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Socio-spatial modelling of social services for older adults in Portugal: implications for Social Work practice in an aging world

P. Álvarez-Pérez[a]*; Fernando Relinque-Medina[b] and M.J. Pena[c]

[a]Department of Political Science and Public Policy, Iscte-University Institute of Lisbon, Lisbon, Portugal, pablo.alvarez@iscte-iul.pt; [b]Department of Social Work and Social Services, Pablo de Olavide University, Seville, Spain; [c]Department of Political Science and Public Policy, Iscte-University Institute of Lisbon, Lisbon, Portugal

Socio-spatial modelling of social services for older adults in Portugal: implications for Social Work practice in an aging world

Urban development and population aging challenge social service accessibility for older adults. This study investigates the allocation of social services for older adults in Portugal using socio-spatial modelling. The focus is on addressing the mismatch between service locations and the needs of older adults. Geospatial and Multiple Linear Regression Models were employed, integrating data from the Portuguese Social Charter and the National Institute of Statistics of Portugal to identify key variables affecting service adequacy across municipalities. High demand and service saturation were predicted in Lisbon, Porto, and Faro, while significant gaps were found in rural areas like Alentejo and inland regions such as Castelo Branco and Guarda. Lower service utilization in economically weaker areas suggests the need for financial support strategies. The study highlights the importance of targeted regional planning to improve resource allocation and service provision for older adults.

Keywords: socio-spatial modeling; geospatial analysis; social services; predictive modeling; older adults; Portugal

Introduction

The equitable distribution of social services is a central tenet of spatial justice, yet significant spatial mismatches between community needs and service provision persist. This study is grounded in the theoretical framework of spatial justice, service accessibility, and territorial cohesion, which collectively shape how equitable opportunities and resources are distributed across regions (Madanipour, Shucksmith, and Brooks 2021; Jones, Goodwin-Hawkins, and Woods 2020). There is strong evidence that Geographic Information Systems (QGIS) are effective methodologies for analyzing these mismatches (Choi, Lee, and Basrak 2021; Gutting, Gerhold, and Rößler 2021). By enabling detailed mapping, QGIS reveals disparities in access to health and social services, particularly for vulnerable populations such as older adults (Choi, Lee,

and Basrak 2021; Naranjo 2024). Our research builds on this foundation by employing advanced QGIS techniques to analyze these dynamics within the Portuguese context, offering a nuanced understanding of the challenges and opportunities for improving social work practice in an aging world.

Methodological approaches to analyzing spatial mismatch have been significantly enhanced by QGIS. The strength of these methods lies in their ability to move beyond simple mapping to incorporate advanced techniques. For instance, the use of population-weighted accessibility indices allows for a more accurate assessment of social amenity provision in urban areas (Gutting, Gerhold, and Rößler 2021), while integration with machine learning provides a powerful approach for optimizing the layout of community facilities (Fu and Li 2025). Mixed-methods QGIS, which combines quantitative data with qualitative lived experiences, has also emerged as a robust technique to uncover service gaps in rural and marginalized settings (Savige et al. 2024). However, a key weakness identified in systematic reviews is that QGIS methodologies remain underutilized within the field of social work, despite their proven potential to map health disparities and inform targeted interventions (Sualp, Yalim, and Gammonley 2024). Furthermore, many analyses focus on a single service type, which can be a limitation, as holistic, multi-service assessments are consistently more effective in addressing the complex needs of older adults (Arakelyan et al. 2023; Hayes et al. 2025).

Despite the growing sophistication of geospatial tools, specific research gaps remain. The literature indicates a clear underutilization of QGIS applications within social work to address grand challenges like closing the health gap, suggesting a need for broader adoption (Sualp, Yalim, and Gammonley 2024). Secondly, many studies focus on the provision of a single service, whereas evidence shows holistic and

multidisciplinary assessments lead to better health outcomes, greater independence, and higher cost-effectiveness (Ho et al. 2023; Virulhakul et al. 2025). This highlights a gap in research that uses QGIS to analyze the entire social service network holistically rather than in siloes. Finally, while predictive models are increasingly used, many could be improved by integrating more comprehensive data, such as multidimensional health indicators and environmental factors, to enhance their accuracy and practical value (Deardorff et al. 2023; Ferris, Glicksman, and Kleban 2016). This study addresses these gaps by applying a holistic, network-wide predictive model within the Portuguese social service context.

Application and limitations of Multiple Linear Regression Models in Social Sciences and decision-making

While GIS is essential for visualizing spatial patterns and identifying *where* service gaps exist, understanding the drivers *behind* these patterns requires a robust statistical methodology. In this study, Multiple Linear Regression (MLR) serves as the predictive component that complements the geospatial analysis. The MLR model integrates demographic and socioeconomic variables—some of which are spatially derived through GIS—to identify the key factors that predict social service utilization. This combined geospatial and statistical approach allows us to move beyond simply mapping disparities to forecasting future needs and understanding the underlying causes of spatial mismatch. The following section, therefore, details the application and limitations of MLR as the predictive tool within our socio-spatial framework.

The Multiple Linear Regression Model is a widely used method for strategic decision-making, as it helps identify predictive variables associated with a dependent variable. It has been extensively applied in social sciences, such as studying behavioral changes in minors (Dawson et al. 2012; Gasevic et al. 2022), understanding complicated grief after

family loss (Goetter et al. 2019), and predicting mental health variables during the COVID-19 pandemic (Malakoutikhah et al. 2022). Additionally, it has been employed to explore attitudes toward individuals with serious illnesses (Melkote and Goswami 2000), factors influencing older adults' health knowledge (Lee et al. 2017), end-of-life care (Han 2016), and barriers to socio-health service use among older immigrants (Soskolne et al. 2006). In the field of social services, the model has been used to investigate the emotional well-being and mental health of professionals (Gur et al. 2022; Riebschleger 2005), examine service access based on ethnic group membership (Wells et al. 2009), and evaluate job satisfaction in gerontological work (Simons and An 2015).

The Multiple Linear Regression Model is also a robust statistical tool for analyzing data from the Instituto Nacional de Estatística (INE) and the Portuguese Social Charter. It helps identify key factors influencing social indicators across regions and provides a practical way to understand the relationships between regional demographics, social services, and other critical variables. This approach is justified by several considerations. First, it helps identify significant factors that greatly influence changes in social indicators, acting as predictive variables (Ren, 2004). Second, it addresses the complexity of social interactions by considering multiple variables simultaneously, which is particularly useful when studying how regional traits, demographics, and social services interact (Ruan, 2024). Third, it provides valuable insights for strategic decision-making at local and national levels, offering a quantitative understanding of the factors impacting social services, welfare, and their outcomes (Krishna et al., 2023). Finally, it is well-suited for large datasets, such as those from

INE and the Portuguese Social Charter, enabling a comprehensive analysis of interrelated factors (Giesser et al., 2021).

