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Distribution of community pharmacies and primary healthcare centers in Portugal: a cross-sectional analysis

Luciana G. Negrão[1], Rita Moreira[2], Ines Chaves-Neves[1]
Isabel V. Figueiredo[2], Fernando Fernandez-Llimos[1],

1. Faculdade de Farmácia, Universidade do Porto, Porto, Portugal 2. Faculdade de Farmácia, Universidade de Coimbra, Coimbra, Portugal.

KEYWORDS

Health Services Accessibility, Pharmacies, Community Pharmacy Services, Primary Health Care, Catchment Area, Health, Geographic Information Systems, Spatial Analysis, Portugal

ABBREVIATIONS

ANF: National Association of Pharmacies

CI: Confidence Interval

HCC: Healthcare Centers

INE: National Institute for Statistics

IQR: Interquartile Range

NHS: National Healthcare System

OECD: Organization for Economic Co-operation and Development

QALY: Quality-Adjusted Life Year

SD: Standard Deviation

ABSTRACT

Introduction: Poor access to community pharmacies has been associated with restricted accessibility to medicines. We aimed to compare the geographic distribution of community pharmacies and healthcare centers (HCCs) and identify sociodemographic variables associated with geographical discrepancies at the municipal level in Portugal.

Methods: Data on HCC, physicians, pharmacies, and pharmacists were collected at the municipality level in 2024. Municipality population and area per healthcare establishment and professional were compared, as well as pharmacies/HCC and physician/pharmacist ratios. Multivariate analyses were conducted between dependent variables and sociodemographic factors.

Results: Portugal municipalities had a mean 516 residents (SD 319) per physician and 1,021 (SD 450) per pharmacist (paired Cohen's d= 1.127 [0.76:1.277]), with a ratio physician/pharmacist of 2.55 (SD 1.55). The surface area covered by professionals was 22.0 km2 (SD 35.8) per physician and 37.9 km2 (SD 57.8) per pharmacist (d=0.449 [0.325:0.572]). However, population per HCC was 22,998 (SD 22,038) while 3,206 (SD 1,087) per pharmacy (d=0.924 [0.783:1.064]) and the area covered was 82.2 km2 (SD 98.3) per pharmacy and 304.6 km2 (SD 287.1) per HCC (d= 0.912 [0.771:1.051]). Positive associations were found between the ratio pharmacies/HCC and percentage of young population, higher educational level, or literacy.

Conclusion: Despite the greater number of physicians than pharmacists, community pharmacies showed a more intensive coverage of Portuguese mainland territory when compared to HCCs. The wider dispersion of pharmacies may facilitate the role of pharmacists as public health agents.

INTRODUCTION

An appropriate geographical distribution of healthcare facilities is important for equitable access to healthcare services. However, regional disparities in healthcare provision have been documented worldwide. A review conducted in 23 different countries refers to challenges in access to primary and specialized care in remote, rural, and undeveloped areas (1). In a systematic review carried out by Kelly et al., 77% of the analyzed studies identified evidence of distance and decay association, with further distances and travel time to healthcare associated with worse health outcomes, such as survival rates, prolonged hospital stays, and failure to attend follow-up appointments (2).

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Correspondence: Fernando Fernandez-Llimos (fllimos@ff.up.pt).

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In Portugal, the "Health at a Glance: Europe 2024" report points to the uneven geographic distribution of physicians as a barrier to healthcare, with a greater density of these healthcare professionals in regional capital cities (3). Disparities in driving time to the nearest hospital were identified between Portuguese municipalities, with municipalities on the coast and urban regions of the country having better accessibility compared to the municipalities in the interior and rural areas (4). These differences in access between interior/coast and urban/rural regions were also described for primary healthcare facilities (5) and in the delivery of screening programs (6).

The contribution of community pharmacies to improving public health and self-care has been widely documented. Non-dispensing pharmacy-led interventions have contributed to improving health outcomes in chronic diseases (7), especially in rural areas (8). Appropriate geographic access to pharmacies has been associated with better adherence to treatment, which results in better health outcomes (9). Additionally, community pharmacies have also played an important role in immunization and screening programs (10,11).

To ensure appropriate access to community pharmacies, some countries have established measures that promote the dispersion of these premises, which has contributed to the general idea of effective territorial coverage (12). However, the existence of discrepancies in geographic access to pharmacies (12), including the existence of pharmacy deserts, defined as communities with low access to pharmacies (13), has been documented. In Portugal, for a new pharmacy to be opened it needs to fulfill the following requirements: 1) minimum capitation of 3500 inhabitants per pharmacy opened to the public in the municipality, except when the pharmacy is installed more than 2 km from the nearest pharmacy; 2) minimum distances of 350m between pharmacies; 3) the pharmacy must be, at least, 100 m away from a health care center, except in locations with fewer than 4000 inhabitants. Nevertheless, there are no publicly funded incentives to establish or sustain a pharmacy in rural areas.

