Doctoral School in Medical Sciences

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HYGIENIC ASSESSMENT OF THE IMPACT OF BORON FROM DRINKING WATER ON MORBIDITY DUE TO OSTEOARTICULAR DISEASES

331.02 - HYGIENE

Summary of the thesis of doctor in medical sciences

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The thesis was developed in the Scientific Laboratory Chemical and Toxicological Hazards, National Agency for Public Health

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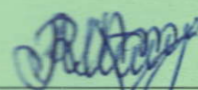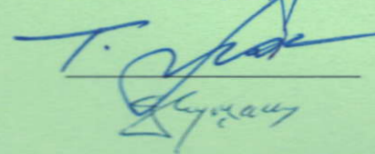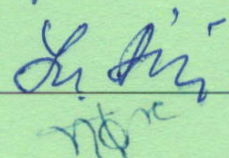*Cebanu Serghei*, MD, PhD, associate professor,
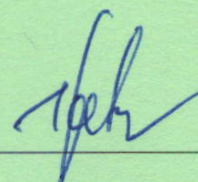Hygiene discipline
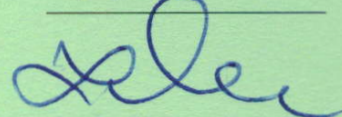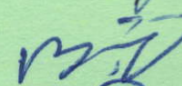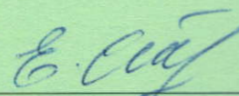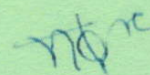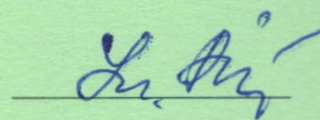
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2

CONTENT

INTRODUCTION

The actuality and importance of the addressed topic. Endemic diseases caused by the excess or deficiency of essential microelements in the environment, including in the drinking water consumed, represent one of the public health problems, researched worldwide. Among the priorities of the World Health Organization (WHO) is ensuring the right of people, regardless of their level of development and social and economic conditions, to have an adequate and safe supply of drinking water. [1].

According to the Sustainable Development Goals, adopted by the UN General Assembly on September 25, 2015, resolution 70/1 – "Transforming our world: the 2030 agenda for sustainable development", goal 6 is dedicated to clean water and sanitation. Point 6.1. provides that by 2030, universal and equitable access to safe and affordable drinking water is to be ensured [2]. The Republic of Moldova has committed to implementing the 2030 Agenda for Sustainable Development, adopting in this regard the National Development Strategy "European Moldova 2030". Through goal 10 – Ensuring a healthy and safe environment, namely specific goal 10.1, Moldova is committed to ensuring the improvement of water, air and soil quality [3].

Concerning the UK Expert Group on Vitamins and Minerals (EVM UK), the WHO highlights the fact that boron appears to be an essential nutrient for the human body, its deprivation resulting in alterations in biological functions, which is harmful and can be corrected by increasing the intake of this microelement [1].

A daily intake of at least 0.4 mg of boron can contribute to strengthening bone mass, and the maximum regulated concentration of boron in drinking water can provide the body with minimal essential benefits [4, 5]. The WHO recommends drinking water in which boron is naturally found as a source of boron [5].

Boron consumption can influence the osteoarticular system in various ways – it reduces the excretion of calcium and magnesium from the body [6, 7, 8], encourages osteogenesis [9, 10], reduces inflammatory joint processes [11, 12], reduces joint discomfort and improves mobility [13, 14], including due to the positive influence on the intestinal microbiome [15, 16]. Osteoarticular pathologies that can be prevented and corrected by boron consumption are osteoarthritis (OA), rheumatoid arthritis (RA) and osteoporosis [4, 13, 14, 17, 18].

According to the WHO report on the social impact of chronic diseases, OA is in the top ten causes of disability [19], causing disability in every 4th woman and every 8th man globally [20]. At the national level, according to statistical data, in 2019 the incidence of OA was 47.9 thousand cases, an increase compared to 2018 (46.9 thousand cases) [21].

RA is a chronic autoimmune disease that causes functional deficits, considerably reducing the quality of life of affected patients. WHO estimates that in the general population the prevalence of RA varies between 0.6 and 1.3%, with an annual incidence of 0.02%. The disease is the most common inflammatory rheumatism, accounting for 10% of rheumatic pathologies [17, 22].

Based on the recommendation of consumption of 2 liters of water/day and its contribution of 40% to the daily boron intake, for an average weight of 60 kg, the WHO recommends a dose of 2.4 mg boron/l for drinking water [23]. National regulations provide for a maximum allowable concentration of 1.5 mg/l, with a value of 2.4 mg/l allowed if high levels of boron in groundwater are caused by geological conditions [24], a situation encountered in the southern region of the country, where maximum values of boron in deep water reach values of up to 3 mg/l [25].