Despite its strengths, the Multiple Linear Regression Model has limitations that must be acknowledged. One key assumption is linearity, which posits a straight-line relationship between independent and dependent variables. However, real-world relationships are often more complex and nonlinear (Sun et al., 2023). Another assumption is the independence of observations, which may not hold in social sciences due to interconnected variables that can skew results. The model also assumes homoscedasticity, meaning the residuals should have consistent variance across independent variables. When this assumption is violated (heteroscedasticity), the accuracy of parameter estimates can be affected (Uchenna & Chijindu, 2024). Additionally, while the model can identify correlations, it cannot establish causation, as hidden factors may influence observed patterns.

Researchers and decision-makers must interpret the results of the Multiple Linear Regression Model carefully, considering its limitations and the broader social and demographic context. Alternative modeling approaches may be necessary to address its shortcomings, and findings should be used judiciously to inform policy and practice. By understanding both its potential and limitations, the model remains a valuable tool for analyzing complex social dynamics and guiding strategic decisions.

Theoretical Framework and Case Study Background

Recent years have seen a clear and growing trend in the application of geospatial tools to analyze and improve service accessibility for older adults (Fogg et al. 2025; Choi, Lee, and Basrak 2021; Noh 2024). This trend is marked by diverse applications, from mapping emergency services (Fogg et al. 2025) to evaluating transportation equity (Noh

2024), and is supported by methodological advancements such as user-centered participatory QGIS design (Aslanoğlu et al. 2024). These tools are critical for understanding and addressing spatial justice, which examines the fair distribution of resources and services (Madanipour, Shucksmith, and Brooks 2021). The interaction between spatial mismatch—where people live far from essential services—and service accessibility determines spatial justice outcomes (Wang, Chen, and Xu 2024; Aksztejn 2020).

However, a key research gap is the underutilization of these powerful tools within social work (Sualp, Yalim, and Gammonley 2024). Another significant limitation in existing research is the tendency to analyze services individually. This is problematic, as holistic assessments that evaluate medical, psychosocial, and functional needs together are consistently shown to be more effective and cost-efficient than single-service analyses (Arakelyan et al. 2023; Ho et al. 2023). Portugal provides a compelling case for this analysis. With known challenges in providing equitable accessibility to services of general interest across its territory (Marques et al. 2019), it is an ideal context for applying a holistic, predictive QGIS model to inform more effective and just social planning.

Spatial Justice

Spatial justice constitutes a fundamental concept for addressing social inequalities from a territorial perspective. Beyond the mere physical distribution of infrastructures, this approach entails guaranteeing effective access, use, and enjoyment of services and resources, while integrating factors such as socioeconomic status, age, mobility, and geographic location. The absence of territorial equity tends to reinforce

existing vulnerabilities, hinder processes of social cohesion, and generate cumulative disadvantages that disproportionately affect groups in situations of greater fragility.

The manifestations of spatial injustice are evident at different levels. First, unequal access to essential services is a critical factor, since in rural or peripheral regions, the distance from and scarcity of resources such as healthcare, transportation, or community activities restrict opportunities for development and deepen social exclusion (Vielmo Moura, 2025). Added to this is territorial stigmatization and urban fragmentation, phenomena that constrain inhabitants' capacity to fully exercise their right to the city and contribute to the reproduction of processes of social segregation (Ziccardi Contigiani, 2019). Likewise, public policies and urban planning that disregard the principle of spatial justice perpetuate the unequal distribution of resources and the invisibility of specific needs, particularly in informal settlements and rural areas (Cardona & Rubio, 2020).

From a theoretical standpoint, spatial justice is closely connected to broader debates on distributive justice, which emphasize equity in the allocation of social goods and services. Theories on the equitable distribution of services highlight the importance of fairness, efficiency, and inclusivity in planning, ensuring that resources reach the populations with the greatest needs (Feitosa et al., 2021). Similarly, the notion of equitable aging extends these principles to demographic change, stressing that older adults should have access to health, social care, and community resources regardless of their geographic location or socioeconomic condition (Perone et al., 2025). Integrating these perspectives into spatial planning strengthens the argument that territorial equity is not only a technical matter of infrastructure provision but also an ethical imperative for ensuring social justice across generations.

In light of these limitations, it is essential to advance strategies that promote greater territorial equity. Resource redistribution should constitute a central priority, directing investments toward underserved areas and tailoring the supply of services to the real needs of the population, especially older adults and vulnerable groups (Nieto-Masot et al., 2019). Similarly, the participation of local actors in decision-making processes becomes an indispensable requirement to ensure that policies respond to the diversity of identities and ways of inhabiting the territory. Finally, inter-municipal cooperation and the design of integral and intersectional public policies emerge as necessary conditions to address territorial equity from a multidimensional perspective (Farinós i Dasí & Gomis Fons, 2017).

This comprehensive approach makes it possible to orient social and urban planning toward more inclusive and sustainable models, in which territory ceases to operate as a factor of exclusion and becomes a central element of integration and social cohesion.

Benefits of spatial modeling applied to social services for older adults

The rapid demographic aging in Portugal has accentuated territorial inequalities in the distribution of social services. While national programs, such as the Portuguese Social Charter, provide an overview of the resources available for older adults, they often fail to capture the spatial gaps that persist between municipalities with high demand and those with underdeveloped infrastructures (Sá Marques et al., 2020). Spatial modeling enables the detection of these disparities, providing an evidence-based foundation for planning interventions where they are most needed. Without such approaches, policies risk reinforcing imbalances by channeling resources

disproportionately toward urban areas already well served, leaving rural and inland regions further disadvantaged (Batista et al., 2025; Sulis & Proietti, 2024).

Beyond identifying service gaps, spatial modeling contributes to a more detailed understanding of inequities within specific subpopulations of older adults. Individuals with lower income, greater dependency, or reduced mobility often face compounded barriers to accessing formal care, even when services exist within their municipality. Geospatial analysis allows the integration of sociodemographic variables—such as income distribution, dependency indices, and health indicators—with the geographic availability of services, thereby revealing mismatches between supply and effective accessibility (Choi et al., 2021; Guida et al., 2022). This methodological perspective strengthens the capacity to address disparities not only between regions but also among the most vulnerable groups within the older population.

Spatial modeling is also essential for anticipating future service needs. Predictive approaches, when combined with demographic projections, make it possible to estimate where saturation of residential care, home support services, or day centers will become critical in the coming decades (Batista et al., 2025). In Portugal, where some municipalities already exhibit occupancy rates above 90%, these tools are invaluable for forecasting pressure points and designing preventive strategies (Zhu, 2022). Such foresight is particularly relevant given the dual challenge of a shrinking workforce and increasing longevity, which together are expected to intensify demands on both formal and informal care networks.