Considering the contribution of pharmacies to public health, these health premises can complement the national public health service and contribute to filling the gaps in accessibility to health services described in Portugal. Given the existence of geographic discrepancies in healthcare access, including pharmacies, we aimed to compare the geographic distribution of community pharmacies and healthcare centers (HCCs) and identify sociodemographic variables associated with geographical discrepancies in the distribution of pharmacies at the municipal level in Portugal.

METHODS

Study design and setting

This was a cross-sectional analysis of the geographic distribution of healthcare centers and physicians, as well as community pharmacies and pharmacists at the municipality level in mainland Portugal. Mainland Portugal is organized in 278 municipalities, which corresponds to the second level of administrative division. The estimated resident population in 2023 was 10.6 million people. Portuguese National Institute for Statistics (INE) considers a population density of 500 residents per squares Km as the limit of rurality (https://www.ine.pt/). Although some cities exist in inland Portugal, more than 70% of the population is located in the coastal region between Braga and Setubal (14).

The Portuguese National Healthcare System (NHS) has universal coverage, and it is mostly funded through general taxation. Until 2024, the NHS was managed at a regional level, by five regional health administrations. Primary care is provided in healthcare centers, where family physicians act as gatekeepers to secondary and tertiary care, mostly provided in hospitals. Community pharmacies are private establishments that can be owned by non-pharmacists, although a pharmacist is required as the responsible technical director. The main source of pharmacies revenue comes from the profit margin applied to the prices of the medications they dispense. In the case of prescription medicines, the prices and remuneration system are established by the government. The services that can be provided by community pharmacies are regulated by law. Flu and COVID-19 vaccination and syringe-exchange services are remunerated by the Portuguese NHS through a fee service model (dispensing hospital medicine through a proximity program is expected to be remunerated in 2025), while the other services are paid out-of-pocket by the patients.

Data collection

The list of municipalities was obtained from the General Directorate of the Territory (https://www.dgterritorio.gov.pt/). The number of community pharmacies in each municipality was obtained from INFARMED (https://www.infarmed.pt/web/infarmed). The number of healthcare centers (HCC) in each municipality and regional health administration was obtained from the Portuguese NHS official database, Business Intelligence - Cuidados de Saúde Primários (BI-CSP) (https://bicsp.min-saude.pt/pt/Paginas/default.aspx), and the number of physicians and pharmacists from the National Institute for Statistics (INE) database (https://www.ine.pt/).

The following sociodemographic variables were also obtained from the INE database: resident population, resident population over 65 years of age, the number of residents with higher education, the number of unemployed residents, the municipality area (in square km), the per capita purchasing power indicator in 2019, the illiteracy rate (%), and the number of tourists per year. All data were collected in June 2023.

Data processing

The number of tourists per year per municipality was divided by 365 and added to the number of residents of each municipality to give the number of the general population increase to the municipality that is brought by tourism.

$$population + turists = \frac{n^{o}\ turists}{365} + n^{o}\ residents$$

The unemployment rate (%) was calculated by dividing the number of unemployed residents to the total of residents of each municipality and multiplied by 100.

$$unemployment\ rate\ (\%) = \frac{n^{o}\ unemployed\ residents}{n^{o}\ residents} \times 100$$

The literacy rate (%) was calculated as the complement of the illiteracy rate (%) of each municipality.

The variables under study were normalized obtaining the following ratios: the municipality population per pharmacy, per HCC, per pharmacist, and per physician; the municipality areas (square km) per pharmacy, per HCC, per pharmacist, and per physician; and the municipality ratio physician/pharmacist and pharmacies/HCC.

Data analysis

Paired t-test were calculated for continuous variables to compare distributions between pharmacists and physicians as well as pharmacies and HCC. Also, effect size measures between the dependent variables were determined through Cohen's d statistics and categorized following Cohen's recommendations into 0.1 to 0.3 small effect, 0.3 to 0.5 intermediate effect, 0.5 and higher strong effect (15).

Pearson's correlation and multivariate linear regression analyses were conducted to investigate the relationship between the dependent variables and sociodemographic factors, using SPSS v25 (IBM, Armonk, NY, United States). A p-value<0.05 was deemed statistically significant.

Overlapping correlations of two dependent variables were compared using the Zou interval (16). Correlation coefficients were considered significantly different when Zou interval does not comprise zero (16). Zou intervals were calculated with the R/R Studio (Posit, Boston, MA) using the cocor package (17).

RESULTS

The 278 municipalities in mainland Portugal have a median population of 14,396 residents [IQR 6,436: 38,673], which reaches 14,626 [IQR 6,589: 38,734] when adding the average number of tourists per day. The median area of a municipality is 228.6 square km [IQR 134.2: 401.8].