Given the chronic and multifactorial nature of OA and RA, but also the need to adjust lifestyle to keep both conditions under control, considering adapting boron intake from drinking water and food products consumed to the recommendations of international authorities represents a strategy that should

not be overlooked, both by rheumatologists and arthrologists, and by public health specialists who are in charge of developing regulatory acts in the field of environmental risk assessment.

The aim of the study: hygienic assessment of the impact of boron in deep drinking water on the morbidity of the population due to osteoarthritis and rheumatoid arthritis and the development of prevention measures.

Objectives of the study:
1. Evaluation of the territorial distribution of boron concentrations in groundwater used for drinking purposes and mapping of the territory of the Republic of Moldova based on the determined concentrations.
2. Estimation of population morbidity due to osteoarthritis and rheumatoid arthritis.
3. Determining the statistical association between boron concentration in deep drinking water and morbidity due to osteoarthritis and rheumatoid arthritis.
4. Development of measures to prevent osteoarthritis and rheumatoid arthritis conditioned by the concentration of boron in deep drinking water.

Scientific research methodology. The research is based on the concept of "environment-health" through which the hygienic assessment of the impact of boron in deep drinking water on osteoarticular morbidity of the population from selected regions of the Republic of Moldova was carried out. Two full descriptive observational studies and two selective descriptive observational studies were conducted within the research. Mixed methods of research and data collection were applied.

Scientific problem. Following the research, the areas of the country with below-the-limit, limit and above-the-limit boron in deep drinking water were identified and classified, which are addressed in the paper as regions with a different potential to contribute to the strengthening of the osteoarticular system. At the same time, the method for estimating boron intake and its influence on the osteoarticular system was developed and the correlation between the investigated osteoarticular morbidity and boron concentrations in deep drinking water was determined. Finally, measures for the prevention of osteoarthritis and rheumatoid arthritis conditioned by boron concentrations in deep drinking water were developed.

The novelty and sscientific originality of the obtained results. Research of the influence of boron on the osteoarticular health of the population is a premiere for the Republic of Moldova. For the first time, this microelement is being addressed not as a contaminant, but as a fortifier of osteoarticular health, the daily intake of which is to be adjusted through the drinking water consumed. Mapping the country's territory according to boron concentrations in deep drinking water will allow identifying regions where locals are more vulnerable to the occurrence of chronic osteoarticular pathologies, and the developed prevention measures will contribute to their effective management.

The theoretical significance. The research is part of national public health policies targeting drinking water quality and its impact on population health. The results of the study will be included in undergraduate and postgraduate curricula, as well as in professional development programs for doctors.

The applicative value of the research. The results obtained in this research formed the basis for the development of measures to prevent osteoarthritis and rheumatoid arthritis in relation with the concentration of boron in deep drinking water, which, used together with cartographic representations of the above-the-limit, limit and below-the-limit boron areas in deep drinking water, can be a support for therapists from several regions of the country. The method of evaluating eating habits and drinking water consumption to estimate boron intake and its influence on the health of the osteoarticular system, designed during the research, can be applied by researchers in the fields of health, chemistry, environment and local public authorities to argue the need to adjust the boron concentration in the consumed drinking water and

the influence of current concentrations of this microelement on the osteoarticular health of the population from different regions of the country.

Implementation of research results. The obtained results were implemented in the practical activity of the specialists of the National Agency for Public Health, of the BioBoron Research Institute from Craiova, Romania and are used in the practical activity of the Hygiene Discipline, Department of Preventive Medicine of the „Nicolae Testemițanu State University of Medicine and Pharmacy".

Approval of the scientific results. The attained scientific results were presented and discussed during the communications at the following scientific forums: International Scientific and Practical Conference "Health and Environment" dedicated to the 95th anniversary of the Republican Unitary Enterprise "Scientific and Practical Center of Hygiene", Minsk, November 24-25, 2022; XI International Medical and Pharmaceutical Congress of Students and Young Researchers, Chernivtsi, Ukraine, April 2-5, 2024; 10th edition of the MedEspera International Congress for Students and Young Doctors, Chisinau, April 24-27, 2024; International Scientific Conference, section State of the Environment and Sustainable Development, on the occasion of the 30th anniversary of ULIM, Chisinau, October 17-20, 2022; National Conference with International Participation "A Safe Environment - Protected Health", Chisinau, November 12-13, 2020; National Conference with International Participation "A Single Health Approach in a World of Changes", Chisinau, November 4-5, 2021; Annual Scientific Conference of the "Nicolae Testemitanu" SUMPh, "Research in Biomedicine and Health: Quality, Excellence, Performance", Chisinau, October 20-22, 2021; National Conference with International Participation "Water and Health: Achievements and Challenges", Chisinau, March 22, 2022; Scientific Conference for Young Researchers "Modern Research Approaches in Hygiene". Chisinau, February 19, 2025.

