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The characterization of population displacement for early diagnosis of osteoporosis: a study on the performance of X-ray and DXA exams in northern Brazil

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Abstract *— DXA is the gold standard for bone density measurement. Brazil is divided into 5 regions (North, South, Southeast, Midwest and Northeast). The northern region has some peculiarities (difficult outpatient access and imaging diagnosis, in addition to the low Human Development Index – HDI) that precludes the rapid diagnosis of diseases. Radiographic Densitometry is a technique that allows the measurement of bone density by means of radiographic images. The aim of this study is to characterize population displacement for DXA and X-ray examinations for osteoporosis diagnosis. To perform the study, quantitative information on the number of DXA and X-rays was extracted. With this, it was possible to design through the Tableau software execution of the algorithm, a model visualization. For the realization of the DXA, the displacement occurs in approximately 426 municipalities in northern Brazil. For radiographic examinations, the dislocation is summarized in 150 municipalities. It can be concluded that the ANS allowed observing the displacement of people between cities to perform the examinations. X-ray and DXA, aiming at the diagnosis of osteoporosis.*

Keywords *— **Social Network Analysis, DXA, X-ray, people movement.***

I. INTRODUCTION

Osteoporosis is a chronic disease affecting men and women, characterized by the gradual loss of bone mineral content. Although incurable, osteoporosis has good treatment options, prolonging the quality of life of its patients.

In the United States, Brixen, Abrahamsen and Kassem (2005) reported that hip fractures affect about 300,000,000 Americans, with a death rate of approximately 25%. It is notorious that the difficulty of specialists in early diagnosis of the disease has raised such statistical indices. According to Merino (2006), in Brazil it is estimated that about 75% of patients discover the disease after bone fracture, that is, already in the advanced stage of the disease.

The Brazilian territory is divided into 5 regions: Midwest, Northeast, North, Southeast and South. The northern region of Brazil has the largest territorial extension of the country, covering 42.27% of the national territory, and being formed by seven states: Acre (AC), Amapá (AP), Amazonas (AM), Pará (PA), Rondônia (RO), Roraima (RR), e Tocantins (TO). Although not a populous region (about 8% of the total population), it concentrates much of the low-income population, with 54% of children under 14 living in this region living in poverty. (IBGE, 2010).

Since bone density testing has been indicated for certain groups in general for people over 50; demand for these exams increases as population increases. The states of the northern region have shown an increase in this target population (figure 1 and figure 2), according to the extraction of quantitative data from the last two demographic censuses conducted by the Brazilian Institute of Statistical and Geographical – IBGE.

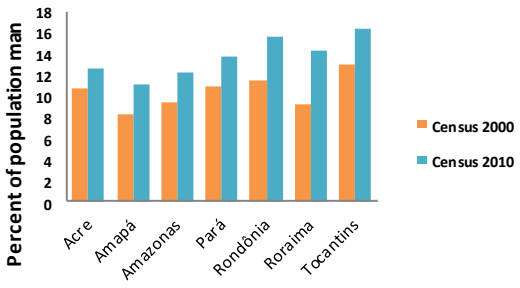

Fig 1: Percentage of man's population ≥ 50 years of age.

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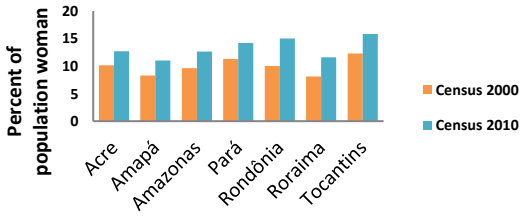

Fig 2: Percentage of woman's population ≥ 50 years of age.

In addition, the region has an unusual feature with other regions of Brazil, the fluvial transport of passengers between cities. Surrounded by rivers and with few paved roads, much of the population displacement is carried out by water (sea and/or river).

