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Older adults frailty in Primary Health Care: a geoprocessing-based approach

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Abstract *This paper aimed to analyze the spatial distribution of older adults' frailty in primary health care, spatially identifying areas with a concentration of seniors, comparing the demand for care. This is an analytical study that employed spatial analysis with older adults who are frail or at risk of frailty enrolled in Primary Health Care, distributed in 32 census tracts. Concerning geolocation, we used Google Earth Pro software and "C7 GPS Data app", to elaborate the thematic and cadastral maps Qgis 2.16. In total, 43% of seniors were classified as at risk of frailty, of which 79.5% were female, with a mean age of 75 years. The organization of the services showed an unequal distribution of the facilities in the territory, and the three health care settings present or not in some tracts and the concentration of older adults where services were difficult to access. The spatial analysis pointed out the distribution and concentration areas of frailty, favoring the comparison of social vulnerability with the possible care of health services, supporting planning actions and management of the distribution of establishments or projects to visit those in need. Thus, geoinformation tools can strengthen access to health services and provide better living conditions for seniors.*

Key words *Spatial Analysis, Frail Older Adult, Primary Health Care*

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Introduction

Frailty is a multifactorial clinical syndrome, influenced by complex and dynamic biological, psychological, cognitive and social interactions[1,2], which can reduce the autonomy and independence of older adults, increasing risks for falls, hospitalization, infections, disabilities, institutionalization and death[3,4]. It comprises a state of vulnerability with more significant risks of exposures that lead to comorbidities and disabilities, and as a consequence, the loss of age-related human body reserve[5,6].

Frailty may be associated with the occurrence of noncommunicable chronic diseases and dependence for the performance of basic and instrumental activities of daily living (BADL and IADL), with impaired cognition, mood, mobility and communication, in isolation or association, and more pronounced among the longevity[7,8]. When present, the primary clinical manifestations are weight loss, exhaustion, slow gait and reduced muscular and aerobic strength that affect the functionality and performance of daily activities[3,9].

The topic of frailty has received worldwide attention, although there is no consensus concerning its definition, in order to understand the factors that determine its occurrence. It is the adoption of preventive measures that can minimize its installation and adverse outcomes, extending the life expectancy and reducing the impact on the quality of life of seniors[10].

Its identification is deficient in the Brazilian health system, and is a challenge for the current health care model, which must increase attention to older adults, minimizing the progression of frailty and reducing adverse events, maintaining the quality of life and assuring autonomy, social interaction and independence, which contribute to a life distant from incapacities.

This reality triggers changes and new challenges for health care services, mobilizing the Health Care Network (RAS) towards better clinical quality, good health outcomes and reduced costs through continuous and comprehensive care, coordinated by Primary Health Care (PHC)[11], and provided by a proactive and multidisciplinary team to identify frailty.

Interdisciplinary and multidimensional care for older adults that includes interactions between physical, psychological, environmental and socio-cultural factors as possible influencers of the frailty phenotype is essential. Thus, these aspects are fundamental in the search for mechanisms that broaden the understanding of this event, whose rates range from 10 to more than 20%, between developed and developing countries, such as Brazil, setting an adverse prognosis for dependence and complications in the ensuing years[4].

One of the mechanisms is to measure the spatial distribution in a given territory of different events, that is, the spatialization and analysis of this reality through georeferencing of occurrences and spatial phenomena, associated with the use of spatial distribution analysis models by geoprocessing found in Geographic Information Systems. The so-called health geography is based on the production of maps of different variables of interest to the characterization of vulnerabilities and potentialities, providing their support and evaluation, which is of great relevance for public health and health management, since it contributes to the identification, localization and monitoring of the population, monitoring diseases and assisting in the planning of health care[12,13].

Although the frailty phenotype has been investigated in national studies, it was not analyzed from a geographic perspective[14,15]. Therefore, it is relevant to use geoprocessing with a potential to help in the understanding of the spatial distribution of seniors and health care services, transforming the process of evaluation, planning and decision-making to the provision of health care for older adults.

