URANIUM DETECTION ASSOCIATION IN PARAÍBA WITH THE INCIDENCE AND PREVALENCE OF CANCER: A DOCUMENTARY STUDY

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Abstract: The relationship between exposure to radioactive elements, such as uranium, and the increase in cancer incidence has been the subject of several scientific investigations. Previous studies indicate that prolonged exposure to ionizing radiation may be associated with an increased risk of development of malignant neoplasms. The objective of the present study was to analyze the

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association between cancer and mortality in Paraíba, especially in some municipalities, where there is uranium. The present work is an ecological study that analyzes the Uranium Association with Cancer. Systematic revisions constitute instruments of integrative analysis of available scientific information, allowing to obtain responses based on evidence to clinically relevant questions. The results show a very strong and positive correlation between these two variables, with a correlation coefficient of 0.989. This indicates that as the incidence of neoplasms in women increases, there is also an increase in mortality from external causes between women, and vice versa. Statistical significance (SIG.) For this correlation is 0.000, indicating that the correlation is highly significant, with a confidence level of 99%. The analysis of the association between cancer and mortality in Paraíba, with special focus in municipalities with the presence of Uranium has revealed significant insights on the possible impacts of uranium exposure on public health. The data obtained indicate a worrying correlation between the presence of uranium and the increase in the incidence of neoplasms and mortality, especially in mining areas and regions with high concentrations of natural radiation.

Keywords: Clinical Studies; Systematic revisions; Meta-analyzes; Clinical Epidemiology; Cardiology based on evidence.

INTRODUCTION

The relationship between exposure to radioactive elements, such as uranium, and the increase in the incidence of cancer has been the subject of several scientific investigations. Previous studies indicate that prolonged exposure to ionizing radiation may be associated with an increased risk of developing malignancies (UNSCEAR, 2020). According to the International Atomic Energy Agency (IAEA), regions with natural uranium deposits may present a potential risk to public health due to soil and water contamination, which requires a thorough analysis of the health impacts of populations residing in these areas (IAEA, 2018).

In the Brazilian context, regional surveys have revealed alarming data. A study conducted by

Nascimento et al. (2021) in areas of the Brazilian Northeast, which includes Paraíba, demonstrated a significant correlation between the presence of uranium in the soil and cancer mortality. The research, published in the Brazilian Journal of Epidemiology, used mortality and environmental quality data to assess the impacts of chronic exposure to high levels of radiation.

In addition, in the international literature, studies such as that of Cardis et al. (2007), published in the International Journal of Cancer, reinforce the need for constant monitoring in regions where the population is exposed to natural sources of radiation. These studies indicate that, despite regional variations, the presence of uranium and other radioactive minerals may represent a significant risk factor for public health.

Therefore, this research seeks not only to map and analyze cancer mortality rates in municipalities in Paraíba with the presence of uranium, but also to contribute to the scientific literature by verifying the existence of a statistically significant correlation between these factors, using data from indexed databases such as PubMed, Scopus and Web of Science. The analysis of these data will allow a better understanding of the impacts of uranium exposure on human health and will guide future public health policies in the state of Paraíba and other regions with similar geological characteristics.

The analysis of uranium occurrences in several regions of Brazil, especially in the Northeast and Paraíba, reveals a complex interaction between regional geology and potential impacts on public health. The significant presence of uranium in metasomatic deposits and its radioactive implications, as observed in studies of uranium minerals and deposits, suggests a substantial concern about the exposure of the population to dangerous levels of radiation. This exposure is especially relevant in mining areas, where economic activity has been a driver of local development, but at the cost of serious health risks, as evidenced by the increase in the incidence of neoplasms and other related diseases.

The results point to the urgent need for continuous monitoring of radiation and the health conditions of affected populations, as well as stricter regulation of mining activities. The study

reinforces the importance of public policies that balance economic development with the preservation of health and the environment, thus preventing more severe consequences in the future. Finally, it is clear that further research is essential to deepen the understanding of the correlations between uranium exposure and the development of serious diseases, such as cancer, aiming at mitigating risks in areas with active or potential uranium deposits.

OBJECTIVE

To analyze the association between cancer and mortality in Paraíba, especially in some municipalities where uranium is present.