Portugal mainland has 56,535 physicians and 15,495 pharmacists recorded at the INE database. For all the municipalities, the mean population per physician was 516 (SD 319) inhabitants, while population per pharmacist was 1,021 (SD 450), which results in a ratio physicians/pharmacists per municipality of 2.55 (SD 1.55). The mean surface area covered per physician was 22.0 square km (SD 35.8), while it was 37.9 square km (SD 57.8) per pharmacist. Paired comparisons of these variables at the municipality level showed differences of effect size that ranged from moderate in area to strong in population (Table 1). Despite the differences of these variables across the five former healthcare administration regions (Supplementary material), no clear geographic pattern was evident for the distribution of physicians (Figure 1A) or pharmacists (Figure 1B) per population, or in the ratio physicians/pharmacists (Figure 1C). However, a geographic pattern is evident in area covered per physician (Figure 1D) or per pharmacist (Figure 1E).

A total of 2,804 pharmacies and 357 HCC are distributed across the Portugal mainland. The mean population per pharmacy is 3,206 (SD 1,087) residents, while the mean population per HCC reaches 22,998 (SD 22,038) residents. The mean surface area covered per pharmacy was 82.2 square Km (SD 98.3), while the mean area per HCC was 304.6 square Km (SD 287.1). The mean ratio pharmacy/HCC per municipality was 6.63 (SD 5.27). Differences in paired analyses presented strong effect sizes for all these variables (Table 1). Differences across the five regions also existed in population per pharmacy and per HCC as well as in area per pharmacy and per HCC (Supplementary material). Evident geographic patterns were found in population per HCC (Figure 2F), population per pharmacy (Figure 2G), ratio Pharmacy/HCC (Figure 2H), area per HCC (Figure 2I) and area per pharmacy (Figure 2J).

In a bivariate analysis, a strong association was found between the ratio physician/pharmacist and percentage with higher education. Intermediate association was found with per capita purchasing power, and literacy rate, while associations were weak with the other sociodemographic variables. Also, strong associations were found between the ratio pharmacies/HCCs with almost all the sociodemographic variables, except with population density (intermediate), and no association existed with unemployment rate (Table 2). Correlations of both ratios with each sociodemographic variable were significantly different in Zou's analyses, except for the percentage of population with higher education degree.

Table 1. Paired analyses between population and area per healthcare establishment and professional at the municipality level.

	Per pharmacist Mean (SD)	Per physician Mean (SD)	Cohen's d**	Pearson R
Resident population*	1,021 (450)	516 (319)	1.127 [0.76:1.277]	0.362
Area (sq km)*	37.9 (57.8)	22.0 (35.8)	0.449 [0.325:0.572]	0.811
	Per pharmacist Mean (SD)	Per physician Mean (SD)	Cohen's d**	Pearson R
Resident population*	3,206 (1,087)	22,997 (22,038)	0.923 [0.782:1.063]	0.568
Population+tourists*	3,230 (1,097)	23,155 (22,166)	0.924 [0.783:1.064]	0.569
Area (sq km)*	82.2 (98.3)	304.6 (287.1)	0.912 [0.771:1.051]	0.577

*Paired t-test p-value<0.001; **Paired Cohen's d using the sample standard deviation of the mean difference.
SD: standard deviation; HCC: healthcare center