This is innovative technology in the context of PHC, which can contribute to the comprehensive, community and territorialized care of the services that underpin the RAS in an intersectoral perspective, facilitating the management of the RAS by enabling greater visualization of available services, better allocation of resources and minimized or dissipated shortcomings, a vital technology to support public health and management.

Thus, it is justified to develop studies that incorporate new contributions regarding the spatial determinants of frailty with possibilities to put into practice the redirection of public policies aimed at caring for older adults who are frail and at risk of frailty, with a view to ensuring and maintaining their functionality.

Therefore, a multidimensional evaluation is necessary in order to understand frailty and its care needs, to improve and maintain the quality of life, which contributes to the recognition of biopsychosocial demands, values, beliefs, feelings, sociodemographic, functional and cognitive factors of seniors[16].

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For this purpose, the Functional Clinical Vulnerability Index-20 (IVCF-20) is an instrument developed in Brazil, based on other frailty screening instruments already cited in the literature, and which is feasible for the screening of frailty in PHC since it can indicate necessary points for interventions that can improve the autonomy and independence of older adults, preventing functional decline, institutionalization and death; it is also suitable for use in geriatric clinics, social interaction centers, urgent and emergency services and long-term care institutions[17].

This study aimed to analyze the spatial distribution of frailty of seniors in PHC, identifying the areas spatially with concentration (middle and high priority of older adults) and comparing the existing care demand with the distribution of the installed health services network.

Methods

This is an analytical study that employed spatial analysis of seniors who are frail and at risk of frailty, whose records were registered at the 12 PHC facilities (UBS) and health care services of the immediate geographic region of Pombal, Paraíba, Brazil, which covers an area of 892.98 km², with an approximate population of 32,110 inhabitants and a population density of 36.17 (inhabitants/km²)[18], developed from January to March 2017.

The study population consisted of older adults aged 65 years or over enrolled in the UBS, and the sample was 183 elderly individuals classified frail or at risk of frailty, after screening for frailty, based on the IVCF-20 proposed by Moraes et al.[17], which consists of 20 questions, distributed in eight realms: age; self-perception of health; activities of daily living (three instrumental and one basic); cognition; mood/behavior; mobility (reaching, grasping and gripping, aerobic/muscular capacity, gait and sphincteric continence); communication (sight and hearing); and presence of multiple comorbidities (polypathology, polypharmacy and/or recent hospitalization). The instrument has a total score of 40 points, classifying seniors as robust, with a score ranging from 0 to 6 points, at risk of frailty, with a score ranging from 7 to 14 points, and frail, with a score ≥ 15 points.

Inclusion criteria to detect frailty were seniors aged 65 years or over, enrolled at the UBS for at least six months, with no mobility impairment that hindered participation in the study, considering only one older adult per residence. Seniors not found at their residence after three visits, or hospitalized, bedridden and with a confirmed medical diagnosis of dementia because it hampered participation in the study in the face of memory decline that interferes with the cognitive performance of seniors were excluded.

After screening for frailty, coordinates with data from the older adults and health care services were manually scored in remote areas in the Google Earth Pro® program (GOOGLE, 2017) or *in loco* by the C7 GPS Dados application, which captures coordinates of positioning of points of interest, with information expressed in geographic coordinates, hexadecimal and Universal Transverse Mercator, saved in KML file format and converted in the program QGis 2.16 for shape, in the SIRGAS 2000 - UTM (Universal Transverse of Mercator) projection system. Both processes (both in office and *in loco*) were necessary due to some limitations of location of information in satellite images, because of the difficulty of identifying households to be registered in top view and low resolution.