THEORETICAL FOUNDATION

The occurrence of uranium in Brazil, Northeast and Paraíba

The signs of uranium occurrence in Paraíba are located in metasomatites of Archean-Paleoproterozoic and Paleoproterozoic protoliths of the Rio Piranhas, São José do Campestre and Alto Moxotó terranes. They are present in Pocinhos, Cajá, Pilões, Barra de Santa Rosa and CB-62 and the Espinharas deposit. In the case of the Espinharas deposit, it is formed by a U-shaped mineralized metasomatic complex, embedded in rocks of the Caicó Complex, distinguishing different types of ore, according to the altered protolith (SANTOS; FERREIRA; JR., 2002).

In the radioactive uranium deposit of São José do Espinharas, northeastern shield, uranium mineralization is related to sodium metasomatism and episianenization of amphibolite facies gneisses and intrusive microgranites. Two major groups of gneisses occur, the granitic leucocratic gneisses and the biotite-amphibole mesophyte gneisses, which have subconcordant structural relationships. The gneisses are cut by intrusive microgranitic dikes of widely varying sizes. Uranium mineralization occurs in all three major rock types, in albitized and episividenate zones discordant to high-grade

metamorphic foliation. These zones resulted from shear stresses and fractures that controlled microgranite intrusions and subsequent percolation of metasomatic mineralizing fluids along grain boundaries and microfractures. (PORTO DA SILVEIRA; SCHORSCHER; MIEKELEY, 1991).

The use of mining is one of the main sources of income that increase numerous municipalities in the territory of Paraíba. In the municipality of Pedra Lavrada located in the Curimataú region of Paraíba, the mining activity has been developed for more than 50 years, and with a monthly production of around five thousand tons, thus making it an economic activity for this region. The extraction of ores such as limestone, feldspar, rose quartz, mica, ruby, beryl, black ore, tantalite, talc, uranium, among others, causes neglect of these workers, thus causing numerous health problems. Concomitant with mining practices, some impacts of a physical, biological and social nature. In addition to the harm caused to health, the activity makes the soil unavailable through erosion, water, flora and fauna. Thus, changes in the ecological balance and the impacts of human activities on mining areas have been causing damage to the health of miners (SOUZA et al., 2010).

The phosphate-rich region of Northeast Brazil, in the coastal sedimentary area of the states of Pernambuco and Paraíba, has levels higher than those of the Northeast Phosphate. The people living in this highly populated area are continuously exposed to ionizing radiation derived from uranium and its progeny. The following concentrations of uranium 226Ra and 222Rn were found in the water bodies crossing the phosphate area, and based on the rate of ingestion of these radionuclides due to water consumption. The average concentrations found for uranium, 226Ra, and 222Rn were 25 mBq/L, 282.2 mBq/L, and 104.7 Bq/L, values higher than those found in the Poços de Caldas plateau, Brazil, and the phosphate-rich area of North Carolina, USA. Increases of 1.25% in the incidence of cancer due to ingestion of 222Rn and 7% of head sarcomas and 3% of occurrences of osteosarcomas due to Ra ingestion were estimated for the local population (LIMA et al., 1996).

The uranium district of Lagoa Real, in Bahia, northeastern Brazil, is the most important uranium province in the country and currently produces this metal in an open-pit mine operated by Indústrias Nucleares do Brasil. The uranium-rich zones are associated with plagioclase-rich rocks

(predominantly albite ± oligoclase), albitites, and metasomatized granite-gneisses, distributed along the striking NNW/SSE shear zones. This age range of the material may have an important implication in exploration and should be included in the diversified age scenario of uranium deposits around the world (LOBATO et al., 2015).

Some studies use the application in Brazil of fission trace records, based on SSNTD (solid-state nuclear trail detectors) to determine the concentrations of uranium in apatite, phosphate concentrates and fertilizers (PASCHOA et al., 1984).

The high occurrence of uranium in the geological formations of the Erzgebirge, the official name of the Ore Mountains, is described in the discovery of uranium by M. Klaproth near the town of Freiberg in 1789 and the description of the so-called 'Schneeberg' disease, lung cancer caused in mine workers by the accumulation of the decay product of uranium, radon, on the subsurfaces of the wells. (Meinrath, Schneider, & Meinrath, 2003).