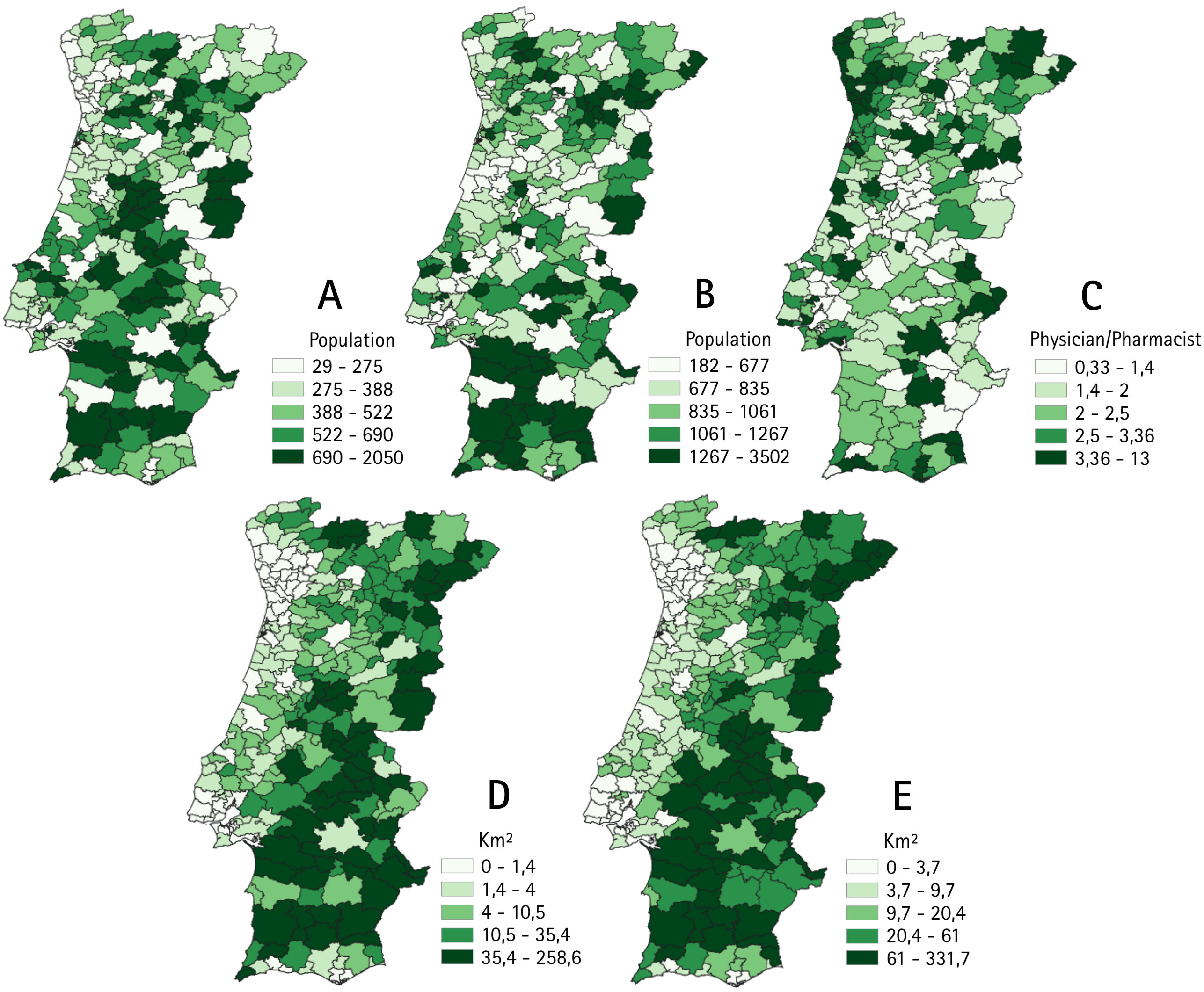

Figure 1. Geographic distributions at municipality level of: A) population per physician; B) population per pharmacist; C) ratio physician/pharmacist; D) area per physician; and E) area per pharmacist.