The development of spatial analysis required the use of the number of inhabitants by census sector[18], a geographic unit used by the Brazilian Institute of Geography and Statistics (IBGE), which corresponds to the cadastral collection control for the demographic census. The urban core of the municipality of Pombal consists of 32 census tracts, subdivided into five districts. The data of the mesh of the census tracts, selections for statistical purposes, face base of sites, state and municipalities used in this paper can be obtained on the IBGE website in *Geociências Downloads*, and these are Brazilian official data on socioeconomic variables (age groups, schooling, income, existing infrastructure, among others), grouped by territorial unit of the census sector, used as spatial control of collection for the demographic census[18]. The census tracts consist of contiguous areas directly related to the political-administrative division, selected in axes of roads and by types of land use in portions of districts, as well as divided into urban and rural sectors.

The SIRGAS/2000 system was used to elaborate the maps in the software QGis 2.16 because it is the official system of Brazilian cartography today. The polygons of census tracts were associated with the alphanumeric tables containing data of the socioeconomic variables through a "join" process since the entries in the tables are individualized by census tract code and it favors indexing and spatial consultations. Then themat-

ic consultations were performed on the spatialization of information on frail and at risk of frailty seniors. Seven thematic maps were elaborated from the data collected in the field and compared with the IBGE socioeconomic data: percentage by total number of inhabitants and total number of older adults aged 65 years or over; percentage of older adults aged 65 years or over, percentage of frail older adults; percentage of frail older adults by age; percentage of older adults at risk of frailty, percentage of older adults at risk of frailty by age; percentage of frail older adults at risk of frailty, total and by age; and distribution of tracts with medium and high priority.

The study was approved by the Research Ethics Committee of the Federal University of Minas Gerais, observing all legal procedures, and respecting Resolution Nº466/12[19] of the National Health Council. Participants were informed about the objectives of the study and signed the Informed Consent Form, ensuring confidentiality of data and anonymity.

Results

In this work, the mapped universe represented the geospatial distribution where the contingent of the elderly population is located, especially considering the frail seniors and those at risk of frailty. There was a predominance of older adults at risk of frailty (132, 43.0%), females (105, 79.5%) and mean age was 75.51 years. Fifty-one seniors were classified as frail (16.6%) and robust (124, 40.4%).

The organization of the services that underpin the RAS showed an uneven distribution of the UBS in the territory. Thus, we can observe that this distribution is decentralized from the areas covered by the family health teams. Some census tracts were highlighted, where the three health care settings were distributed, and tracts without health care services, requiring the restructuring of these services in the perspective of complying with the principles and guidelines of the Unified Health System by the Municipal Health Secretariat and public authorities (Figure 1).

The high concentration of older adults aged 65 years or over predominated in six census tracts (Figure 1). These high concentration areas include only one secondary health care and two primary care services for 4,430 seniors, with evidence of 12 frail seniors and 23 seniors at risk of frailty.

Figures 2A/B and 2C/D represent a set of maps in the selected urban core that provides the rate of frail seniors and those at risk of frailty. Figure 2A shows two tracts with a high rate of frail seniors and three health care services. Figure 2B shows areas with a low percentage of seniors aged 65 or over.

In Figure 2C, when the distribution of older adults at risk of frailty is analyzed, we find two tracts with a high percentage of these older adults and only one health care service for a total of 102 seniors, of which nine are considered at risk of frailty.

Following analysis to obtain the age proportion, Figure 2D contains a tract without health care services that requires immediate attention, with a population of 37 older adults over 65 years of age, of which seven are at risk of frailty.

Figure 3 shows that seniors are geographically distributed across a large part of the central urban area of the municipality, but three census tracts are worth highlighting concerning the concentration of medium and high priority care areas because older adults are frail or at risk of frailty. The primary, secondary and tertiary care facilities are located together with the spatialization of seniors. The analysis of the location of the services compared to the neediest portions of the city warns of the need to review resources since three service facilities at all three levels are located in the vicinity of a medium-priority tract. However, in the areas of highest care priority, one of them has only one primary service facility, while another area has no service facilities in the vicinity. The high priority areas consist of 2 census tracts and a population of 16 older adults who are frail or at risk of frailty, emphasizing that no healthcare services are available in the north tract. Thus, it will be necessary to perform resource management to reconcile vulnerabilities and potentials.