In 1994, the World Health Organization – WHO proposed the criteria for the diagnosis of osteoporosis using the values obtained by the T score. Conventional radiography is not sensitive to detect bone loss, but only after a significant reduction – around 30 to 50%, and is therefore not effective for early diagnosis of osteoporosis. Different techniques have been used to quantitatively analyze bone mass. Among these, we can mention: Dual-Energy X-ray Absorptiometry (DXA) and Radiographic Densitometry - DR. (Louzada, 1994; Macedo and Araujo, 1997; Meirelles, 1994)

1.1. Radiographic Densitometry – DR

Scientifically, the first use report of this technique was elaborated by Price (1901), to estimate the bone and dentin density using a copper-made densitometric reference. Already Louzada (1994) used a specific alloy aluminum ladder (material with bone-like x-ray absorption characteristics) in its bone density assessments. Oliveira and Gouveia (2018), proposed a polynomial selection algorithm to measure bone density by radiographic densitometry.

1.2. Social Network Analysis – SNA

Graph theory, including social network analysis, has been widely used in the fields of social science, computer science, biology, chemistry, public health and other fields of knowledge (Arora, 2019, Alamsyah, 2019, Jacomy et. al., 2014; Hongyi et. al., 2019; Saheb, 2019; Zhao, 2019).

Aragão et. al. (2018) used a graph network through social network analysis to characterize the displacement of the bovine population in the state of Pará – Brazil, in 2017. Already Oliveira et al. (2019) used the model to determine the population displacement of people in the northern region for mammography.

The objective of this study is to characterize population displacement for DXA and X-ray examinations for osteoporosis diagnosis.

II. MATERIALS AND METHODS

2.1 Study AREA

Northern Brazil extends over an area of approximately 3.853,575,6 km^2. According to IBGE region is estimated to have about 18.430.980 million, of which 17% of citizens are over 49 years old, distributed in about 450 municipalities. (IBGE, 2010)

2.2 DXA and X-ray Equipment Quantitative.

The study was conducted in the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins. Through the program of access to information of the Brazilian Ministry of Health, it was possible to obtain the information on the quantity of equipment (DXA and X-ray) by municipality and the operating situation of the device (in use or not). With the aid of spreadsheet data were grouped into: Source-Destination; Latitude; Longitude; Total appliances in use and municipality.

With the Tableau® software, the municipalities were included in the state map. Through the line filter it was possible to project the displacement of people to the nearest location of the equipment.

III. RESULTS AND DISCUSSION

Figure 3 and Figure 4 show the results of population displacement performed in the state of Acre-AC for imaging (DXA and X-ray). It is observed that the population displacement occurs in twenty-one municipalities for DXA (Figure 3). To perform the X-ray examination, person movement occurs in only five municipalities (Figure 4).

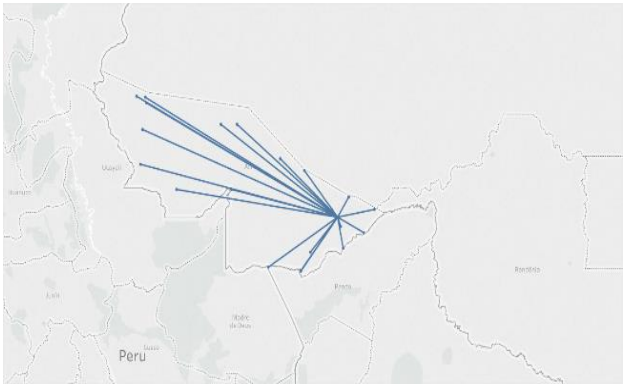

Fig. 3: Geographic map of population displacement for Dual Energy X-ray Absorptiometry - DXA examination in the state of Acre-AC.