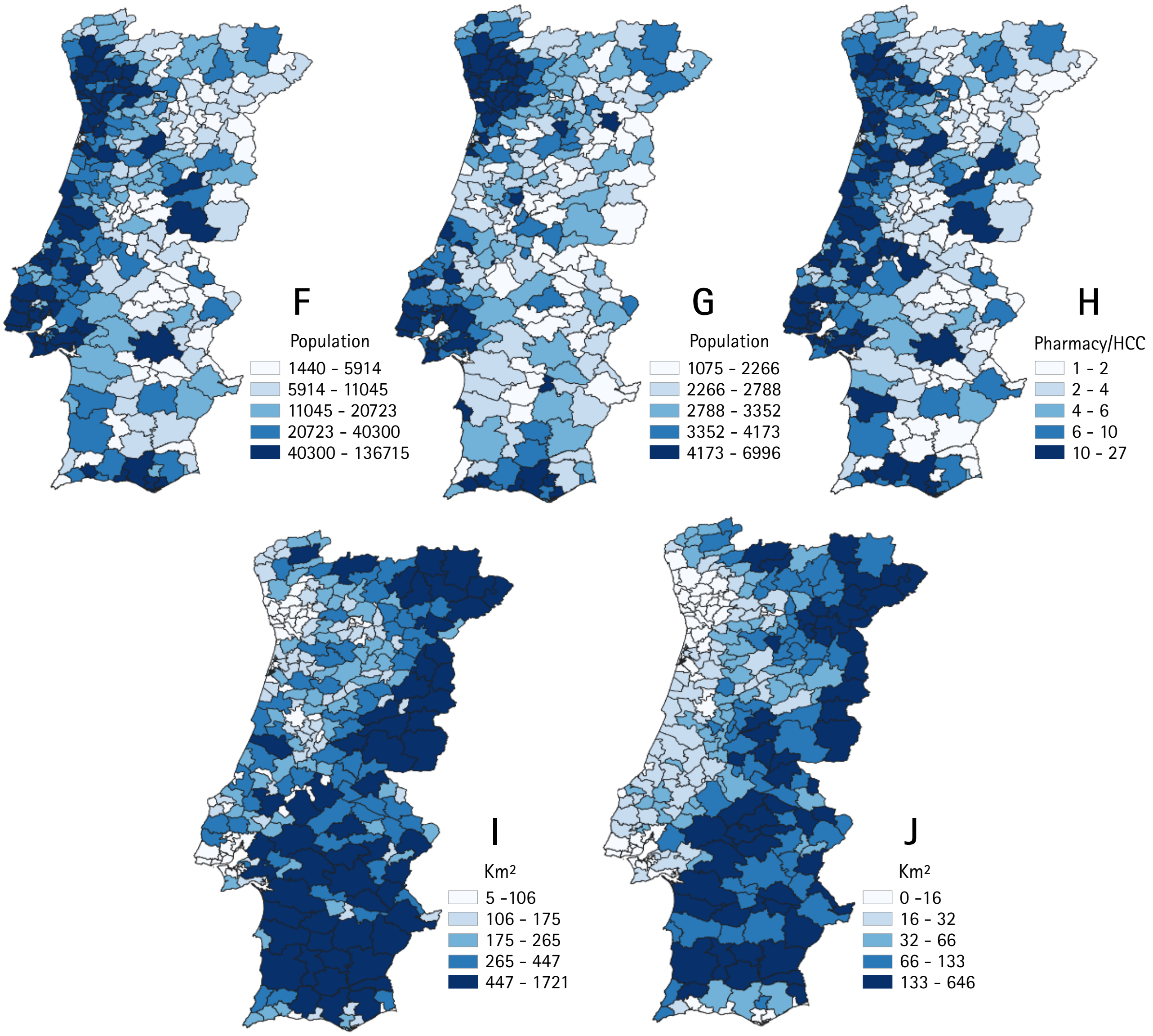

Figure 2. Geographic distributions at municipality level of: F) population per HCC; G) population per pharmacy; H) ratio pharmacy/HCC; I) area per HCC; and J) area per pharmacy.

Table 2. Correlations between ratio physicians/pharmacist and pharmacies/HCC with sociodemographic variables at municipality level

	Ratio Physicians/Pharmacists		Ratio Pharmacies/HCCs		Interval de Zou
	p-value	R [95 %CI]*	p-value	R [95 %CI]*	
Population density	<0,001	0,219 [0,104:0,328]	<0,001	0,396 [0,291:0,490]	-0,310:-0,043
% pop >65 years	<0,001	-0,294 [-0,398: 0,182]	<0,001	-0,502 [-0,585:-0,408]	0,081:0,335
% pop w/ higher education	<0,001	0,526 [0,435:0,606]	<0,001	0,619 [0,541:0,687]	-0,201:0,014
Per capita purchasing power	<0,001	0,436 [0,336:0,527]	<0,001	0,588 [0,505:0,660]	-0,268:-0,037
% Literacy	<0,001	0,334 [0,225:0,434]	<0,001	0,583 [0,500:0,656]	-0,370:-0,129
% Unemployment	0,039	0,124 [0,006:0,238]	0,278	0,065 [-0,053:0,182]	-

Correlation between Ratio physician/pharmacist and Ratio pharmacies/HCCs = 0.249 [0.136:0.357]
*Pearson's correlation. HCC: healthcare center; CI: confidence interval

Intermediate correlations were found between the population per pharmacist with all the sociodemographic variables except with unemployment rate. Correlations with these variables were stronger than with the population per physician, with significant differences between the two correlations. Similar results were obtained for the correlations between the sociodemographic variables and population per pharmacy and per HCC, as well as with the area per pharmacy and per HCC, also with statistical differences between the analogous correlations. Differences disappeared when comparing the correlations between area per physician and area per pharmacist with the sociodemographic variables (Supplementary material).

On a multivariate analysis for the ratio physicians/pharmacists with all the sociodemographic variables studied, significant association was found with population density, population with higher education degree, and unemployment rate. In a similar analysis for the ratio pharmacies/HCCs, statistical association was found with percentage of population older than 65, population with higher education degree, and literacy rate (Table 3).

Table 3. Multivariate analyses of ratio physicians/pharmacists and the ratio pharmacies/HCC with all the sociodemographic variables

Dependent Variable: Ratio physicians/pharmacists	B	p-value	95%CI
Population density (inh/km2)	0,001	0,010	-0,001:0,000
% pop >65 years	-0,015	0,391	-0,048:0,019
% pop w/ higher education	0,229	<0,001	0,160:0,299
Per capita purchasing power in 2019	-0,006	0,519	-0,023:0,012
% Literacy	-0,023	0,514	-0,091:0,046
% Unemployment	0,091	0,002	0,033:0,148
Adjusted R-square = 0.450; Durbin-Watson = 1.974			
Dependent Variable: Pharmacies per health care center	**B**	**p-value**	**95%CI**
Population density (inh/km2)	0.001	0.831	-0.001:0.001
% pop >65 years	-0.108	0.038	-0.209:-0.006
% pop w/ higher education	0.368	0.001	0.157:0.579
Per capita purchasing power in 2019	0.034	0.209	-0.019:0.086
% Literacy	0.276	0.009	0.070:0.483
% Unemployment	0.045	0.610	-0.130:0.220
Adjusted R-square = 0.304; Durbin-Watson = 1.961			

DISCUSSION

In this study, we described the distribution of healthcare premises and professionals at municipality level in Portugal, highlighting existing inequalities. We identified that pharmacies and healthcare centers in urban municipalities and metropolitan areas need to assist more people when comparing to interior and rural municipalities of Portugal. However, in interior and rural areas these premises need to cover a wider area. When considering the ratio between these health institutions, there is a clear concentration of pharmacies in urban municipalities. In multivariate analyses, the pharmacies/HCC ratio positively correlated with the percentage of population with higher education and literacy rate. Similarly, we identified differences in the population and area that physicians and pharmacists need to attend, with less broad areas they need to cover in the littoral and metropolitan areas.