Discussion

The maps obtained through the spatial analysis allowed a situational diagnosis of the spatial distribution of frailty in seniors in the city of Pombal-PB. Thus, we could observe that frailty among older adults by census tract is randomly distributed, identifying the census tracts with the highest concentration of cases, an essential fact for the allocation of conducts and actions aiming at the early diagnosis of frailty.

The characterization of the sample profile showed that the risk of frailty is more frequent

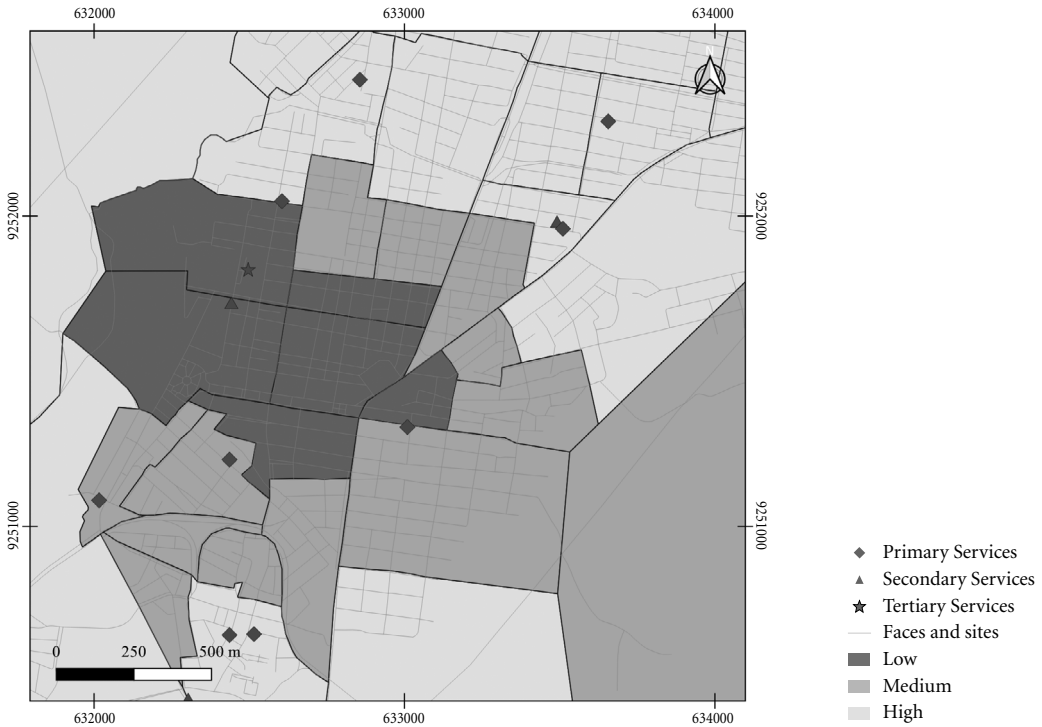

Figure 1. Distribution of areas with older adults aged 65 years or over by census tract and spatialization of health care services. Pombal-PB, 2017.

Source: IBGE Vector base SIRGAS 2000 UTM 24 S, Data collected by authors-2017.

in female seniors. Studies conducted in other Brazilian cities have also found similar data. One of the aspects discussed in the literature explains that this can result from intrinsic gender-based frailty, the lower concentration of lean mass and declining muscle strength when compared to men. Also, other issues are relevant, such as greater vulnerability to extrinsic factors such as sarcopenia[20,21].

The phenomenon of the feminization of old age is an inherent risk to the development of frailty, aggravated by the overload of diseases in advanced ages[3]. Another factor that may contribute to this predominance is the greater longevity compared to men, which increases the risk of incidence for chronic noncommunicable diseases, inherent in the physiological and functional modifications of human aging, and may cause limitations that make them at higher risk of adverse events[22].