Portuguese Social Charter

The "Social Charter" of Portugal, also known as the "*Carta Social Portuguesa*" or "*Rede de Serviços e Equipamentos Sociais*" (Network of Social Services and Facilities), is a tool that establishes an integrated network of resources and social services available in the

country (Carvalho et al., 2023). These social resources aim to ensure the well-being and protection of citizens, particularly those facing situations of vulnerability and need (https://www.cartasocial.pt/inicio)

It is divided into three intervention areas: Childhood and Youth, Adult Population, and Family and Community. Within the Adult Population area, resources are allocated to various groups, including Older Adults, Adults with Disabilities, Individuals with Mental Illness, and Homeless Individuals.

This article specifically analyzes the social resources outlined in the Social Charter for Older Adults, categorized into five types of responses or resources, including the Community Center, which provides recreational activities and support services for older adults, promoting their social participation and well-being, the Day Care Center, which offers daytime care and activities for older adults or individuals with disabilities, enabling them to remain active and receive assistance while their caregivers work or rest, the Night Care Center, designed to provide accommodation and nighttime care for older adults who need assistance but prefer to continue living in their homes during the day, the Residential Structure for Older Adults, including Senior Homes and Residences, which are establishments that provide accommodation and care for older adults or individuals with special needs requiring constant attention, and the Home Care Service for Older Adults, a social service aimed at helping and supporting older adults in carrying out daily activities in their homes, with the primary goal of enabling them to continue living independently in their familiar environment and community while receiving the necessary care without having to move to a residential institution.

In this context, spatial modeling emerges as an essential complement to maximize the potential of the Social Charter. Combining the available information with

geospatial analysis tools makes it possible to identify territorial inequalities, gaps in service coverage, and the specific needs of older population across different regions. Moreover, by integrating sociodemographic variables and aging projections with the geographic location of resources, spatial modeling enables the anticipation of pressure on certain services and the guidance of more equitable and sustainable public policies (Batista et al., 2025; Choi et al., 2021) . In this way, the Social Charter, when combined with spatial modeling, ceases to be merely a data repository and becomes a strategic tool for territorial and social planning.

The Case of Portugal

This study adopts a case study approach focused on the national context of Portugal to explore the spatial accessibility and adequacy of social services for older adults. Portugal represents a particularly pertinent scenario due to the combination of rapid demographic aging, marked regional disparities in economic development, and the uneven distribution of social care services. These conditions make the country an ideal laboratory for analyzing how sociodemographic, economic, and territorial factors intersect and influence installed capacity, saturation levels, and future demand for care (Batista et al., 2025).

A first key aspect is the territorial inequality in service coverage. In regions such as Aveiro, for example, access to home support services shows strong contrasts between municipalities, creating significant gaps for older adults with functional limitations. Spatial analysis demonstrates that optimizing the location of services at a supramunicipal scale can significantly improve both equity and efficiency, reducing travel distances as well as territorial inequalities.

Similarly, vulnerability factors associated with centralization and economic constraints have contributed to distancing services and human resources from aging populations, particularly in rural and inland areas. In these territories, the adequacy of services is even more problematic, making it essential to strengthen the proximity and diversification of resources, especially regarding primary care, rehabilitation, and long-term care (Leão, 2021) . Improving these conditions is crucial not only to respond to current needs but also to anticipate demands stemming from the accelerated aging of the population.

Finally, the use of disaggregated data and predictive models provides the Portuguese case with a robust methodological framework for analysis. The combination of official information with spatial modeling tools makes it possible to identify intraregional dynamics, link patterns of supply and demand with specific socioeconomic conditions and anticipate future scenarios of service saturation or deficit. This approach endows the Portuguese case with international reference value, as it offers solid empirical evidence for social planning and strategic decision-making in societies facing similar socio-spatial challenges.

This study aims to address the identified gaps by pursuing the following research goals:

1. To apply QGIS methodologies, which are currently underutilized in social work (Sualp, Yalim, and Gammonley 2024), to conduct a holistic, network-level analysis of the spatial mismatch of social services for older adults in Portugal.
2. To develop a predictive model that integrates multidimensional factors to forecast future social service needs, helping to overcome the limitations of single-factor models (Santoni et al. 2017).
3. To provide actionable, data-driven insights for policymakers and planners to advance equitable service provision, in line with the principles

of spatial justice and territorial cohesion (Madanipour, Shucksmith, and Brooks 2021).

Materials and methods

In this study, a comprehensive analysis of older adults' resources and services was conducted, employing a combined geospatial and statistical approach.
To enhance clarity, Graph 1 presents a visual summary of the methodological steps followed in this study, from data collection to model projection.

Graph 1 here

Database construction: dependent and independent variables

First, a database was created using data on resources for the elderly collected from the Portuguese Social Charter (*Carta Social de Portugal*), disaggregated at the municipality (*concelho*) level. The social services available for the elderly in the Social Charter are: home support, residential center, day center, night center, and conviviality center (or community center). The variables obtained for each service are the capacity of each resource (number of available places), the number of free places, and the number of users.

Once the database was configured with the Social Charter data, variables from the National Institute of Statistics of Portugal (INE) were included. A filtering process was carried out on the available variables. Thus, out of a total of 25 areas in which all the available INE indicators are distributed, the areas with a direct relationship with the elderly were selected. These are: 1) Construction and Housing; 2) Population; 3) Health; 4) Social Security; 5) Territory; 6) Living Conditions and Citizenship

From these areas, all variables with disaggregation by municipality (NUTS-

2013) were selected, and whose data were updated at least biennially, with the objective of having recent data and ensuring that the intended model can be updated periodically. In total, the following 19 variables were selected:

Table 1 here

Based on the available data, several second-order variables were calculated, which will serve as the dependent variables for the model. This are: 1) Total users of elderly resources; 2) Total service saturation; and 3) Total capacity per population >65

Analytical procedures: Georeferenced Interval Analysis; Bivariate Correlation Analysis; Predictive Model Development; Regression Analysis and Feasibility Testing

Using QGIS, we conducted a georeferenced interval analysis. This step was pivotal in assessing the saturation levels of each type of older adults service, offering valuable insights into the spatial distribution of resources across the country.

A second-level analysis involved a bivariate correlation analysis, utilizing the Pearson correlation coefficient to understand relationships between dependent and independent variables. Variables demonstrating significant correlations ($p < 0.01$) were identified for subsequent analysis.

Our modeling approach incorporated a predictive model based on linear regression. Independent variables exhibiting significant correlations underwent regression analysis, contributing to the establishment of a multiple linear regression model ($Y=a+bx$), where: Y is the dependent variable; A is the constant; B is the coefficient; and X is the independent variable data.

