitants.

As can be seen, the physicians are located disproportionately in municipalities on the coast, with the largest numbers of physicians per 1,000 inhabitants located in the Porto area (in the municipalities of Porto, Maia, and Matosinhos), Coimbra, and the Lisbon area (in the municipalities of Lisbon, Cascais, and Oeiras). The region of Alentejo and the North stand out as less covered areas.

The first question that arises is whether an increasing numbers of physicians itself leads to better spatial distribution. The estimate of the Gini index confirms that the physicians are unevenly distributed (Table 4) and even suggests a slight increase in the geographic inequality in the distribution of physicians per 1,000 inhabitants between 1996 and 2007. Not surprisingly, there is a greater inequality in the distribution of specialists than in GPs. Nonetheless, the distributions of both GPs per 1,000 inhabitants and specialists per 1,000 inhabitants have become slightly more unequal. The estimated CVs also suggest that inequality did not change dramatically during the period. Similar analyses conducted in other countries [15–17] have also found that, despite the increase in the number of doctors, the overall inequality in geographic distribution has not decreased.

Despite the prevalence of overall geographic inequality there has been some progress regarding the number of municipalities with less than one physician per 1,000 inhabitants. In 1996, approximately 59% of municipalities were unserved, representing almost 2.8 million Portuguese. The percentage of unserved municipalities decreased to 43% in 2007, affecting 2 million Portuguese (approximately 20% of the population). A more dramatic picture emerges from Fig. 1, i.e. the unserved municipalities tend to be geographically contiguous.

Table 5 shows the number of physicians per 1,000 inhabitants by groups of municipalities according to population size. The data confirm that physicians are disproportionately concentrated in the most populous municipalities.

Table 5 also presents the result of decomposition of the Gini coefficient in 2007, following Pyatt's method [30]. The decomposition exercise indicates that, as expected, the inequality between groups of municipalities is higher than the inequality between the municipalities within groups. As expected, unserved municipalities are the ones with smaller populations.

Comparing the periods 1996 and 2007 (Table 6), there appears to be a trend towards a better distribution of physicians per 1,000 inhabitants, by group of municipalities. This fact results not only from a higher mobility of doctors

Table 3 Evolution of the number of specialists and general practitioners (GPs) and population size in Portugal

Year	Specialists			GPs		Total
	Number	Growth rate (%)	Percentage of total	Number	Growth rate (%)	
1996	20,502		68.56	10,701		29,902
1997	21,205	3.43	69.68	10,578	−1.15	30,431
1998	21,866	3.12	70.34	10,677	0.94	31,087
1999	22,043	0.81	69.41	11,066	3.64	31,758
2000	22,813	3.49	70.20	11,192	1.14	32,498
2001	23,193	1.67	69.79	11,584	3.50	33,233
2002	23,508	1.36	69.65	11,785	1.74	33,751
2003	24,666	4.93	71.62	12,087	2.56	34,440
2004	25,506	3.41	72.43	12,364	2.29	35,213
2005	26,403	3.52	73.06	12,831	3.78	36,138
2006	26,982	2.19	73.07	13,220	3.03	36,924
2007	27,529	2.03	72.63	13,817	4.52	37,904