International studies point to frailty in elderly Americans aged 65 years and over, with a higher concentration in females and rates of 10% to 25%, which hike to more than 40% in the age group over 80 years[9,22], requiring an exclusive look at the multidisciplinary team.

The planning of health actions must ensure access to services to meet this profile, and services consequently do not have information about the conditions of older adults. Access to services facilitates the retrieval of this information, establishing interventions that can enhance the autonomy and independence of seniors, in a RAS context, preventing functional decline, institutionalization and death.

Thus, practices that favor an active and healthy lifestyle, considering older adults' specificities and singularities, such as healthy eating, physical activity, immunization, prevention of hypertension, tobacco use, dyslipidemia and falls can be promoted from the perspective of preventing undesirable events such as fractures from falls, depression and functional dependence, which cause higher SUS costs[23].

Spatial analysis showed the census tracts with a high percentage of frail older adults and seniors

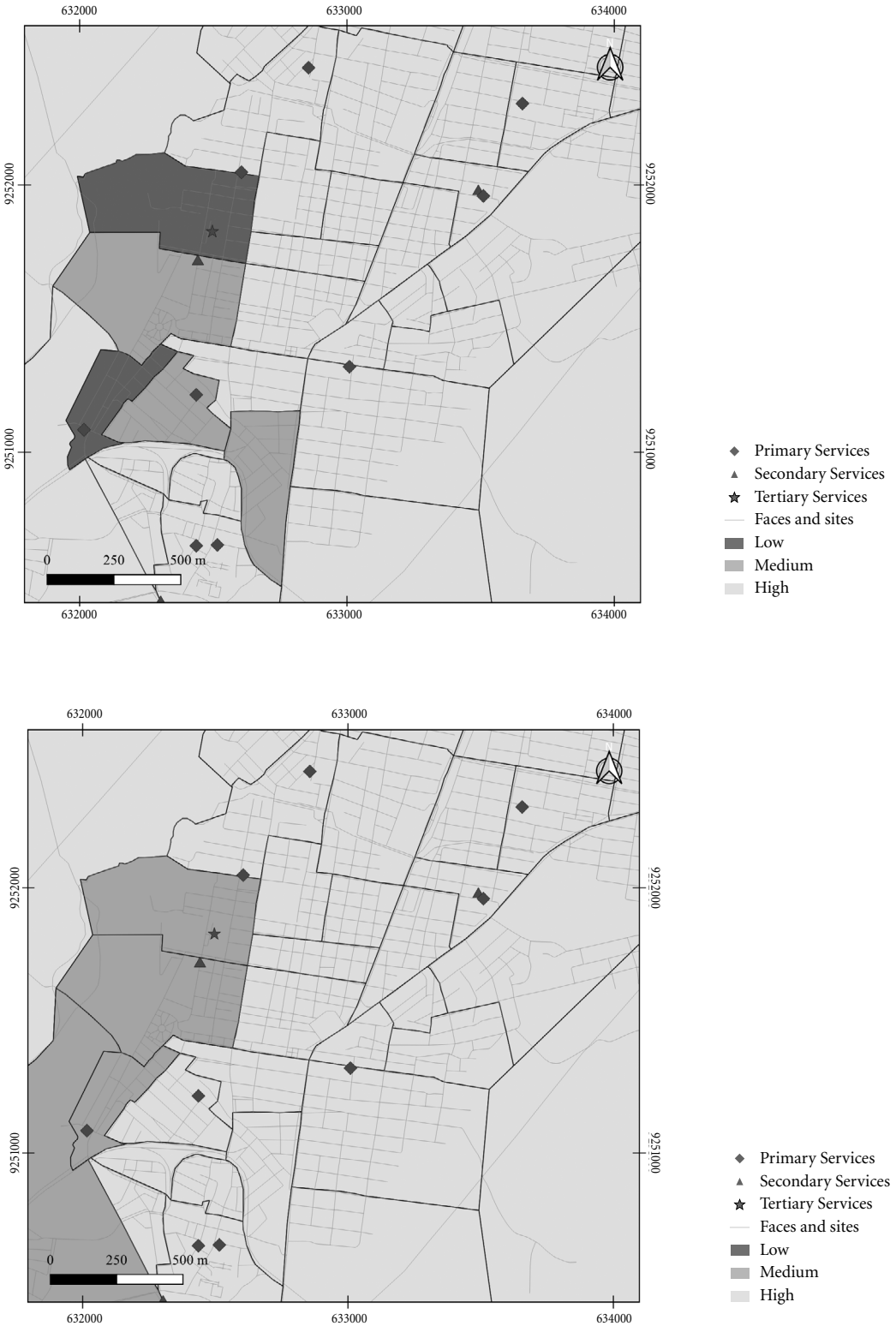

Figure 2A/B. Distribution of areas with frail older adults by census tract and age, spatialization of health care services. Pombal-PB, 2017.

Source: IBGE Vector base SIRGAS 2000 UTM 24 S, Data collected by authors-2017.