The research results were discussed and approved at the meeting of the Scientific Council of the National Agency for Public Health (minutes no. 2 of 28.03.2025), at the meeting of the Scientific Seminar within the "Nicolae Testemițanu" State University of Medicine and Pharmacy, profile 331.Public Health; 333. Occupational Health and Biomedicine, specialties: 331.03. Social Medicine and Management; 331.04. Healthy Lifestyle; 331.01. Epidemiology; 331.02. Hygiene; 333.01. Occupational Hygiene (minutes of 30.06.2025).

Publications on the thesis topic. 11 papers were published, of which: three articles in international and national SCOPUS indexed journals, three articles in national peer-reviewed journals (category B), two theses in international scientific collections and three theses in the proceedings of national scientific conferences, of which 4 works are single-authored, a third-degree diploma at an international scientific forum, a silver and a gold medal at national and international invention salons, an innovator's certificate, a certificate from the State Agency for Intellectual Property regarding the registration of copyright objects and related rights.

PhD thesis structure. The thesis is presented on 177 pages, includes a list of abbreviations, a list of figures and tables, an introduction, three chapters, discussions, general conclusions and practical recommendations, a bibliography with 134 sources, 14 annexes, 22 tables and 83 figures, a statement of responsibility and the author's CV.

For the development of the doctoral thesis, the positive opinion of the Research Ethics Committee of the "Nicolae Testemițanu" State University of Medicine and Pharmacy was obtained (minutes no. 1 of September 7, 2020). At the same time, research capabilities were developed by successfully completing: the CITI program: Human Research, Group 1- Biomedical - IRB-01, Stage 1-Basic Course of the University of Iowa and the ERASMUS+ study mobility (KA 107) within the Doctoral School of the University of Medicine and Pharmacy in Craiova, Romania.

THESIS CONTENT

1. OSTEOARTICULAR MORBIDITY IN RELATION WITH BORON INTAKE FROM DIFFERENT SOURCES

Details were reviewed regarding boron intake from various sources, boron metabolism in the human body, risks and regulatory aspects of boron consumption, adverse effects attributed to boron consumption, recommendations regarding maximum daily boron intake and the issue of osteoarthritis and rheumatoid arthritis and the risk factors that influence it. Finally, adequate boron intake from drinking water and other sources was described as a preventive measure for osteoarticular diseases.

2. RESEARCH MATERIALS AND METHODS

To achieve the proposed purpose and objectives, a research was conducted based on the „environment-health" concept for the hygienic assessment of the impact of water quality, namely boron concentrations, on the health of the osteoarticular system of the population in the selected regions. The data was collected, analyzed and interpreted according to the design represented in the figure 1.

At **the 1st stage**, the review of the specialized literature on the impact of boron from different sources on the health of the human body was studied. The in-depth research of national and international works in the *MEDLINE (PubMed), Google Scholar, ProQuest, Scopus and Research Gate* databases allowed the identification of deep drinking water as an important source of boron and, respectively, the osteoarticular system as one strongly influenced by this microelement. Subsequently, the purpose and objectives of the work were established, the research plan and the questionnaire that was applied to survey the population included in the study were developed. At the same time, at this stage, the working methods were highlighted.

The 2nd stage consisted of two parts. In **the first part,** a full descriptive observational study was conducted on osteoarticular morbidity (incidence and prevalence) due to rheumatoid arthritis and inflammatory polyarthropathies for the period 2016-2020. Data on morbidity due to osteoarthritis, a chronic degenerative pathology, were available only as part of the chondropathies group, which is why they were not included in this research.