The Pearson correlation coefficient (R) was calculated, followed by R-squared and adjusted R-squared to gauge the model's predictive power. An analysis of variance

(ANOVA) was performed to confirm the feasibility of constructing the linear regression model ($p < 0.05$). Further, constant (a) and coefficients (b) were computed for each independent variable, with significance assessed through Student's t-test ($p < 0.05$).

Finally, we tested the constructed model using data related to the population aged 50-65. This testing phase aimed to provide insights into dependent variables with sufficient lead time, ultimately facilitating strategic decision-making processes.

Results

Territorial distribution of resources for older adults individuals

The typology of resources outlined in the social charter for older adults individuals includes community centers, day centers, night centers, residential structures for older adults (senior homes and residences), and home support services.

This information is categorized by districts and municipalities, providing details on the number of facilities for each typology, the offered and occupied capacity, and the number of users currently occupying these spaces as of the consultation date.

The following table presents, disaggregated by districts, the overall facilities for older adults, the number of offered and occupied spaces, the ratio of offered to occupied spaces (in %), and the ratio of offered spaces per the population of individuals aged 65 and older, based on data collected by the INE.

Table 2 here

Among the collected results, it can be observed that night centers are the facilities with the highest occupancy rate, reaching 99.44%. However, this resource is significantly scarce, as it is unavailable in 11 out of the 18 districts, and it reaches saturation or oversaturation (equal to or exceeding 100%) in 5 districts.

The next resource with a higher occupancy rate is residential care, achieving an occupancy percentage of 91.64%. This resource accommodates the highest number of users (95,457 individuals). Special attention is warranted for the districts of Évora, Braganza, and Faro, which surpass a 95% average occupancy, with 96.33%, 95.92%, and 95.95.23 percentage points, respectively. The remaining resources exhibit an average occupancy rate ranging from 53.08% for day centers to 67.36% for home support services (HSS).

However, one of the most striking aspects in the preceding table is the considerable dispersion of data concerning the number of spaces per thousand inhabitants aged 65 and older. For instance, in the case of HSS, values range from 9.75 spaces per thousand inhabitants aged 65 and older in Faro to 155.25 in the Lisbon district, highlighting a significant inequality in available resources across different geographical areas. This disparity is also pronounced in residential care, where Faro once again marks the lowest rate of spaces per inhabitant, totaling 11.20 residence spaces per thousand inhabitants aged 65 and older, in contrast to the 123.04 recorded in the Lisbon district.

Graph 2 illustrates the spatial relationship between the saturation of older adults services and personal income levels, revealing an inverse pattern between economic prosperity and service availability.

Still, if we compare the geographical distribution of resources for older adults and the distribution of income levels (graph 1), we can see a clear inverse relationship, as shown in the following map. Thus, in the northern area, where municipalities with a high saturation of resources for the older adults are concentrated, it coincides with a relatively low personal income rate, just the opposite of what happens in the southern area, in the regions of Algarve and Alentejo, where saturation is medium-low, while

these municipalities have a medium-high personal income rate. Thus, a tendency towards an inverse relationship between the personal income rate and the saturation of resources for older adults can be confirmed.

Graph 2 here

Regression model for predicting resource saturation level for older adults.

Once the descriptive statistical analysis of the territorial reality of capacity and utilization of resources for older adults has been conducted, we proceed to design a regression model. This model aims to identify predictor variables for the level of resource usage. Subsequently, using the obtained data, we can calculate the trend of resource usage in the coming decades to forecast resource saturation. This facilitates the strategic decision-making process to prevent the collapse of resources for older adults, considering the context of population aging and the progressive urban concentration of the Portuguese population (Tan et al. 2020; Petropoulos et al. 2022; Sarker 2021).

The initial step involves conducting a hypothesis test to determine whether sociodemographic variables indeed correlate with the capacity and usage of social resources. To this end, a Pearson correlational analysis has been performed on the 19 sociodemographic independent variables extracted from the INE, disaggregated by *concelhos*, and three dependent variables related to the capacity and usage of older adults resources: total capacity per population aged 65 and older, total users, and overall resource saturation level.

Table 3 here

According to Table 3, for the dependent variable "Total users of older adults resources," we observe more significant correlations than for the other dependent variables. The variables with the most significant correlations are number of old-age pensioners and old-age pensions (thousands of €), with a significance of 0.906, pre-

hospital occurrences due to diabetes (0.905), beneficiaries of social inclusion benefits from social security (0.884), beneficiaries of social insertion income from social security (0.844), per capita purchasing power (0.671), gross income per capita (0.607), population density (0.596), and mortgage credit granted to individuals per capita (0.540).

Considering the data provided by the correlational analysis in the hypothesis test, it is observed that the correlations for the dependent variable "total users of older adults resources" are notably more significant than for the other two dependent variables. Therefore, this variable is adopted as the dependent variable, and independent variables with higher correlation indices are selected, specifically those with a correlation value above 0.5. Subsequently, a multiple linear regression analysis is performed to measure the model's predictability. This analysis yields a high Pearson's R-squared coefficient (0.924), indicating that 84.7% of the data can predict the number of users, which is sufficiently high. The ANOVA test provides a value minor than 0.05 (0.00) confirming the possibility of constructing a linear regression model with these variables.

More concretely, the ANOVA value of 0.00 confirms the feasibility for the construction of the regression model with the 9 predictor variables for the dependent variable relating to the total number of users. The model, composed of these independent variables, yields the values observed in the following table. However, it is noted that the significance of the Student's "t" for several of the calculated coefficients exceeds the value of 0.05, indicating that they are not statistically significant.

Therefore, those variables with a Student's "t" significance greater than 0.05 are discarded from the model, leaving it reduced to 4 independent variables: average value of old-age pensions (Sig. = 0,015), population density (Sig. = 0,000), average value of

income tax settled per capita (Sig. = 0,008), mortgage credit granted to individuals (Sig. = 0,02), and one dependent variable, which is the total number of users of older adults resources. The model is retested, the model exhibits a very high Pearson's coefficient (0.915), indicating that the independent variables have high predictability concerning the dependent variable (total number of users of older adults resources). The R-squared value shows that 83.8% of the data can predict the total number of users. The adjusted R-squared value also maintains a high percentage (83.6%), providing sufficient robustness and statistical solidity to the model.

On the other hand, the analysis of variance (ANOVA) again yields a significance value of 0.000, verifying the feasibility of constructing the model. Thus, upon analyzing the linear regression model, the constant is obtained with a "t" significance level that remains low for the 4 independent variables: 0,008 for average value of old-age pensions, 0,000 for population density, 0,001 for average value of income tax settled per capita, and 0,012 for mortgage credit granted to individuals variable. Upon obtaining the standardized coefficients, we apply the calculation of multiple linear regression using the four independent variables. If we compare the total users calculated from the predictor variables with the total users extracted from the Social Charter data, we observe a strong correlation, obtaining very close mean values, as shown in the following table. Similarly, the correlation between both samples is high, reaching a correlation value of 0.915.