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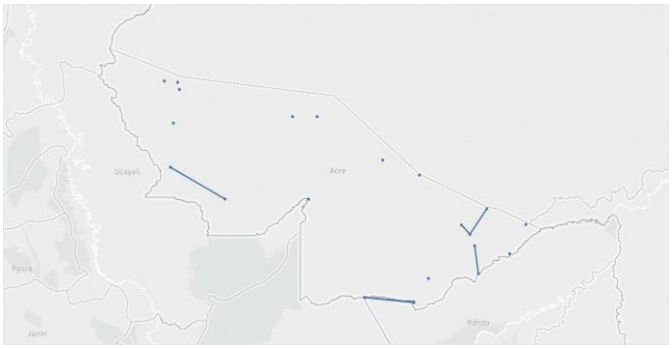

Fig. 4: Geographic map of population displacement for X-ray examination in the state of Acre-AC.

Figure 5 and Figure 6 show the results of population displacement performed in the state of Amazonas-AM to perform imaging exams (DXA and X-ray). It is observed that the displacement occurs in sixty municipalities for DXA (figure 5). Considering the X-rays exam, people' displacement occurs just in two municipalities (figure 6).

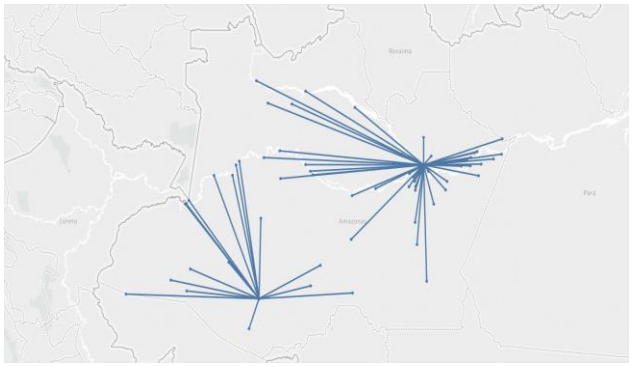

Fig. 5: Geographic map of population displacement for dual energy X-ray Absorptiometry – DXA examinations in the state of Amazonas-AM.

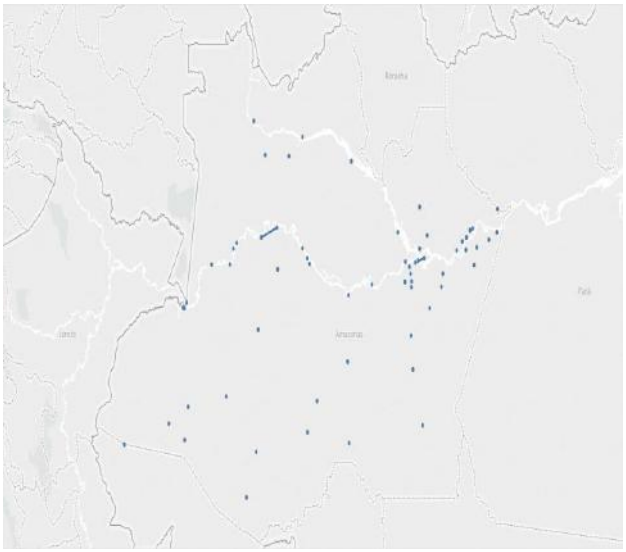

Fig. 6: Geographic map of population displacement for X-ray examination in the state of Amazonas-AM.

Figure 7 and Figure 8 show the results of population displacement performed in the state of Amapá-AP for imaging (DXA and X-ray). Population displacement occurs in fifteen municipalities for DXA (Figure 7). To perform the X-ray examination, the movement of people occurs in only nine municipalities (figure 8).