The data was taken from the Health Data Management Department of the National Agency for Public Health. In the case of the prevalence of rheumatoid arthritis and inflammatory polyarthropathies in adults, the data obtained was represented cartographically using the Datawrapper 2024 software (https://www.datawrapper.de/) to identify the regions of the country where these pathologies register maximum/minimum rates.
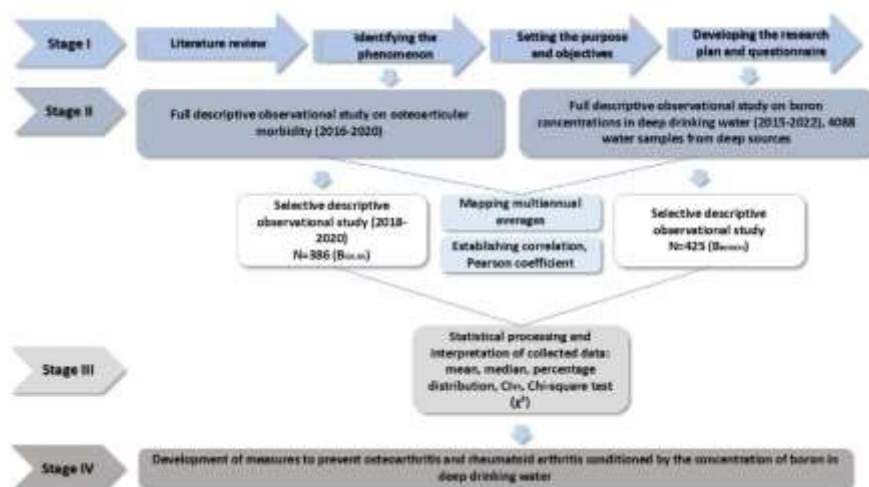

Figure 1. **Study design**

In **the second part,** a full descriptive observational study was conducted on boron concentrations in deep drinking water - public wells and artesian wells, separately, for the period 2015-2022. The data was taken from the territorial Public Health Centers (2015-2021) and from the Electronic Register of Drinking Water Supply Sources of the National Agency for Public Health (artesian wells, 2022), the total number of samples investigated being 4088. Subsequently, the annual and multiannual averages were calculated using Microsoft Excel 2021 and represented cartographically using the Datawrapper 2024 software (https://www.datawrapper.de/).

Following the mapping of boron concentrations in water from public wells and artesian wells in the Republic of Moldova and the fact that national legislation provides for a limit of 1.5 mg/l of boron (Law no. 182 of 19.12.2019 on drinking water quality), the study regions were identified:

- *Below-the-limit* (0-1 mg/l): districts Cahul, Calarasi, Briceni, and Drochia;
- *Limit* (1,1 – 1,6 mg/l): districts Comrat and Vulcanesti;
- *Above-the-limit* (over 1,6 mg/l): district Ceadir-Lunga.

At the end of this stage, a comparative assessment was carried out of the mapping of the prevalence of adults with rheumatoid arthritis and inflammatory polyarthropathies for the period 2016-2020 and of the mapping of boron concentrations in water from public wells in the Republic of Moldova for the period 2015-2021 and from artesian wells for the years 2015-2022. At the same time, using the Microsoft Excel 2021 program, the Pearson correlation coefficient was calculated between the morbidity (prevalence and incidence) of adults with rheumatoid arthritis and inflammatory polyarthropathies and boron concentrations in deep drinking water (artesian wells).

Following the full study on boron concentrations in deep drinking water, a selective descriptive observational study was conducted that included the evaluation of dietary and drinking water consumption habits, along with the health of the osteoarticular system of the inhabitants of areas with above-the-limit, limit and below-the-limit boron in underground drinking water. For this purpose, the questionnaire method was applied through the own questionnaire approved by the Research Ethics Committee, opinion no. 1 of 07.09.2020. The study included adults over 18 years of age from the following localities: Ciadir-Lunga district (Ciadir-Lunga town, Cazaclia village, Djoltai village), Comrat district (Comrat town, Budjac village, Chirsovo village), Cahul district (Cahul town, Lopatica village, Crihana village, Lebedenco village, Ursoaia village, Pelinei village), Vulcanesti district (Vulcanesti town, Carbalia village), Calarasi district (Calarasi town, Sipoteni village), Briceni district (Criva village, Medveja village), Drochia district (Drochia town, Sofia village, Cotova village). The research group consisted of 425 people with an established diagnosis of OA and RA (B_{BOR}) – 322 patients with OA and 103 patients with RA.

The research group was calculated in the EpiInfo 7.2.2.6 program, the „StatCalc- Sample Size and Power" section based on the following parameters: confidence interval for 95.0% (CI_{95}) significance of the results, statistical power of 80.0%, the association between boron and osteoarticular diseases is on average up to 10.0% [11], design effect „deff" = 2 (duration of use of drinking water in the region/concentration of boron in drinking water), adjustment for the non-response rate, estimated at 10.0%. The adjusted group size is 334, and 425 patients with osteoarticular diseases (osteoarthrosis and rheumatoid arthritis) were included in the research.

The inclusion criteria in the research: age +18 years, established diagnosis of osteoarthritis or rheumatoid arthritis, both sexes, agreement to participate in the study.

The exclusion criteria from the research: age under 18 years, no diagnosis of osteoarthritis or rheumatoid arthritis, other osteoarticular pathology, refusal to participate in the study, no informed consent.