Our findings showed that municipalities with a lower percentage of people with higher education and literacy rates, as well as with lower population density, primarily situated in rural regions, had a lower pharmacies/HCC ratio. In the Organization for Economic Co-operation and Development (OECD) countries, between 1995-2015, higher education correlated positively with vaccination rates in children and life expectancy, while negatively correlated with infant mortality (18). Higher education was also positively associated with good general self-rated health status, healthy weight, non-smoking habits, and lower alcohol consumption in the UK (19).

In the USA, pharmacy deserts communities have been associated with lower levels of education, no health insurance, language barriers, chronic diseases, and areas with high proportion of racial or ethnic minorities (13). In Portugal, a study conducted with 2011 data highlighted the disparities in pharmacy accessibility between urban and rural areas. In high-density regions, 95% of the population was able to reach a pharmacy within 10 minutes by car, compared to only 65% of the population in low-density regions (5). Likewise, we also identified that areas with a lower concentration of pharmacies, mainly located in inland and rural municipalities, have a lower population density and a higher percentage of elderly people.

The role of community pharmacies in public health has been increasing, resulting in better health outcomes both in patient and population-level. In the UK, with the aim of relieving the burden on general practitioners, the NHS reimburses community pharmacies for the management of chronic diseases (20) and minor ailments (21). Pharmacy-based minor illness services are safe and cost-effective, and increase population access to primary care, especially in remote or high-deprived areas (21). Other countries, such as Spain, have also implemented a formal minor ailments service provided by community pharmacies (22). Additionally, during the COVID-19 pandemic, community pharmacies played a major role in public health by providing advice, testing, and administering COVID-19 vaccines (10,23). The literature reported that communities classified as pharmacy deserts were associated with a higher risk of COVID-19 infection, based on the COVID-19 Community Vulnerability Index (24), thus demonstrating the importance of accessibility to community pharmacies in public health.

There is also evidence of the positive contribution of Portuguese community pharmacies in public health. The INspira study showed that education and intervention on inhalation technique in patients with respiratory conditions led to a reduction in scheduled medical appointments (25). An evaluation of point-of-care tests for HIV, HCV and HBV utilization reported that community pharmacies seem to improve population access, especially for individuals tested for the first time, heterosexuals, and some immigrants (26). A study on the impact of community pharmacies on the syringe-exchange program estimated that 7,000 new HIV infections were prevented in the first 8 years of the program, leading to savings of approximately 400 million euros (27). It is also estimated that medicines proximity programs for the delivery of hospital-only medication in community pharmacies allow annual savings of 260 euros per patient, as well as better access and adherence to medication (28). The inclusion of community pharmacies in the administration of influenza and COVID-19 vaccines to those aged over 60 years, without a prescription order and fully reimbursed by the Portuguese NHS, led to a reduction in the average distance to the nearest vaccination point, mainly in municipalities with lower population density, lower purchasing power index, and higher aging index, resulting in greater vaccination coverage in municipalities with the greatest reduction in average distances (29). Services provided by Portuguese community pharmacies showed an overall improvement of 8% in the quality of life, with 260,245 additional quality-adjusted life year (QALYs), and savings of 879.6 million euros in 2014 due to their provided services (30).

This body of evidence reinforces the importance of proper access to community pharmacies in public health and the beneficial effects of regulation policies. Recently, the Portuguese Ministry of Health has progressively integrated community pharmacies into certain initiatives to support NHS objectives. These measures can greatly benefit vulnerable populations, such as the elderly and people with a poorer education, especially those in rural regions. A study conducted in the city of Pamplona, Spain, analyzed the implications of the deregulation policies, specifically on the restrictions for the opening of new pharmacies (31). Despite the increase in the number of pharmacies after deregulation, the population that already had the worst accessibility, defined as a pedestrian distance to the nearest pharmacy greater than 1000 m, did not substantially change. New pharmacies were opened mainly in the city center or near existing pharmacies, with the number of pharmacies with a competitor within 250 m increasing from 68 to 143. These results show that deregulation resulted in the concentration of pharmacies, without increasing accessibility of the underserved population (31).

The geographical differences in the distribution of pharmacies identified by our study show that there is potential for enhancement in the existing regulation policies in Portugal. Otherwise, the beneficial effects of the integration of community pharmacies into the activities of the Portuguese NHS may not be fully achieved in lower population density areas.