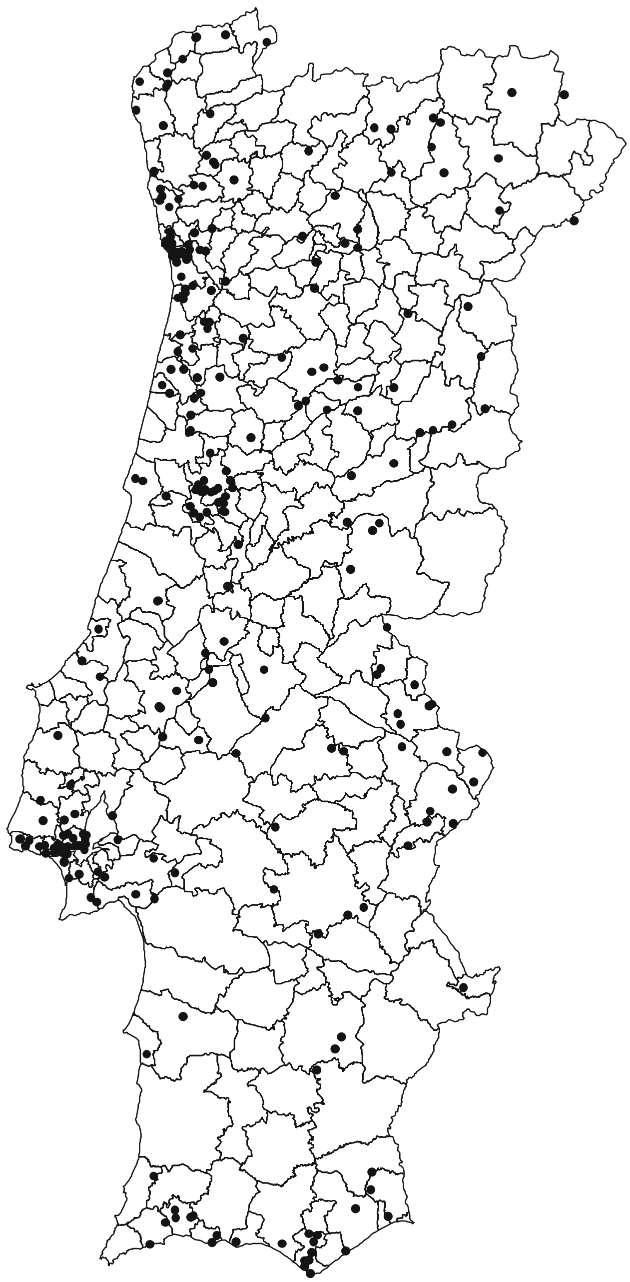

Fig. 1 Number of physicians per 1,000 inhabitants, by municipality, in 2003

Table 4 Inequality measures of geographic distribution of physicians per 1,000 inhabitants. *CV* Coefficient of variation

	1996 Gini[a]	CV	2007 Gini	CV
Physicians	0.433	1.276	0.437	1.295
GPs	0.400	1.026	0.406	1.017
Specialists	0.502	1.482	0.508	1.546

[a] The Gini coefficient is the most widely used single measure of health care geographic inequality [6, 15–17, 21, 25]

to less populous municipalities. Indeed, in the group of less populous municipalities, developments in the opposite direction between the number of physicians and the size of resident population explain the growing number of physicians per 1,000 inhabitants, which slightly exceeds the growth rate in the absolute number of physicians.

Moreover, despite the high concentration of physicians in the most populous municipalities, the number of practitioners in these municipalities continues to grow. This trend suggests that, despite the intensity of competition, these municipalities continue to be attractive to physicians. Consider the distribution of GPs and specialists per 1,000 inhabitants in the most populous municipalities. The lower growth in the number of GPs per 1,000 inhabitants relative to the number of specialists per 1,000 inhabitants is in accordance with literature that suggests that the increased intensity of competition in these areas tends to lead to GPs being located in less crowded areas [26–28]. It should also be noted that the increase in the number of doctors per 1,000 inhabitants in the less populous municipalities was not enough to reverse the overall estimate of inequality in distribution.

Determinants of physician localisation

"Static" model

Table 7 displays the estimated coefficients of the different models proposed. The results suggest a positive association between the size of population and the number of physicians per 1,000 inhabitants. Moreover, it highlights the fact that the size tends to affect the decisions of specialists more than of GPs. This result is in line with expectations, since the return of some specialties requires a high population base. The size of the population (market) explains only 15% of the total variation in GP density and 27% of the variation in specialist density. When the model controls for the other variables, the estimated value decreases sharply and, more importantly, it is no longer statistically significant in the case of GPs. The estimated coefficient is still positive but no longer statistically significant in the case of the regression of specialists when the model controls for the districts' dummy variables.