Following the research on osteoarticular morbidity, a selective descriptive observational study was conducted, which included the collection and evaluation of data from the medical histories of patients with

the established diagnosis of seropositive osteoarthritis and rheumatoid arthritis hospitalized during 2018-2020 in the arthrology and rheumatology departments of the IMSP Republican Clinical Hospital „Timofei Mosneaga". The study included a group of 386 patients ($B_{OA, RA}$) - 322 patients with OA and 64 patients with RA.The study group included all patients with the diagnosis of seropositive osteoarthritis and rheumatoid arthritis, both from urban and rural areas, in a number close to the research group calculated for the evaluation of dietary habits and drinking water consumption, along with the health of the osteoarticular system of residents of areas with above-the-limit, limit and below-the-limit boron in groundwater.

At **the 3rd stage**, after creating the databases containing the results of the analysis of the medical histories of patients in $B_{OA, RA}$ and the questionnaires of patients included in B_{BORON}, using the IBM SPSS Statistics 20 program, they were processed and the mean, median, CI_{95} percentage distribution and the Chi-square (χ^2) test were calculated. Subsequently, the obtained statistical indicators were interpreted and systematized in table form in Microsoft Word 2021.

The 4th stage included formulating appropriate conclusions and developing measures to prevent osteoarthritis and rheumatoid arthritis caused by the concentration of boron in deep drinking water.

3. CHARACTERISTICS OF OSTEOARTICULAR MORBIDITY AND ITS DETERMINING FACTORS IN RELATION TO BORON CONCENTRATION IN GROUND DRINKING WATER

3.1. Territorial distribution of boron concentrations in deep drinking water in the Republic of Moldova

The territorial distribution of boron concentrations in well water attests to the fact that in all districts of the Republic of Moldova, except for the Ciadir-Lunga district, the average boron concentration for the period 2015-2021 can be assessed as below-the-limit (0-1 mg/l). In the Ciadir-Lunga district, the assessed value can be qualified as above-the-limit (1.7 mg/l) (Figure 2).

The territorial distribution of boron concentrations in artesian well water reveals that most districts of the Republic of Moldova are located in the range of below-the-limit boron concentrations in deep drinking water (0-1 mg/l), while Comrat and Taraclia can be classified as districts with boron in drinking water located at the limit (1.1-1.6 mg/l), and Ciadir-Lunga – as a district with above-the-limit boron in deep drinking water (over 1.6 mg/l) (Figure 3).
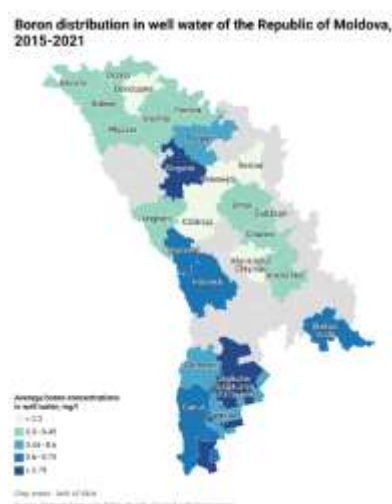

Figure 2**. Mapping of boron concentrations in well water of the Republic of Moldova, 2015-2021**

Figure 3. **Mapping of boron concentrations in artesian well water of the Republic of Moldova, 2015-2022**

3.2. Territorial distribution of osteoarticular morbidity in the Republic of Moldova

Mapping of the prevalence of rheumatoid arthritis and inflammatory polyarthropathies in adults in the Republic of Moldova during 2016-2020 reveals an uneven distribution (Figure 4). According to the International Classification of Diseases, 10th edition (ICD-10-AM), the inflammatory polyarthropathies group (M05-M14) includes seropositive rheumatoid arthritis, other rheumatoid arthritis, psoriatic and enteropathic arthropathies, juvenile arthritis, juvenile arthritis in diseases classified elsewhere, gout, other microcrystal arthropathies, other specific arthropathies, other arthritis, arthropathy in other diseases classified elsewhere.

Figure 4. **Mapping of the prevalence of adults with rheumatoid arthritis and inflammatory polyarthropathies, 2016-2020**

Based on the average prevalence recorded in the country during 2016-2020 period (Min 8.3; Max 47.76 per 10,000 inhabitants), in regions where a limit concentration of boron in deep drinking water is attested (Taraclia – 1.4 mg/l in artesian wells and Gagauzia ATU – 1.4 mg/l in artesian wells) the prevalence of rheumatoid arthritis and inflammatory polyarthropathies in adults recorded average figures (Taraclia – 16.46 per 10 thousand inhabitants), or high figures (Gagauzia ATU – 34.32 per 10 thousand inhabitants).