Fig. 7: Geographic displacement map for Dual Energy X-ray Absorptiometry – DXA examination in the state of Amapá-AP

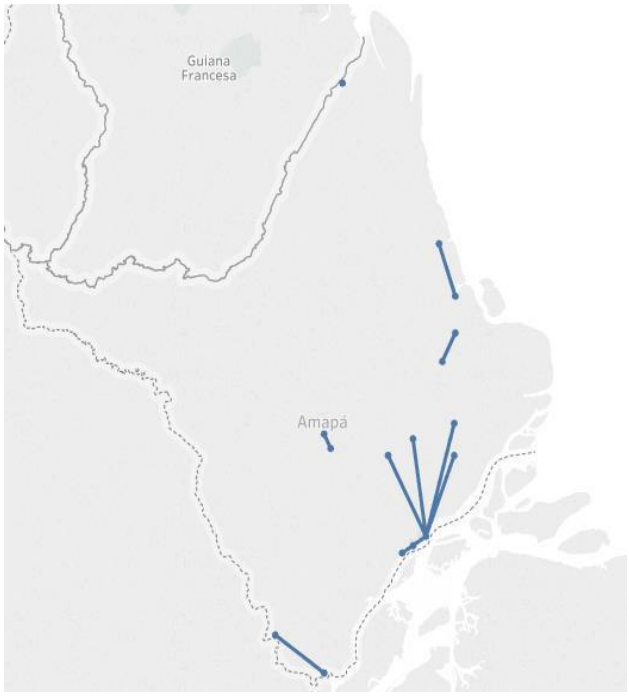

Fig. 8: Geographic map of population displacement for X-ray examination in the state of Amapá-AP

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Figure 9 and Figure 10 show the results of population displacement performed in the state of Roraima-RR for imaging (DXA and X-ray).Population displacement occurs in fourteen municipalities for DXA (Figure 9). For the X-ray examination, the movement of people occurs in only seven municipalities (Figure 10).

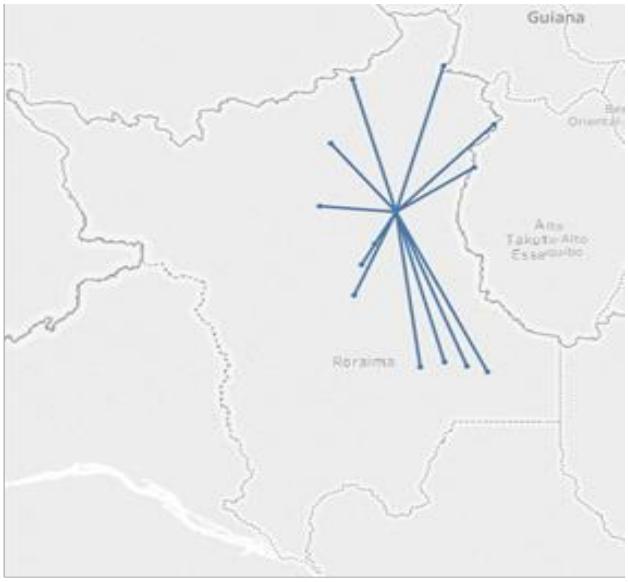

Fig. 9: Geographic map of population displacement for Dual Energy X-ray Absorptiometry – DXA examination in the state of Roraima-RR

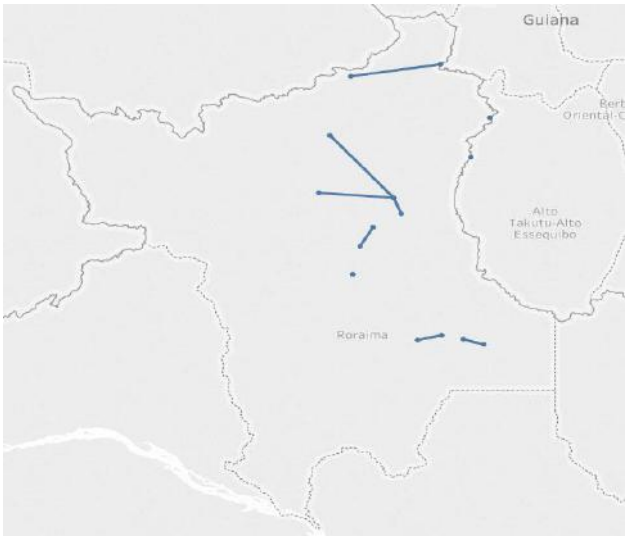

Fig. 10: Geographic map of population displacement for X-ray examination in the state of Roraima-RR.