Looking at the second specification of both models (Table 7), the estimated coefficients indicate that municipalities with larger supplies of NHS beds tend to attract, on average, more physicians per 1,000 inhabitants. This result is consistent with the hypothesis that the concentration of health resources by the NHS tends to generate a concentration of physicians. However, the magnitude of the estimated coefficient indicates that the elasticity is small. The municipality's purchasing power is an important factor in explaining the location decisions of physicians. Doctors'

Table 5 Average number of physicians per 1,000 inhabitants according to municipality size—2007

Population (in thousands)	Number of municipalities	Physicians	GPs	Specialists
<10	93	1.189	0.590	0.599
10–20	65	1.257	0.585	0.666
20–50	63	1.798	0.740	1.058
50–100	34	2.507	0.866	1.640
100–150	8	5.453	1.838	3.616
150–200	11	4.374	1.510	2.864
>200	4	10.693	3.062	7.630
Decomposition Gini				
Between		0.305	0.181	0.344
Within		0.058	0.071	0.063
Overlap		0.089	0.154	0.101

Table 6 Growth rate of number of physicians (1996–2007)

Population (thousands)	Growth in the number of physicians	Growth in the number of physicians per 1,000 inhabitants	Growth in the number of GPs per 1,000 inhabitants	Growth in the number of specialists per 1,000 inhabitants
<10	0.486	0.496	0.902	0.521
10–20	0.551	0.574	0.610	0.823
20–50	0.529	0.407	0.600	0.423
50–100	0.530	0.380	0.355	0.445
100–150	0.808	0.363	0.113	0.236
150–200	0.303	0.184	0.114	0.237
>200	0.303	0.205	0.094	0.259

Table 7 Location decisions—ordinary least squares (OLS) regression estimates—static model (2007). Robust standard errors (SEs) are in parentheses

	LN (GPs)	LN (GPs)	LN (GPs)	LN (specialists)	LN (specialists)	LN (specialists)
LNPOP2007	0.254 (0.040)**	0.037 (0.058)	−0.019 (0.061)	0.412 (0.046)**	0.074 (0.057)*	0.030 (0.070)
LNBEDS2007		0.034 (0.010)**	0.031 (0.011) **		0.026 (0.012)**	0.021 (0.012)*
LNPP2007		1.182 (0.173)**	1.791 (0.235)**		1.539 (0.191)**	2.392 (0.276)**
AGEING2007		0.002 (0.001)**	0.002 (0.001)**		0.001 (0.001)	0.000 (0.001)
CENTRAL2007		0.659 (0.249)**	0.522 (0.256)*		0.953 (0.267)**	0.694 (0.301)*
CONSTANT2007	−9.956 (0.40)**	−13.053 (0.772)**	−15.215 (0.995)**	−11.299 (0.458)**	−14.647 (0.806)**	−17.870 (1.117)**
DDISTRICTS2007	No	No	Yes[a]	No	No	Yes[a]
Observations	278	255	255	278	255	255
R-squared	0.15	0.36	0.53	0.27	0.45	0.55

* Statistically significant at 5%, ** statistically significant at 1%

[a] *F* tests statistics reject the null hypothesis that the dummies are all equal to zero with a *P*-value of 0.0000

availability appears to be a "luxury good". This result may be due to two factors: first, the regions with higher purchasing power tend to offer a larger potential market for private health care practice; second, in terms of determining residence, these areas also tend to be more attractive. As expected, the specialists are more sensitive to differences in purchasing power.

Municipalities with general central hospitals have, on average, a higher number of physicians per 1,000 inhabitants, which is in line with the literature reviewed. Additionally there is evidence that population needs have little if any impact on the physicians' location decisions. The estimated coefficient for the aging variable is positive and statistically significant for GPs but of small magnitude.

The third column of Table 7 presents the results of the models when controlling for the unobservable differences between districts. The differences between districts are statistically different from zero, indicating that the specifics of the districts should be considered in the estimate determining the density of physicians per municipality. The introduction of this variable changes the level of significance of some variables, which cease to be statistically significant at conventional levels.