In the below-the-limit boron concentration in deep drinking water areas, where the recorded figures were the lowest (Cimislia - 0.01 mg/l in artesian wells, Donduseni - 0.15 mg/l in wells, 0.2 mg/l in artesian wells and Basarabeasca - 0.02 mg/l in artesian wells), the prevalence was also medium (Cimislia - 15.78 per 10 thousand inhabitants and Donduseni - 21.28 per 10 thousand inhabitants) or high (Basarabeasca - 25.58 per 10 thousand inhabitants).

On the other hand, in the districts where the highest prevalence of adults with rheumatoid arthritis and inflammatory polyarthropathies was recorded (Soroca - 47.76 per 10 thousand inhabitants, Balti - 46.6 per 10 thousand inhabitants, Cantemir - 44.9 per 10 thousand inhabitants and Singerei - 33.84 per 10 thousand inhabitants) boron concentrations in deep drinking water were in all cases in the below-the-limit range (0-1 mg/l).

Following the calculation of the Pearson correlation coefficient between the average boron concentrations in water from artesian wells during the period 2015-2022 and the average prevalence and incidence values of adults with rheumatoid arthritis and inflammatory polyarthropathies during the period 2016-2020, a weak positive correlation was found between both boron concentrations and prevalence values, as well as between boron concentrations and incidence values (Figures 5, 6).
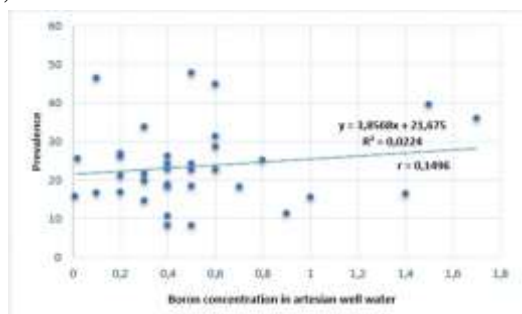

Figure 5. **Linear regression of the interdependence between boron concentration in artesian well water and prevalence of RA and inflammatory polyarthropathies**
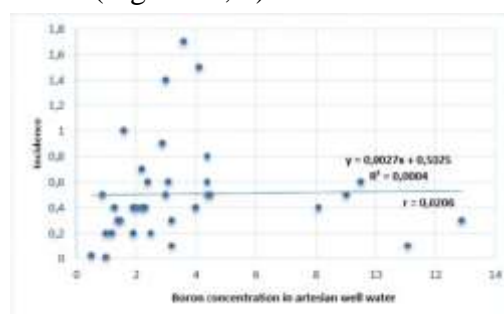

Figure 6. **Linear regression of the interdependence between boron concentration in artesian well water and incidence of RA and inflammatory polyarthropathies**

3.3. Characteristics of socio-demographic and behavioral factors of the population affected by osteoarticular diseases from areas with various boron concentrations in groundwater drinking water

Socio-demographic characteristics of the group of patients with OA and RA surveyed

The socio-demographic characteristics of the group of patients surveyed included place of residence and origin, age, sex, anthropometry (weight, height), BMI, profession, work regime and seniority.

A significant statistical association was found between the group of patients with OA and RA analyzed and the district of residence of the subjects ($\chi2 =264.578$, df=6, p<0.001) (table 1).

The research group was largely made up of natives, defined as people who were born in the locality where the survey took place - 79.1% (CI$_{95}$ 75.1-82.8).

Table 1. **Distribution of surveyed respondents and osteoarticular pathologies by districts**

Area	District	Average boron concentration in ground drinking water (2015-2019), mg/l		Proportion of respondents			Of which			
							OA		RA	
		Wells	Artesian wells	Abs.	%	CI$_{95}$	Abs.	%	Abs.	%
Above-the-limit	Ceadir-Lunga	1,8	1,9	90	21,2	17,6-24,9	63	70	27	30
Limit	Vulcanesti	-	1,1	61	14,4	11,3-17,6	-	-	61	100
	Comrat	-	1,4	22	5,2	3,3-7,5	22	100	-	-
Below-the-limit	Calarasi	0,1	0,5	59	13,9	10,6-17,2	55	93,2	4	6,8
	Briceni	0,3	0,3	29	6,8	4,5-9,4	18	62,1	11	37,9
	Drochia	0,1	0,5	80	18,8	15,3-22,8	80	100	-	-
	Cahul	0,8	0,9	84	19,8	16-23,5	84	100	-	-

Of the 322 cases of OA (100%), it most frequently occurred at the age of under 50 years (18-50 years) - 24.8% (CI$_{95}$ 19.9-29.8) and at the age of 56-60 years - 19.3% (CI$_{95}$ 14.9-23.9), and in the case of RA out of 103 cases, at the age of under 50 years (18-50 years) - 31.1% (CI$_{95}$ 22.4-40) and at 51-55 years - 16.5% (CI$_{95}$ 9.6-23.8). In the case of both OA and RA, there was a significant statistical association between the studied group and age ($\chi2 = 15.115$, df=7, p=0.035).