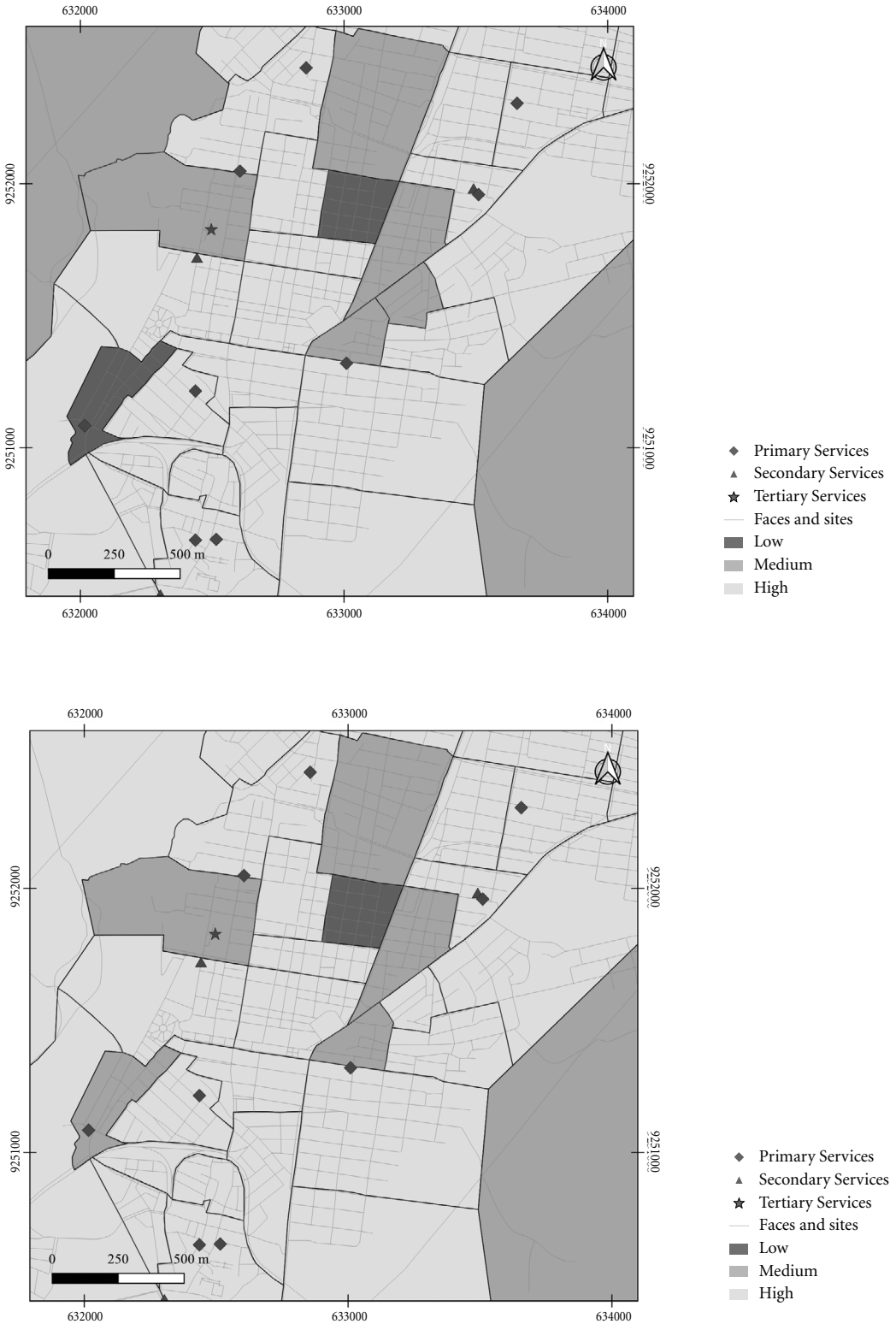

Figure 2C/D. Distribution of areas with older adults at risk of frailty by census tract and age, spatialization of health care services. Pombal-PB, 2017.

Source: IBGE Vector base SIRGAS 2000 UTM 24 S, Data collected by authors-2017.

Figure 3. Distribution of areas with concentration, medium and high priority of the elderly by census tract and spatialization of health care services. Pombal-PB, 2017.

Source: IBGE Vector base SIRGAS 2000 UTM 24 S, Data collected by authors-2017.

at risk of frailty, in which functional clinical vulnerability was distributed heterogeneously, defining them as priority action sectors. It will be necessary to establish a strategic resource management plan to reconcile existing vulnerabilities and potentials.

In order to facilitate this demand, the IVCF-20 is characterized as a functional clinical vulnerability screening tool that can be applied by trained high- and mid-level professionals, indicating interdisciplinary interventions to improve the autonomy and independence of seniors, planning PHC actions with definition of risk groups for differentiated care in the UBS[17], allowing the establishment of an individualized care plan to promote a better quality of life.

The use of this instrument can provide data that, if well used, contribute to better living conditions. It is an essential attribute for health promotion, prevention and management of frailty, which if previously diagnosed, makes regression easier. Under the SUS, whose main gateway to health care services is PHC, it can contribute to comprehensive senior care, recognizing their biopsychosocial demands.

The tracts with the highest percentage of frailty and at risk of frailty allowed an immediate view of the distribution of seniors, facilitating the understanding of the risk of collective areas or people clusters. They are classified as tracts with a more significant number of older adults[18], consisting of streets close to the hospital, school and commercial areas, as well as an urban *quilombola* community. This information supports and justifies health care with a focus on the prevention of functional clinical vulnerability since frailty and at risk of frailty rates are high.

Thus, spatial analysis from these rates is a valuable tool for risk stratification in the diverse senior population. Its previous detection and prevention can delay disability and premature death when interventions are applied early, thus reducing risks[22].

Spatialization of health care services facilitated the perception of its distribution in the municipality, and this distribution hardly meets the real

needs of older adults who are frail and at risk of frailty, since public transport services to the UBS and other services that underpin the municipal RAS are restricted, characterizing a region with poor planning of physical infrastructure, vast areas and micro areas distant from the UBS, which suggests the relocation of households or streets between closer UBS, with the perspective of ensuring greater coverage of care to older adults.

Care provided from the RAS of the municipality studied occurs with limited availability of specialists in geriatrics and gerontology, difficult access to other care settings due to restricted referral and counter-referral actions, hindering the continuity and integrality of care, and the available means for the resolution of the specificities of seniors.

This condition is also found in the metropolitan region of São Paulo, which reported the lack of health services and actions specific to elderly care, or incipient initiatives for comprehensive care of this segment, with inexistent lines of care or referral and counter-referral flow, which shows poor and unintegrated services, lack of easy access to the various complex care settings, and few investments in the training of the multidisciplinary team in elderly care[24].