Table 4 here

Once the viability and validity of the model have been defined and demonstrated, an annual trend analysis of the model is conducted using a second multiple regression analysis for each municipality. This analysis yields a standardized coefficient (Beta) greater than 1, indicating an upward trend in the number of users of

resources for older adults in 82.73% of the municipalities, and only decreases in the remaining 27.27% of municipalities. The municipalities where the estimated average rate of user increase is highest are shown in the following table (10).

Table 5 here

Lastly, the population estimate for 10 and 20 years is calculated using the annual regression slope, employing the formula for the equation of a straight line:

$$P(t) = P0 + \beta * t$$

Where: $P(t)$ is the population at time (t); $P0$ is the initial population (at time t=0); β is the annual regression slope; and t is the time in years

The following table shows the evolution of the saturation of resources for older adults. Currently, only 4 municipalities are above 90% occupancy; however, the predictive model calculates that in 20 years, 23 municipalities will reach this percentage.

Table 6 here

To better understand the spatial dynamics over time, graph 3 compares the current saturation levels with projections at 10 and 20-year intervals.

According to graph 3, which presents a comparative analysis of the current situation and projected saturation levels of resources for older adults at 10 and 20-year intervals, it is evident that the northwestern region of Portugal will experience the most significant strain on its older adults care resource system. The data indicates a progression from 4 municipalities currently exhibiting a saturation rate exceeding 90%, to 6 municipalities reaching this threshold within a decade, and ultimately 14 municipalities attaining this level of saturation within two decades.

Graph 3 here

Summary of Key Findings

The results reveal notable disparities in the distribution and utilization of older adult care resources across Portuguese municipalities. Night care centers, though scarce, show near-total occupancy, while residential structures also face high demand, particularly in districts like Évora, Faro, and Bragança. Significant regional inequalities emerge, with Lisbon exhibiting high service availability, in contrast to under-resourced areas such as Faro and Alentejo. The predictive regression model, validated with strong statistical indicators, identifies four key socioeconomic variables as significant predictors of service usage. Projections indicate a growing trend of saturation in many municipalities over the next 10 to 20 years, highlighting the urgent need for strategic, data-informed planning to ensure equitable access to care for the aging population.

Discussion

This study was guided by three primary goals: to apply a holistic QGIS methodology to analyze the spatial mismatch of services for older adults in Portugal; to develop a predictive model using multidimensional factors to forecast future needs; and to provide actionable insights for advancing equitable service provision. Our results successfully addressed these goals. The geospatial analysis revealed significant regional disparities in service availability and saturation, confirming that a spatial mismatch exists. The multiple linear regression model identified key socioeconomic variables that predict service utilization, providing a validated tool for forecasting. Collectively, these findings offer a data-driven evidence base for policymakers to address the challenges of an aging population in line with the principles of spatial justice (Madanipour, Shucksmith, and Brooks 2021).

The socio-spatial modeling approach adopted in this study proved effective for

identifying underserved areas and optimizing resource allocation, an outcome consistent with the strengths of QGIS methodologies demonstrated in other contexts (Choi, Lee, and Basrak 2021; Gutting, Gerhold, and Rößler 2021). However, the process was not without its challenges. The integration of large, disparate datasets from the Portuguese Social Charter and the National Institute of Statistics presented significant methodological complexities, a common issue in community needs assessments that rely on administrative data (Kazda et al. 2009). Despite these difficulties, the chosen methodology provided a robust framework for analysis, confirming the value of applying advanced spatial techniques to social service planning.

Our findings both confirm and complement existing research. The identification of significant service disparities between urban and rural regions in Portugal aligns with previous work highlighting accessibility challenges within the nation's polycentric urban system (Marques et al. 2019). This is evidenced by high-demand pressures in districts like Évora, Faro, and Bragança, and the stark contrast in service availability between Lisbon and under-resourced areas like Alentejo. Furthermore, our result showing that socioeconomic factors are key drivers of service utilization and spatial mismatch complements a broader body of international literature. Studies in China, for example, have similarly found that socioeconomic status is a primary determinant of spatial inequalities in access to public services (Wang, Chen, and Xu 2024), reinforcing the conclusion that these patterns are not unique to Portugal but represent a widespread challenge in social planning.

This study has several limitations that should be acknowledged. First, our analysis relied on quantitative public databases. While this provided a comprehensive national overview, it did not capture the nuanced, lived experiences of older adults, which could be better explored through a mixed-methods approach that integrates

qualitative data (Savige et al. 2024). Second, while our multiple linear regression model was statistically robust, its predictive power may be more limited than that of newer, more complex machine learning models, which have shown moderate but promising accuracy in identifying high-utilization individuals (Sourkatti et al. 2024). Finally, the cross-sectional nature of the data provides a static snapshot and does not capture the longitudinal dynamics of service needs over time.

Based on the study's findings and limitations, we propose several directions for future research. A clear priority should be the adoption of mixed-methods QGIS approaches to triangulate quantitative spatial data with qualitative insights into the barriers and facilitators of service access (Savige et al. 2024). Such qualitative work would be particularly valuable for designing targeted policies to close the service difference in rural areas like Alentejo and the inland regions of Central Portugal (ex. Castelo Branco and Guarda). Further studies could also explore the application of advanced machine learning models to potentially improve the accuracy of predicting service needs (Fu and Li 2025; Sourkatti et al. 2024). Finally, given that QGIS remains underutilized in social work, future research should focus on developing user-centered, participatory geospatial tools that can help bridge the gap between academic research and practical, on-the-ground social work planning (Sualp, Yalim, and Gammonley 2024; Aslanoğlu et al. 2024).

Global implications derived from the Portuguese data and analysis for Social Work practice

Social Work is committed to promote the well-being of people, groups and communities, while addressing inequalities affecting vulnerable populations. Data show a sociodemographic reality and the impacts that it has on resources distribution, making these interventions as necessary. However, preventing dependency associated with

aging, although is not shown through data, can reduce services requiring and can improve quality of life. A focus should be put into psico-physical and social health for previous generations (40ies and 50ies) to arrive at retirement and beyond with the highest autonomy possible.

On the other hand, Social Work practice must include a *macro-practice* associated with a political implication (not partisan) related to our core value of social justice. As data shown, regional disparities in resource distribution demands from social workers to focus on the application of our theoretical, practical and instrumental competences, specifically community assessments and social diagnosis that can lead to advocate for equitable resource allocation. This must involve working collaboratively with policymakers to ensure rural and underserved regions receive adequate support. Social workers expertise in understanding community dynamics ensures that policies are inclusive and responsive to diverse needs, creating a bridge between individuals and systems. In this way, a bottom-up approach to policymaking is proposed in which social workers are considered as experts to target the real needs of populations.