Of the total number of respondents (425), 329 (77.4%, CI$_{95}$ 73.4-81.2) were women and 96 were men (22.6%, CI$_{95}$ 18.8-26.6).

Obesity was the most prevalent both in the general group of respondents - 43.5% (CI$_{95}$ 38.8-48.2), and in those suffering from OA - 44.7 (CI$_{95}$ 39.8-49.7). In the case of RA patients, overweight was the most common - 43.7% (CI$_{95}$ 34.9-54.2).

Most respondents were not working - 45.4% (CI$_{95}$ 40.7-50.1). Both in the general group studied - 78.1% (CI$_{95}$ 73.6-82.1), and in the group of patients with OA - 76.7% (CI$_{95}$ 72-81.4) and RA - 82.5% (CI$_{95}$ 74.3-89.3), the most frequent activity regime was full-time. Work experience of over 20 years was the most frequent - 53.4% (CI$_{95}$ 48.5-57.9). A significant statistical association was established between the type of job performed and the activity regime ($\chi2 = 21.969$, df=6, p=0.001), as well as between the job performed and the professional work experience - ($\chi2 = 55.317$, df=8, p<0.001).

Sociodemographic characteristics of the group of patients with OA and RA studied based on data from medical records

Following the analysis of the medical records of patients diagnosed with OA and RA, it was possible to collect socio-demographic data (sex, definitive clinical diagnosis, age, living environment, profession, extent of the disease, hereditary and collateral characteristics, living and working conditions and onset of menopause).

The distribution of the 386 patients included in the research by gender was as follows: 80.8% (CI_{95} 76.7-84.7) women and 19.2% (CI_{95} 15.3-23.3) - men. Of the total number of patients included in the research following the analysis of medical records, 23.1% (CI_{95} 18.7-27.2) were from urban areas, and 76.9% (CI_{95} 72.8-81.3) from rural areas. Of the group of patients studied, the largest share was among those aged 61-65 years - 24.4% (CI_{95} 19.9-28.5) and those aged 56-60 years - 22.3% (CI_{95} 18.4-26.7).

Most frequently, both patients with OA - 81.4% (CI_{95} 76.8-85.4) and those with RA - 76.6% (CI_{95} 65.7-86.4) were not working, including due to retirement or disability. Sedentary work was practiced by 16.1% (CI_{95} 12.4-20.5) patients with OA and 20.3% (CI_{95} 11.1-30.6) patients with RA, and physical work by only 2.6% (CI_{95} 1.3-4.4) patients.

Patients with OA most frequently suffered from this pathology for 6-10 years - 31.7% (CI_{95} 26.3-37.1) or less than 5 years - 22% (CI_{95} 17.6-27.1). In the case of RA, the duration of the disease was most frequently 6-10 years - 34.4% (CI_{95} 23.2-46.0) and over 20 years - 34.4% (CI_{95} 22.4-46.3).

Assessment of the quality and consumption characteristics of drinking water in the case of the patients surveyed

The quality of drinking water was assessed by the respondents themselves, based on their knowledge and subjective assessments. The characteristics of drinking water consumption included data on the connection of the home to the centralized water supply and sewage network, the source of the water, as well as the habits of the respondents – the origin and type of water consumed for drinking and food preparation purposes, and the amount of water consumed daily.

The majority of respondents in the general group lived in houses connected to the centralized water supply network - 83.3% (CI_{95} 79.8-86.8), with the highest share recorded in Briceni district (100%) (Table 2). At the same time, the majority of respondents stated that their home is not connected to the centralized sewage network - 41.6% (CI_{95} 36.9-46.8).

Most frequently, respondents consumed water from the centralized water supply network both for drinking purposes - 37.6% (CI_{95} 33.4-42.1), and for food preparation - 50.1% (CI_{95} 45.6-55.1). The district where water from the network was most frequently consumed for both purposes (86.2% for drinking purposes and 96.5% for food preparation) also turned out to be Briceni. In the case of the entire sample, the largest share of drinking water came from artesian wells - 67.8% (CI_{95} 63.3-72.5), in Briceni district this came exclusively from artesian wells (table 2).

38.4% (CI_{95} 33.6-42.8) respondents knew about the quality of the drinking water they consumed, and 61.6% (CI_{95} 57.2-66.4) did not know. Most respondents assessed the quality of the drinking water they consumed as good – 40.2% (CI_{95} 36.0-44.7) or satisfactory - 35.8% (CI_{95} 31.5-40.2).