Limitations

Our analysis was restricted to mainland Portugal, omitting the two archipelagos. Madeira and Azores archipelagos are autonomous regions that have special characteristics, resulting from their insularity, and legislation that may differ from that of mainland Portugal, including that regarding community pharmacies. Nonetheless, we were able to describe the distribution of community pharmacies at the municipality level, identifying obvious discrepancies. Additionally, each pharmacy can have four dependent pharmaceutical stations, that can be installed in places where there is no pharmacy or a pharmaceutical station within 2 km. However, pharmaceutical stations can only dispense medications and are not allowed to provide pharmaceutical services, so their contribution to public health improvement is limited.

CONCLUSION

The distribution of primary care premises is not uniform in Portugal, with a lower concentration of pharmacies in rural municipalities. These municipalities with a lower concentration of pharmacies were associated with lower levels of education. Community pharmacies and pharmacy-based services can help to improve health outcomes in vulnerable populations, so it is essential to guarantee geographical dispersion and adequate access to pharmacies in the most isolated and rural regions. The implementation of legislation and specific measures, as is already the case in Portugal, plays a key role in ensuring this dispersion. Nonetheless, our findings indicate that there is potential for enhancement.

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ANNEXES

Distribution of population per pharmacist and per physician across the healthcare administration regions

Resident Population per pharmacist

	N	Mean	SD	Minimum	Maximum
Norte	85	1,062	450	270	3,224
Centro	78	852	279	182	1,560
Lisboa e Vale do Tejo	52	936	508	239	3,502
Alentejo	47	1,243	496	518	2,430
Algarve	16	1,256	433	615	2,252
Total	278	1,021	450	182	3,502

ANOVA F=8.079, df=4; p<0.001

Resident Population per physician

	N	Mean	SD	Minimum	Maximum
Norte	85	448	246	46	1,145
Centro	78	517	350	29	2,050
Lisboa e Vale do Tejo	52	500	295	57	1,573
Alentejo	47	667	356	110	1,704
Algarve	16	485	368	96	1,570
Total	278	516	319	29	2,050

ANOVA F=3.806, df=4; p=0.005

Distribution of area per pharmacist and per physician across the healthcare administration regions

Area (sq km) per pharmacist

	N	Mean	SD	Minimum	Maximum
Norte	85	26.5	40.6	0.1	244.1
Centro	78	27.0	36.8	0.6	236.1
Lisboa e Vale do Tejo	52	11.3	17.4	0.0	74.4
Alentejo	47	104.3	83.6	12.8	331.7
Algarve	16	43.4	73.1	1.8	287.5
Total	278	37.9	57.8	0.0	331.7

ANOVA F=27.413, df=4; p<0.001

Area (sq km) per physician

	N	Mean	SD	Minimum	Maximum
Norte	85	12.2	16.8	0.0	81.4
Centro	78	20.2	35.0	0.1	198.2
Lisboa e Vale do Tejo	52	7.8	15.3	0.0	80.0
Alentejo	47	60.0	52.7	2.6	258.6
Algarve	16	16.8	25.7	0.3	79.0
Total	278	22.0	35.8	0.0	258.6

ANOVA F=22.196, df=4; p<0.001

Distribution of population per pharmacy and per healthcare center across the healthcare administration regions

Resident Population per pharmacy					
	N	Mean	SD	Minimum	Maximum
Norte	85	3.569	1.042	1.183	5.975
Centro	78	2.870	847	1.320	5.186
Lisboa e Vale do Tejo	52	3.610	1.173	1.219	6.996
Alentejo	47	2.466	851	1.075	4.733
Algarve	16	3.782	1.094	2.015	5.624
Total	278	3.206	1.087	1.075	6.996
ANOVA F=15.178, df=4; p<0.001					
Resident Population per health care center					
	N	Mean	SD	Minimum	Maximum
Norte	85	25.296	22.708	2.738	136.715
Centro	78	18.312	16.691	2.657	80.978
Lisboa e Vale do Tejo	52	36.273	26.942	3.518	107.079
Alentejo	47	9.813	9.840	1.440	53.591
Algarve	16	29.217	23.350	2.523	72.348
Total	278	22.998	22.038	1.440	136.715
ANOVA F=11.999. df=4; p<0.001					

Distribution of area per pharmacy and per healthcare center across the healthcare administration regions

Area (sq km) per pharmacy					
	N	Mean	SD	Minimum	Maximum
Norte	85	61.0	70.0	0.4	380.3
Centro	78	75.3	77.1	6.5	354.1
Lisboa e Vale do Tejo	52	30.6	33.2	0.4	186.0
Alentejo	47	185.7	129.5	48.4	646.4
Algarve	16	92.7	139.7	11.9	575.0
Total	278	82.2	98.3	0.4	646.4
ANOVA F=23.526, df=4; p<0.001					
Area (sq km) per health care center					
	N	Mean	SD	Minimum	Maximum
Norte	85	222.5	205.0	5.2	1173.6
Centro	78	293.2	248.3	53.2	1438.2
Lisboa e Vale do Tejo	52	211.2	218.9	5.9	1115.7
Alentejo	47	572.6	388.2	145.2	1720.6
Algarve	16	312.3	225.0	61.3	764.0
Total	278	304.6	287.1	5.2	1720.6
ANOVA F=16.355, df=4; p<0.001					