Figure 11 and Figure 12 show the results of population displacement performed in the state of Pará-PA to perform imaging examinations (DXA and X-ray). Population displacement occurs in one hundred and seventy-three municipalities to perform DXA (Figure 11). To perform the X-ray examination, person movement occurs in only twenty-one municipalities (figure 12).

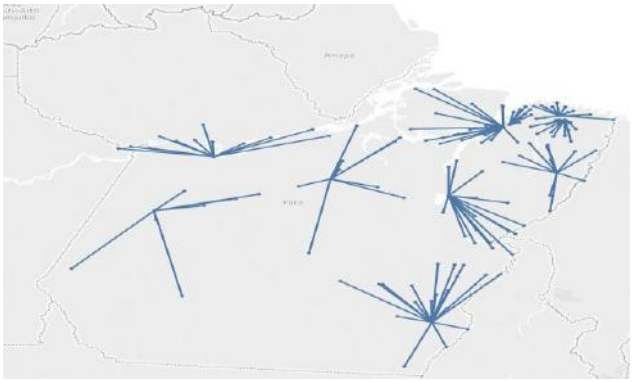

Fig. 11: Geographic map of population displacement for Dual Energy X-ray Absorptiometry (DXA) examination in the state of Pará-PA.

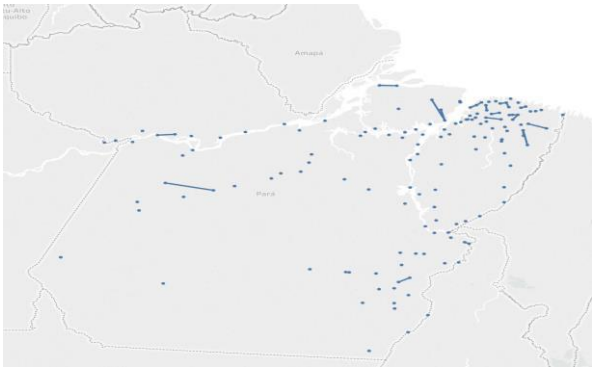

Figure 12: Geographic map of population displacement for X-ray examination in the state of Pará-PA

Figure 13 and Figure 14 show the results of population displacement performed in the state of Rondônia-RO to perform imaging examinations (DXA and X-ray). Population displacement occurs in one hundred and thirty-five municipalities for DXA (Figure 13). To perform the X-ray examination, person movement occurs in only thirty-two municipalities (Figure 14).

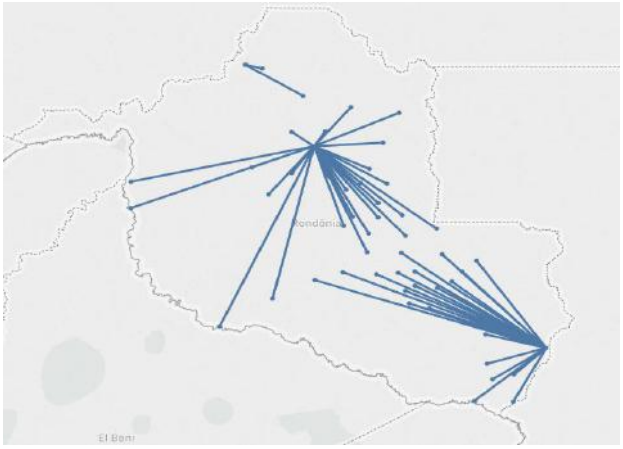

Fig. 13: Geographic map of population displacement for Dual Energy X-ray Absorptiometry (DXA) examination in the state of Rondônia-RO