Even though our practice is always contextualized and adapted to the specificity of each case (individual or collective), we recognise that predictive tools can help social workers for several reasons: from a proper diagnosis and, for instance, identifying at-risk populations, to planning interventions. QGIS could be useful for practitioners to decide and prioritize interventions. This approach can lead to a more effective practices and adaptation to the technological advancements.

Economical barriers impacting services access are a reality for many elder people, and it is not just found in the Portuguese case (Mai and Li 2022; Osborn et al., 2017; Turley et al., 2017). Traditionally, Social Work has had a role dealing with this issue. Nowadays, new alternatives should be explored to solve these barriers, going

beyond subsidies (contributory or not) and retirement pensions. Financial support programs, advocating for policy change, working on income assistance programs or subsidized services can be alternatives. Also, promoting the participation of elder people should be the basis for these measures, since elder participation in policymaking and decision making improve needs resolution (Leach & Jankowski, 2024; Bunn et al. 2018), although this participation requires training and flexible services to be effective (Casado et al., 2020).

Conclusion

This study successfully demonstrated the utility of socio-spatial modelling in revealing significant and inequitable disparities in social service provision for older adults in Portugal. By developing a predictive model that identifies key drivers of service demand, our findings provide evidence base for proactive and targeted policymaking. This research contributes to the fields of social work and public health by offering a replicable methodology to translate complex spatial and demographic data into more equitable and effective social planning. Ultimately, these insights can aid policymakers in advancing the goals of spatial justice and territorial cohesion for aging populations.

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Declaration of Generative AI and AI-assisted technologies in the writing process

As English is not the authors' native language, a large language model (Gemini 2.5 Pro,

accessed October 2025) was utilized to assist in the final preparation of the manuscript. The use of this tool was focused on enhancing linguistic quality by improving grammar, spelling, and sentence structure for overall readability. The authors directed all substantive revisions based on peer-reviewed feedback and take full responsibility for the scientific content and final version of this publication.

Declaration of interest statement

The authors declare no conflicts of interest. The study was conducted independently, with no influence from the institutions or organizations associated with the provision of data or resources. All findings and interpretations are the sole responsibility of the authors.

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Appendices

Appendices

Graph 1. *Methodological Process*

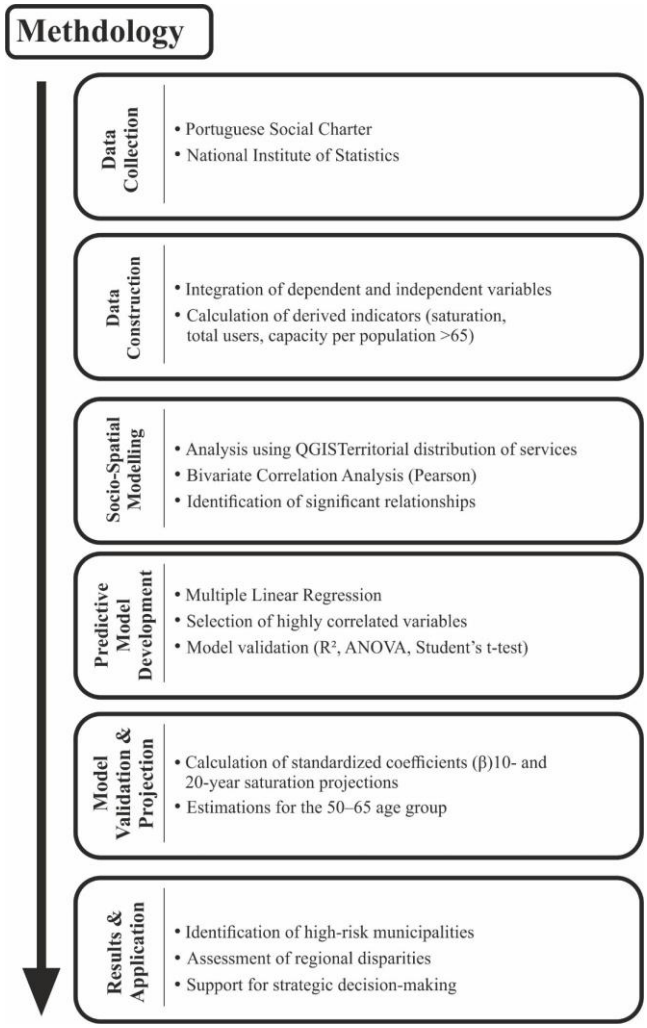


Table 1: *Variables of study*

Category	*Indicators*
Housing	Mortgage credit granted to individuals per inhabitant (€/hab.)
Population	Population >65
	Aging Index
	Population density
	Active population renewal index
Health	Pre-hospital occurrence of diabetes
	Longevity Index 2022
Social Security	Number of older adults pensioners 2021
	Older adults pensions (thousands of €) 2021
	Average pension value 2021
	Average value of older adults pensions
	Beneficiaries of Social Inclusion Benefit from social security (No.) *(Monthly financial benefit aimed at improving the social protection of people with disabilities/impairments)*
	Beneficiaries of Social Insertion Income from social security (No.) *(This benefit aims to provide individuals and their families with support adapted to their personal situation, contributing to the satisfaction of their essential needs and promoting their progressive labour, social and community integration)*
Territory	Potentiality index *(The relationship between the two halves of the female population that are theoretically more fertile)*
Living Conditions	Gross income per inhabitant (€) 2020
	Per capita Purchasing Power 2019
	Income tax on individuals settled per inhabitant (€)
	Gini coefficient 2020 (%)
Citizenship	Older Adults Dependency Index 2022 *(The ratio between the elderly population and the working-age population, usually defined as the quotient between the number of people aged 65 or older and the number of people aged between 15 and 64.)*

Source: own elaboration from INE

Table 3. *Pearson Correlational Analysis between the Capacity and Use of Resources for the Older Adults and the Sociodemographic Profile*

Variable	*Total capacity per population >65*	*Total users of older adults resources*	*Total saturation*
Population >65	-.119*	-.005	.162**
Aging index	-.094	***-.241*****	-.253**
Dependency index of older adults 2022	-.094	***-.241*****	-.267**
Longevity index 2022	-.003	***-.181*****	-.374**
Number of old-age pensioners 2021	.617**	***.906*****	.113
Old-age pensions (thousands €) 2021	.682**	***.906*****	.094
Per capita purchasing power 2019	.455**	***.671*****	.124*
Gross income per capita (€) 2020	.365**	***.607*****	.036
Average pension value 2021	.251**	***.475*****	.110
Gini coefficient 2020 (%)	.241**	***.442*****	.183**
Pre-hospital occurrences due to diabetes	.656**	***.905*****	.101
Potentiality index	.093	.093	-.019
Population density	.389**	***.596*****	.100
Index of renewal of population in working age	.178**	***.341*****	.220**
Beneficiaries of social insertion income from social security (number)	.623**	***.844*****	.080
Average value of pensions in velhice	.251**	***.485*****	.106
Average value of old-age pensions Income tax on individuals settled per capita (€)	.434**	***.689*****	.062