This reflects on the continuity of care, coordinated by the PHC, which must identify the specificities of the attached population, promoting articulation with all the RAS, to address the geographic, organizational, cultural, financial or access-related needs[25], in order to expand and qualify humanized and comprehensive access, strengthening the link between health professionals and older adults, facilitating the operationalization of the RAS.

Despite the good PHC coverage rate (100%)[26], this setting demands actions for the health of seniors based on the community and integrated to the specifics of older adults, which encourage their proactivity, with specialized care articulated with the RAS to achieve equity, integrality and universality.

It is challenging to ensure to older adults the integrality and access to health care services, an exclusionary and unequal reality to the entire Brazilian population[27]. Thus, understanding the medium and high priority tracts enables planning care and contributes to the decision-making about the ideal location of health care services, more appropriate when based on local geographic, socioeconomic, cultural or political characteristics.

Ensuring accessibility involves management investment in infrastructure, which can provide long-term and high financial resources, with increased coverage of health care services, improved water supply network, sewage, housing and education, as well as the creation of areas for interaction and leisure, with the provision of quality transportation and safe public roads[28].

Another difficulty of the municipality refers to the architectural barriers regarding road access, since roads without maintenance or suitable conditions for the travel of pedestrians with limited mobility may represent potential risks for older adults' falls, favoring a slower and prolonged trip, with excessive sun exposure.

At this stage, the lack or turnover of professionals in the UBS and the infrastructure problems are a disruption of health care to seniors who are frail or at risk of frailty, who may suffer loss of autonomy and independence, becoming more vulnerable to trauma, infections or psychological changes, which translates into more significant need for health care.

In view of this situation, seniors who are frail or at risk of frailty need UBS with architecture and environments that ensure safe access and allow good mobility, in order to rehabilitate events that compromise their basic and instrumental activities of daily living, where municipal management is in charge of ensuring access and continuity of health care, regardless of the level of autonomy of older adults[29].

Thus, to assist actions that result in improved accessibility, spatial analysis facilitated the identification of unattended regions, allowing interventions to strengthen the RAS to implement referral and counter-referral, to enable services to act to change the frequency, distribution of intersectoral diseases and inequalities and to comply with the universality and integrality provided for in the SUS, which will result in healthy aging and promotion of quality of life[30].

Therefore, spatial analysis is a tool that assists in the control and prevention of health problems, triggering changes in lifestyle and adoption of healthy practices that increase independence, autonomy and life expectancy, especially increased access to healthcare services[20].

As a result, decentralized practices and interventions that consider the capacity and individuality of each older adult can be developed, among which are interactive groups for the elderly population, as a strategy that collaborates and promotes active and autonomous aging with inclusion and social participation.

Conclusion

Spatial analysis facilitated the identification of frailty distribution among the senior dwellers of the city of Pombal-PB, and the clear visualization of the areas with the highest concentration of older adults who are frail or at risk of frailty, and who consequently require more public and multidisciplinary team efforts for the planning, monitoring and evaluation of interventions that allow autonomy and independence of seniors, as well as actions that contribute to PHC coverage, improving access to health care services in the perspective of a resolutive RAS and considering the specificities of older adults.

Spatial analysis is an essential tool for strengthening actions to combat frailty and enable access to health care services, advising on decision-making and the implementation of public policies that contribute to better living and health conditions of seniors.

The study showed some limitations in the discussion because it was a spatial analysis with older adults, with little information from other studies or published literature. Regarding spatial analysis processes, health geography topics have been studied, but publications such as this pave the way to specific discussions of variables related to the health of older adults.

Collaborations

FFQ Freitas participated in the conception and design, literature review, data collection, contributed to the analysis and interpretation of data, writing the initial and final version of the manuscript. AB Rocha participated in the co-orientation of the project, contributed to the spatial analysis and interpretation of data, contributed to the analysis and critical review of the manuscript. ACM Moura participated in the co-orientation of the project, contributed to the spatial analysis and interpretation of data, contributed to the analysis and critical review of the manuscript. SM Soares was responsible for project orientation, data analysis and interpretation, critical review and approval of the final version of the manuscript.

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