Correlations between population and area per pharmacist and population and area per physician with sociodemographic variables at municipality level

	Population/pharmacist		Population/ physician		Zou's interval
	p-value	R [95 %CI]	p-value	R [95 %CI]	
Population density	<0.001	-0.237 [-0.345:-0.123]	<0.001	-0.287 [-0.392:-0.175]	-0.077:0.177
% pop >65 years	0.103	-0.098 [-0.020:0.213]	<0.001	0.372 [0.267:0.470]	-
% pop w/ higher education	<0.001	-0.386 [-0.482:-0.281]	<0.001	-0.600 [-0.670:-0.519]	0.105:0.325
Per capita purchasing power	<0.001	-0.333 [-0.433:-0.224]	<0.001	-0.485 [-0.570:-0.389]	0.035:0.270
% Literacy	<0.001	-0.320 [-0.422:-0.210]	<0.001	-0.518 [-0.599:-0.426]	0.082:0.315
% Unemployment	0.137	0.089 [-0.029:0.205]	0.609	-0.031 [-0.148:0.087]	-
Correlation between Population/pharmacist and Population/ physician = 0.362 [0.255:0.460]					
	Area/pharmacist		Area/physician		Zou's interval
	p-value	R [95 %CI]	p-value	R [95 %CI]	
Population density	<0.001	-0.219 [-0.328:-0.104]	<0.001	-0.207 [-0.317:-0.092]	-0.083:0.059
% pop >65 years	<0.001	0.474 [0.377:0.560]	<0.001	0.504 [0.411:0.587]	-0.094:0.033
% pop w/ higher education	<0.001	-0.383 [-0.479:-0.278]	0.012	-0.426 [-0.518:-0.325]	-0.023:0.110
Per capita purchasing power	<0.001	-0.304 [-0.407:-0.194]	0.211	-0.321 [-0.423:0.212]	-
% Literacy	<0.001	-0.692 [-0.749:-0.626]	<0.001	-0.679 [-0.737:-0.610]	-0.065:0.038
% Unemployment	0.912	0.007 [-0.111:0.124]	0.899	0.008 [-0.110:0.125]	-

Correlation between Area/pharmacist and Area/physician = 0.811 [0.767:0.848]
* Pearson's correlation.
CI: confidence interval

Correlations between population and area per pharmacy and population and area per HCC with sociodemographic variables at municipality level

	Population/pharmacy		Population/ HCC		Zou's interval
	p-value	R [95 %CI]	p-value	R [95 %CI]	
Population density	<0.001	0.234 [0.119:0.342]	<0.001	0.406 [0.303:0.500]	-0.274:-0.070
% pop >65 years	<0.001	-0.598 [-0.669:-0.517]	<0.001	-0.607 [-0.677:-0.528]	-0.074:0.092
% pop w/ higher education	<0.001	0.328 [0.223:0.433]	<0.001	0.564 [0.478:0.639]	-0.333:-0.141
Per capita purchasing power	<0.001	0.332 [0.235:0.433]	<0.001	0.363 [0.257:0.461]	-0.133:0.070
% Literacy	<0.001	0.575 [0.491:0.649]	<0.001	0.649 [0.575:0.712]	-0.157:0.007
% Unemployment	0.067	0.110 [-0.008:0.225]	0.053	0.116 [-0.002:0.231]	-
Correlation between Population/pharmacy and Population/ HCC = 0.568 [0.483:0.643]					
	Area/pharmacy		Area/HCC		Zou's interval
	p-value	R [95 %CI]	p-value	R [95 %CI]	
Population density	<0.001	-0.266 [-0.372:-0.153]	<0.001	-0.291 [-0.395:-0.180]	-0.078:0.128
% pop >65 years	<0.001	0.565 [0.479:0.640]	<0.001	0.293 [0.182:0.397]	0.177:0.369
% pop w/ higher education	<0.001	-0.398 [-0.493:-0.294]	0.012	-0.151 [-0.264:-0.034]	-0.349:-0.145
Per capita purchasing power	<0.001	-0.322 [-0.424:-0.212]	0.211	-0.075 [-0.191:0.043]	-
% Literacy	<0.001	-0.738 [-0.788:-0.680]	<0.001	-0.495 [-0.579:-0.401]	-0.329:-0.163
% Unemployment	0.335	-0.058 [-0.175:0.060]	0.179	-0.081 [-0.197:0.037]	-

Correlation between Area/pharmacy and Area/HCC = 0.577 [0.493:0.651]
*Pearson's correlation.
HCC: healthcare center; CI: confidence interval