Mortgage credit granted to individuals per capita (€/hab.)	.352**	***.540***	.176**
Beneficiaries of social security benefits for inclusion (number)	.589**	***.884***	.154*

****. The correlation is significant at the 0.01 level (two-tailed).**
***. The correlation is significant at the 0.05 level (two-tailed).**

Table 4. *Statistics of related samples*

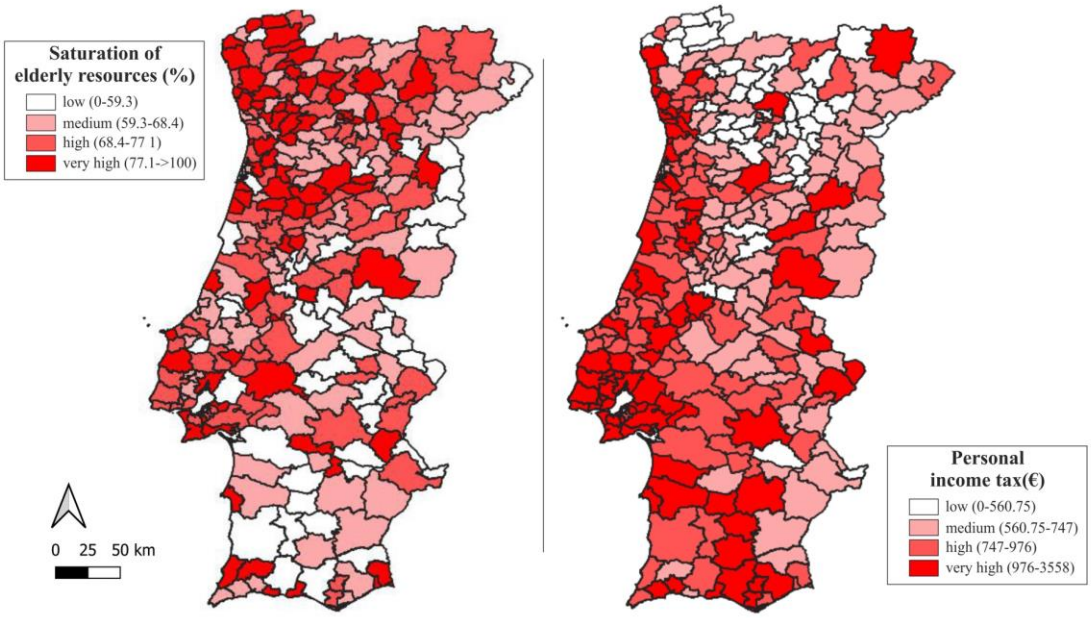
Variables	*Mean*	*N*	*Standard Deviation*	*Standard Error of the Mean*
Total users	791.8481	270	1016.36968	61.85429
Predicted users	788.4514	270	924.25665	56.24847

Table 5. *Municipalities with Highest Annual Increase in Resource Users for Older Adults*

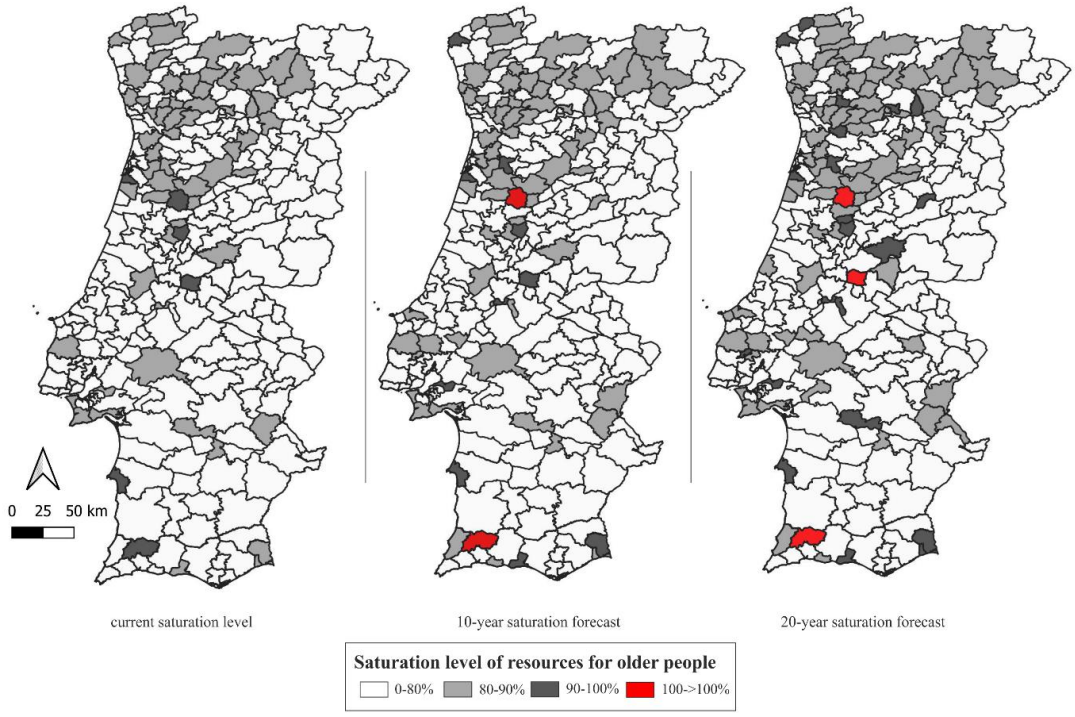
Municipality	*Old-age pension regression*	*Population density*	*Tax regression*	*Mortgage credit regression*	*Beta*
Santo Tirso	.986	-.988	0.987	-.839	*1.375*
Amarante	.983	-.989	0.975	-.823	*1.370*
Penacova	.985	-.998	0.99	-.765	*1.369*
Castelo Branco	.986	-.958	0.984	-.819	*1.368*
Coimbra	.993	-.905	0.983	-.808	*1.364*
Anadia	.986	-.955	0.997	-.766	*1.364*
Covilhã	.983	-.994	0.976	-.765	*1.364*
Figueira da Foz	.992	-.950	0.97	-.742	*1.362*
Espinho	.987	-.861	0.996	-.878	*1.361*
Guarda	.977	-.989	0.991	-.766	*1.360*
Lamego	.982	-.996	0.963	-.752	*1.360*
Fafe	.981	-.980	0.961	-.785	*1.360*
Seia	.984	-.997	0.964	-.713	*1.359*
São João da Madeira	.983	-.996	0.975	-.709	*1.359*
Barcelos	.988	-.962	0.982	-.700	*1.358*
Oliveira de Azeméis	.984	-.910	0.975	-.830	*1.358*
Marco de Canaveses	.981	-.949	0.96	-.818	*1.357*
Águeda	.983	-.933	0.981	-.784	*1.357*