Uranium: its health hazards

Uranium (CASRN 7440-61-1) is the heaviest naturally occurring element. It is radioactive and initiates a decay series that includes other radioactive elements, including radium, thorium, and radon. It is used, following enrichment, as fuel for nuclear reactors and fissionable material in nuclear bombs. Evidence suggests that primary toxicity is like a heavy metal. Established health effects include nephrotoxicity, genotoxicity, and developmental defects. Emerging evidence suggests additional impacts on the brain, reproduction, including estrogenic effects, and gene expression (BRUGGE, 2014).

Uranium is used in the war industry (atomic bombs and fuzes for hydrogen bombs) and as a fuel in nuclear power plants to generate electricity. Traces of uranium are found in almost all sedimentary rocks of the Earth's crust, although it is not very abundant in concentrated deposits. It produces low-intensity poisoning (inhalation, or absorption through the skin), also producing side

effects, such as: nausea, headache, vomiting, diarrhea and burns. It affects the lymphatic system, blood, bones, kidneys and liver.

Its effect on the body is cumulative (which means that the mineral, as it is not recognized by the living being, is not eliminated, being gradually deposited, especially in the bones), and the radiation thus exposed can cause the development of cancers. For mine workers, cases of lung cancer are frequent. In Figure 1, we see the Uranium reserves in Brazil, the Espinharas reserve that covers a good part of Paraíba and Rio Grande do Norte, in the regions of Seridó Oriental and Patos.

Although there is no extraction of ore in Ouro Branco, other mines can cause the extraction of Uranium indirectly, and leave it loose in the environment, contaminating the waters in the rainy season, thus leaving the water veins in contact with the ore, as in the case of the extraction of the Itacolomy do Norte stone, extracted in Serra do Porção, in the municipalities of Ouro Branco and Várzea.

Studies have revealed possible correlations between the proteins p53, BCL-2 and hMSH2 in the process of tumorigenesis. However, to date, available reports examining the status of these molecules in normal brain tissues, gliosis, and gliomas are still scarce. Sixty (60) brain tissue specimens (52 gliomas and eight glioses) obtained from patients with brain tumors were studied. The value of this investigation derives from the fact that it examined the entire continuum of lesional steps involved in the development of gliomas. The study revealed observations about these tumors: (i) gliomas were more common in the parietal and frontal regions and (ii) upregulation of p53, hMSH2 and BCL-2 protein expression occurs in gliomas, resulting from the presence of uranium in drinking water (WORLD HEALTH ORGANIZATION (WHO), 2012).

METHODOLOGY

The present study addresses a systematic review, followed by a meta-analysis of the association of uranium with cancer. Systematic reviews are instruments for integrative analysis of

available scientific information, allowing evidence-based answers to clinically relevant questions. Meta-analyses correspond to systematic reviews with a component of quantitative analysis of results. The process of preparing a systematic review follows a rigorous and standardized methodology that structures: 1) the formulation of a relevant and practical clinical question; 2) the explicit selection of studies (primary or secondary) to be included in the review, 3) the critical evaluation of potentially relevant studies, 4) the synthesis of the information present in the selected studies and 5) statistical analysis of the results. This article addresses the particular aspects of each of these stages, describing the basic structure of a systematic review, its methodologies and problems.

RESULTS AND DISCUSSION

The table presents descriptive statistics related to mortality from external causes among men and women, as well as the incidence of neoplasms (cancer) in both sexes, in addition to the age of the participants. A total of 209 observations were analyzed for the mortality and incidence of neoplasm variables, and 6 observations for the age variable.

For mortality from external causes among men, the mean observed was 38.44 cases, with a standard deviation of 135.49, indicating a large variation in the data, with values ranging from 2 to 1748 cases. Among women, mortality from external causes presented a mean of 6.77 cases, with a standard deviation of 24.64, and a range between 0 and 320 cases.

Regarding the incidence of neoplasms, men had a mean of 63.08 cases, with a standard deviation of 244.84, and the values ranged from 1 to 3215 cases. In women, the average was 101.35 cases, with a standard deviation of 392.03, and a variation between 0 and 5074 cases, which suggests a wide dispersion in the data.