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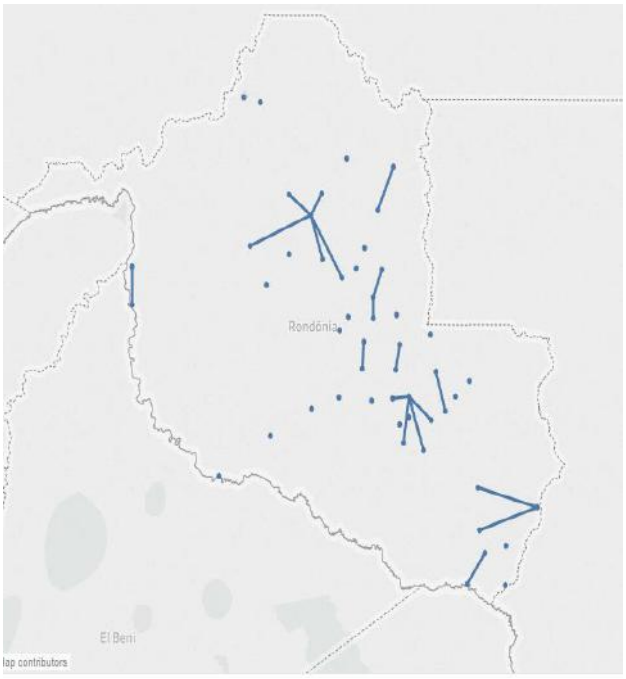

Fig. 14: Geographic map of population displacement for X-ray examination in the state of Rondônia-RO.

Figure 15 and Figure 16 show the results of population displacement performed in the state of Tocantins-TO to perform imaging exams (DXA and X-ray). Population displacement occurs in one hundred and thirty-five municipalities to perform DXA (Figure 15). To perform the X-ray examination, person movement occurs in only thirty-two municipalities (Figure 16).

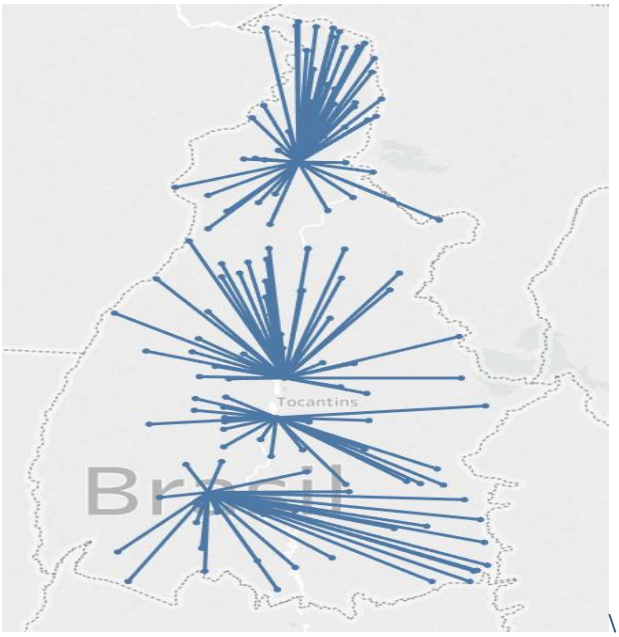

Fig. 15: Geographic map of population displacement for Dual Energy X-ray Absorptiometry (DXA) examination in the state of Tocantins-TO.

Fig. 16: Geographic map of population displacement for X-ray examination in the state of Tocantins-TO.

IV. CONCLUSIONS

We can conclude that the movement of people for X-ray examination is relatively lower compared to DXA, as shown by Social Network Analysis. However, in order for X-ray equipment to be used to measure bone density, such devices need to be configured / adapted for this purpose.

This upgrade to X-ray equipment will allow for such, an increase in the quality of health service provided for the affected populations and thus improve their quality of life.

Also, further research can be conducted, based on this study, to provide a value for the economic impact of using X-ray based Osteoporosis diagnosis. This impact can be considered taken several dimensions. The two of them are the distance for people displacement and the amount of time wasting on displacement. The scale of both will allow for considering as a good public investment, the adoption of X-ray equipment upgrade for osteoporosis diagnosis.

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