Table 6. *Projected Resource Saturation for Older Adults: A 10 & 20-Year Outlook*

District	*Municipality*	*Total saturation*	*Total sat. 10y*	*Total sat. 20y*
Faro	Monchique	97.854	102.522	107.191
Viseu	Mortágua	97.222	101.365	105.508
Castelo Branco	Vila de Rei	94.896	97.780	100.664
Setúbal	Sines	93.586	96.728	99.871
Faro	Castro Marim	88.596	94.159	99.722
Santarém	Constância	79.856	89.205	98.553
Aveiro	São João da Madeira	87.059	92.386	97.714
Setúbal	Alcochete	88.000	92.812	97.625
Santarém	Vila Nova da Barquinha	86.161	91.879	97.597
Aveiro	Ílhavo	90.411	93.331	96.251
Coimbra	Lousã	90.257	92.419	94.581
Vila Real	Sabrosa	85.135	89.593	94.051
Viana do Castelo	Caminha	87.844	90.916	93.988
Faro	Albufeira	89.474	91.649	93.825
Coimbra	Vila Nova de Poiares	81.423	86.579	91.736
Vila Real	Santa Marta de Penaguião	82.474	87.080	91.687
Porto	Lousada	85.990	88.624	91.258
Guarda	Manteigas	74.534	82.731	90.928
Lisboa	Sobral de Monte Agraço	78.571	84.737	90.904
Viana do Castelo	Valença	82.687	86.537	90.388
Castelo Branco	Oleiros	84.777	87.563	90.349
Évora	Viana do Alentejo	87.402	88.769	90.137
Aveiro	Castelo de Paiva	85.273	87.665	90.057



Graph 2. Comparison of Older adults Resource Saturation and Personal Income Tax Distribution Across Portugal



Graph 3. Geographic Distribution of Predicted Resource Saturation for Older Adults

Table 2. Summary of Senior Facilities by District: Total Facilities. Offered and Occupied Places. Occupancy Rate. and Places per Senior Resident

	Home Care Service (HCS)					*Senior Home and Residence*				*Night Care Center*					*Day Care Center*					*Community Center*				
District	*Nº Facilities*	*Nº Offered*	*Nº Occupied*	*Occupancy rate*	*Places per 1.000 inhab>65*	*Nº Facilities*	*Nº Offered*	*Nº Occupied*	*Occupancy rate*	*Places per 1.000 inhab>65*	*Nº Facilities*	*Nº Offered*	*Nº Occupied*	*Occupancy rate*	*Places per 1.000 inhab>65*	*Nº Facilities*	*Nº Offered*	*Nº Occupied*	*Occupancy rate*	*Places per 1.000 inhab>65*	*Nº Facilities*	*Nº Offered*	*Nº Occupied*	*Occupancy rate*	*Places per 1.000 inhab>65*
Aveiro	173	6430	5337	83.0	46.6	173	6498	5431	83.6	47.1	0	0	0		0	143	4345	2908	66.9	31.5	18	490	291	59.4	0.1
Beja	58	3418	1664	48.7	36.2	68	3529	3260	92.4	37.4	0	0	0		0	49	1463	355	24.3	15.5	4	95	70	73.7	0.0
Braga	222	8597	5904	68.7	86.8	168	6751	6325	93.7	68.2	1	12	12	100	0.1	137	3393	2450	72.2	34.3	17	720	435	60.4	0.2
Bragança	90	3443	2424	70.4	35.8	102	3453	3312	95.9	35.9	0	0	0		0.0	74	1640	610	37.2	17.1	5	206	161	78.2	0.1
Castelo Branco	142	3940	2722	69.1	43.6	107	4525	4217	93.2	50.1	1	19	19	100	0.2	119	2939	1205	41.0	32.5	8	675	472	69.9	0.1
Coimbra	192	6851	4899	71.5	62.0	146	6176	5714	92.5	55.9	0	0	0		0	164	4970	2435	49.0	45.0	13	822	570	69.3	0.1
Évora	80	3125	1901	60.8	34.7	98	3375	3251	96.3	37.5	0	0	0		0	82	1889	761	40.3	21.0	26	1248	792	63.5	0.3
Faro	78	3076	1912	62.2	9.8	77	3478	3312	95.2	11.2	0	0	0		0	49	2097	783	37.3	6.6	10	648	479	73.9	1.9
Guarda	191	5622	3352	59.6	39.0	143	5626	5255	93.4	39.0	5	72	74	102.8	0.5	151	3022	1088	36.0	21.0	4	140	64	45.7	0.0
Leiria	138	6594	4797	72.8	109.0	164	6250	5873	94.0	103.3	0	0	0		0.0	122	3152	1567	49.7	52.1	28	674	321	47.6	0.5
Lisboa	343	20363	13003	63.9	155.3	399	16138	14256	88.3	123.0	3	37	35	94.6	0.3	239	10789	6255	58.0	82.3	66	4993	3602	72.1	0.5
Portalegr	69	2723	1159	42.6	23.9	84	3760	3495	93.0	33.0	0	0	0		0	61	1473	568	38.6	12.9	18	1357	768	56.6	0.2
Porto	286	12245	8681	70.9	75.5	227	8823	7839	88.9	54.4	0	0	0		0	202	7605	5239	68.9	46.9	83	3605	2267	62.9	0.5
Santarém	154	5804	3541	61.0	41.1	169	7009	6495	92.7	49.6	0	0	0		0	135	4308	2099	48.7	30.5	35	1688	1143	67.7	0.3
Setúbal	104	5260	3942	74.9	27.8	146	6091	5599	91.9	32.2	0	0	0		0	95	4641	2100	45.3	24.5	21	1183	877	74.1	0.1
Viana do Castelo	74	3212	2262	70.4	69.4	65	2618	2437	93.1	56.6	2	14	13	92.9	0.3	52	1299	888	68.4	28.1	15	430	210	48.8	0.3
Vila Real	109	4438	3217	72.5	39.2	91	3307	3144	95.1	29.2	1	6	6	100.0	0.1	46	1114	516	46.3	9.8	5	135	110	81.5	0.0
Viseu	181	7416	5099	68.8	32.0	156	6755	6242	92.4	29.1	1	18	18	100.0	0.1	107	2410	1371	56.9	10.4	4	75	66	88.0	0.0
TOTAL	2684	112557	75816	67.4	53.7	2583	104162	95457	91.6	49.5	14	178	177	99.4	0.1	2027	62549	33198	53.1	29.0	380	19184	12698	66.2	0.2