The age variable, analyzed for 6 observations, showed a mean of 22.67 years, with a standard deviation of 1.03, and values ranging from 21 to 24 years. These data indicate a relatively concentrated age group among the participants.

The data reveal significant variability in both mortality from external causes and the incidence of neoplasms, especially among women, suggesting the need for more detailed analyses to understand the factors underlying these variations.

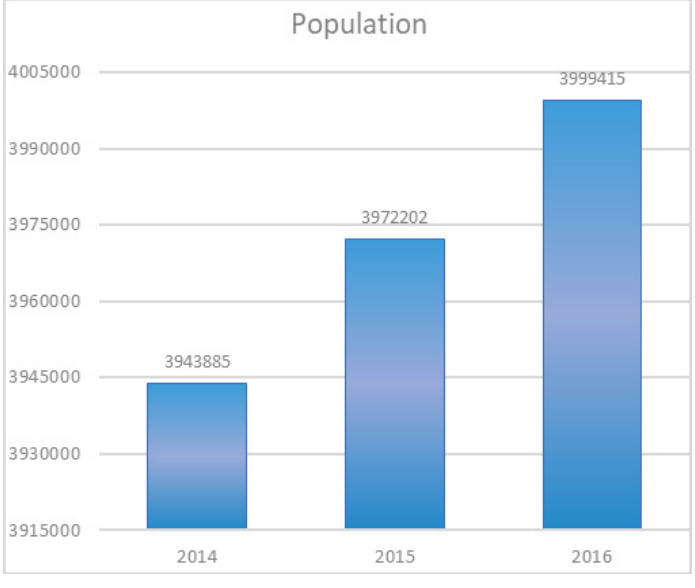
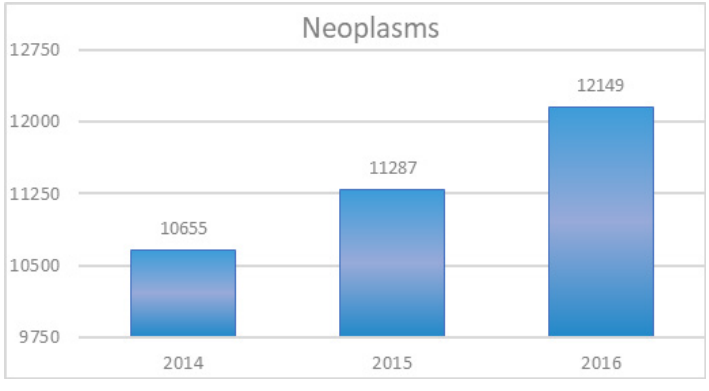


Table 2 shows Pearson's correlation between the variables "Mortality from external causes in women" and "Incidence of neoplasms in women". Pearson's correlation measures the strength and direction of the linear relationship between two variables.

The results show a very strong and positive correlation between these two variables, with a correlation coefficient of 0.989. This indicates that as the incidence of neoplasms in women increases, there is also an increase in mortality from external causes among women, and vice versa. The statistical significance (Sig.) for this correlation is 0.000, indicating that the correlation is highly significant, with a 99% confidence level.

These data suggest a robust relationship between mortality from external causes and the incidence of neoplasms in women, which may indicate common or interrelated underlying factors, and it is important to further investigate to understand the causes of this association.



CONCLUSION

The analysis of the association between cancer and mortality in Paraíba, with a special focus on municipalities with the presence of uranium, revealed significant insights into the possible impacts of uranium exposure on public health. The data obtained indicate a worrying correlation between the presence of uranium and the increase in the incidence of neoplasms and mortality, especially in mining areas and in regions with high concentrations of natural radiation.

The results suggest that while the correlation cannot be directly attributed to the presence of uranium without a more detailed quantitative analysis, the observed trend is consistent with evidence from previous studies on the health risks associated with exposure to uranium and its decay products. The high incidence of cancer and mortality rates in the affected areas point to the need for further investigation into uranium exposure and its health consequences.

Therefore, it is imperative that stricter environmental monitoring measures and public health policies that address the risks associated with uranium exposure are implemented. In addition, it is recommended that additional studies be conducted that can provide a more accurate understanding of the causal relationships between uranium exposure and observed health conditions. These actions are essential to protect the health of populations living in areas with uranium deposits and to ensure sustainable development that minimizes health risks.

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