There is empirical evidence showing the relatively low mobility of practitioners once they have settled within one particular region [23]. Thus, variation in the number of doctors per 1,000 inhabitants within municipalities tends to be small and explained mainly by the entry of new graduates. Therefore, we estimated a model regressing data from 1996 for the (log) number of GPs and specialists per 1,000 inhabitants in 2007 (Table 8). Overall, the results suggest that 1996 variables explain a large share of the doctors' geographic distribution. The results are qualitatively similar to those reported in Table 7. Nonetheless, the population size and availability of beds have a stronger impact on doctors' location decisions in 1996 than in 2007. These results appear to confirm the relative low mobility of doctors.

"Dynamic" model

We turn now to consideration of the "dynamics" of location of physicians (Table 9). First, the low R^2 of the first model estimated should be noted, suggesting that the traditional variables have a limited capacity to explain the variations in the ratio of the number of physicians per 1,000 inhabitants. When the model controls for the unobservable characteristics of the districts, the explanatory power of the model increases substantially.

The results suggest the existence of forces of competition in the location decisions during the period under review. The coefficient of the variable DENSITY96 is negative and statistically significant, supporting the hypothesis that, at least from a certain degree of competitive intensity, the

Table 8 OLS regression estimates—static model (2007). Robust SEs in parentheses

	LN (GPs)	LN (GPs)	LN (specialists)	LN (specialists)
LNPOP1996	0.126 (0.067)	0.134 (0.070)	0.228 (0.076)**	0.238 (0.085) **
LNBEDS1996	0.150 (0.036)**	0.118 (0.042)**	0.240 (0.047)**	0.180 (0.050)**
LNPP1996	0.726 (0.129)**	1.000 (0.146)**	0.998 (0.139)**	1.320 (0.176)**
AGEING1996	0.002 (0.001)**	0.002 (0.001) **	0.000 (0.001)	0.001 (0.001)
CENTRAL1996	0.517 (0.254)*	0.301 (0 263)	0.405 (0.271)	0.167 (0.317)
CONSTANT	−5.001 (0.709)**	−6.261 (0.732)**	−6.818 (0.735)**	−8.293 (0.883)**
DDISTRICTS		Yes[a]		Yes
Observations	180	180	180	180
R-squared	0.485	0.628	0.633	0.685

* Statistically significant at 5%, ** Statistically significant at 1%

[a] *F* test statistics reject the null hypothesis that the dummy coefficients are jointly equal to zero with a *P*-value of 0.0000

Table 9 OLS regression estimates—"dynamic" model. Robust SEs in parentheses

	Δ GPs per 1,000 inhabitants	*Δ* GPs per 1,000 inhabitants	*Δ* specialists per 1,000 inhabitants	*Δ* specialists 1,000 inhabitants
DENSITY96	−0.456 (0.139)**	−0.562 (0.165)**	−0.575 (0.119)**	−0.621 (0.150)*
DENSITY96 SQUARED	0.020 (0.006)**	0.024 (0.008)**	0.025 (0.005)**	0.026 (0.007)**
VARPOP	−1.049 (0.484)*	−0.651 (0.549)	−0.699 (0.359)	−0.380 (0.497)
VARBEDS	0.093 (0.145)	0.148 (0.149)	0.315 (0.137)*	0.323 (0.135)*
AVERAGEPP	0.007 (0.004)	0.013 (0.006)*	0.012 (0.002)**	0.016 (0.005)**
VARCENTRAL	0.007 (0.002)	0.356 (0.990)*	0.376 (0.386)	0.336 (0.899)
CONSTANT	0.774 (0.233)**	0.479 (0.308)**	0.512 (0.219)*	0.304 (0.280)
DDISTRITO	No	Yes[a]	No	Yes[a]
Observations	267	267	255	255
R-squared	0.05	0.21	0.07	0.21

* Statistically significant at 5%, ** statistically significant at 1%

[a] *F* test statistics reject the null hypothesis that the dummy coefficients are jointly equal to zero with a *P*-value of 0.0000

physicians tend to avoid locating themselves in these areas. Nonetheless, the competition factor seems to have a slightly stronger effect on specialists than on GPs, contrary to what was envisaged in our initial hypothesis and in the literature [26–28]. One possible explanation is the lower average age of GPs. Data from the Portuguese Medical Association shows that almost one-third of the non-specialists are younger than 31 years old.[2] It is likely that the majority of these young GPs are still in training and therefore less able to spread geographically. Further work should look deeper into this question.

The growth in the population seems to have adversely affected the growth in the number of GPs resident in the municipality although the estimated coefficient is significant only for GPs. There is no evidence of adjustments in the number of GPs per 1,000 inhabitants following variations in the installed capacity of the NHS. On the contrary, specialists' location decisions appear to reflect the changes in the installed capacity of the NHS.

The number of physicians per 1,000 inhabitants appears to have grown in the most prosperous municipalities. Nonetheless, the estimated coefficients are small and insignificant at conventional levels of significance in some specifications. Moreover, purchasing power appeared to impact more on the variation in specialist density than we would expect. A significant part of the change in the growth of the number of physicians within municipalities is explained by district factors.

Conclusions

Analysis of the asymmetries in geographical distribution of physicians per 1,000 inhabitants in mainland Portugal shows a country with serious and persistent imbalances. Examination of the map of the distribution of physicians per 1,000 inhabitants shows areas of high concentrations of resident physicians in relation to the population, along with vast areas with densities of physicians below the minimum recommended by WHO. Despite the rapid growth in the number of doctors, their geographic distribution is still highly asymmetric. The distribution of specialists appears to be more unequal than that of GPs. Surprisingly perhaps, during the period observed, the growth in the ratio of specialists appears to not have contributed significantly to the overall increase in geographic inequality.

Analysis of the variation in the number of physicians per 1,000 inhabitants suggests that there are competitive forces in the market for physicians. The competition has not been enough, however, to generate an equitable geographical distribution of physicians. The results show that some policies concerning the allocation of physical resources by the NHS are important. In particular, central hospitals appear to attract physicians (and seem to also generate a process of accumulation of private resources). As a result, the ongoing trend of restructuring the NHS, which increases the concentration of resources, may exacerbate inequalities. Moreover, the evidence suggests that efforts towards more equitable geographical coverage made in the period under review, particularly in the number of beds, did not contribute significantly to a reduction in the inequality of the distribution of physicians. Changes in supply conditions appear more likely to affect new entrants than the mobility of installed practitioners. The location of physicians mainly follows asymmetries in purchasing power, although the average income within municipalities had little impact on recent physician location dynamics.

The evidence reinforces the idea that it is difficult for the market to ensure an equitable distribution of physicians. In these circumstances, a policy of incentives regarding the location of physicians may be effective. Policies targeting new entrants are likely to be more effective. There is considerable evidence that physicians respond to financial incentives [4, 9, 18]. International experience suggests other types of policy to promote better distribution of physicians, such as educational policies (promoting rural health through medical courses, discriminatory policies on access and funding for students from areas with shortages of physicians, location of universities), immigration policies, and regulatory policies concerning the market for health care [36].

Limitations of the analysis and further research

This paper should be seen as a preliminary study of geographic imbalances in the density of physicians in Portugal. Some limitations should be addressed in subsequent work: (1) the results suggest that other levels of aggregation of data must be tested at the geographical level, (2) data on accessibilities could enrich the understanding of the determinants of residence and allow better judgment of equity, (3) further work should also explore the availability of data for a larger number of years for a more careful econometric time analysis, (4) spatial correlations should be explored using spatial econometric models. Moreover, a promising route for further work is to compare the decisions of younger versus older doctors as well as the behaviour of foreign doctors. This could provide important information for policy purposes. This study did not intend to evaluate equity of access to health care. Future work should examine the complex relationships between the

[2] https://www.ordemdosmedicos.pt/?lop=stats_medicos&type=1&ano=2006

distribution of the health resources, equity, and the efficiency of the system.

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