The majority of respondents in the general group consumed 1.5-2 l of water/day - 52.9% (CI_{95} 48.5-57.6), most frequently in the Briceni (69%) and Drochia (68.8%) districts. The least amount of water (0.5-1 l/day) was consumed in Ceadir-Lunga (44.5%), and the most (over 2 l/day) in Vulcanesti (47.5%).

The estimated daily boron intake was calculated by multiplying the average boron concentration/source by the amount of drinking water consumed by the largest share of the local population. The figures obtained indicate that the highest boron intake is in the residents of Comrat (0.9-3 mg/day) and Cahul (0.9-1.8 mg/day) districts, in both cases due to the consumption of a larger volume of water (1.5-2 l/day) (Table 2).

Table 2. **Peculiarities of drinking water consumption by the population in areas of the Republic of Moldova with various boron concentrations in deep drinking water**

Area	District	Average B concentration in well water, mg/l, 2015-2021	Average B concentration in artesian well water, mg/l, 2015-2022	Home connection to water supply, %	Drinking water consumption from the water supply network, %	Drinking water consumption from well, %	Water consumption for food preparation from the network, %	Water consumption for preparing food from the well, %	Water comes from artesian wells in the network, %	0.5-1 l/day consumption, %	1.5-2 l/day consumption, %	over 2 l/day consumption, %	Daily boron intake, both sources, mg
Above-the-limit	Ceadir-Lunga	1,7	1,7	96,7	31,1	14,4	40	13,3	85,5	44,5	40	15,5	0,85-1,7
Limit	Vulcanesti	0,5	1	81,9	40,9	22,9	57,4	19,7	68,8	14,7	37,8	47,5	1-2
	Comrat	0,6	1,5	95,4	45,4	9,1	81,8	4,5	81,8	36,4	54,5	9,1	0,9-3
Below-the-limit	Calarasi	0,2	0,6	94,9	25,4	36,4	49,1	27,1	62,7	23,7	55,9	20,3	0,3-1,2
	Briceni	0,4	0,3	100	86,2	0	96,5	3,5	100	24,1	69	6,9	0,45-0,8
	Drochia	0,3	0,5	70	20	35	26,2	43,7	62,5	23,7	68,8	7,5	0,45-1
	Cahul	0,6	0,9	65,5	48,8	32,1	54,8	34,5	41,6	34,5	54,8	10,7	0,9-1,8

Characteristics of the dietary habits of the patients surveyed

The dietary habits studied among the respondents were the number of servings of fruits and vegetables consumed daily, whether they were included in the menu only in season, the habit of consuming products rich in boron, and also how many standard alcoholic beverages the respondents used to consume per week.

The majority of respondents included in the research - 52.5%, (CI$_{95}$ 47.8-57.2) consumed 1-2 servings of fruit daily, most frequently in Briceni district (86.2%). The least amount of fruit was consumed in Ceadir-Lunga district (less than one serving/day) - 64.4%, and the most in Vulcanesti district (over 2 servings/day) - 57.4% (table 3).

The respondents included in the research mostly consumed less than 2 servings of vegetables and greens/day - 46.8% (CI$_{95}$ 42.1-51.5), although the difference between the share of those who consumed 2-3 servings/day was not very large - 41.9% (CI$_{95}$ 37.2-46.6). The fewest vegetables (less than 2 servings/day) were consumed in Ciadîr-Lunga district (77.8%), and the most (over 3 servings/day) in Vulcanesti district (55.8%) (table 3).

The majority of respondents included in the research consumed fresh fruits and vegetables regardless of the season - 39.5% (CI$_{95}$ 34.8-44.2), most frequently in Vulcanesti district (67.2%) (table 3).

The most common boron-rich foods consumed by respondents were tomatoes - 80% (CI$_{95}$ 76.2-83.5), legumes - 79.5% (CI$_{95}$ 75.5-83.1) and nuts of all types - 75.3% (CI$_{95}$ 71.3-79.5). The least consumed by respondents were avocados - 82.8% (CI$_{95}$ 79.3-86.1) and dried fruits - 60% (CI$_{95}$ 55.5-64.7).

The statistical association between the morbidity of OA and AR in the studied group and the consumption of boron-rich products was investigated separately for each product. Thus, of all the products listed in the questionnaire, only the consumption of dried fruits ($\chi2 = 12.336$ df=1, p<0.001) and sunflower

and pumpkin seeds ($\chi^2 = 6.497$, df=1, p=0.011) was found to be statistically significantly associated with the morbidity of OA and AR. The highest consumption of dried fruits was recorded in Briceni district (69%), and of seeds in Cahul district (78.6%) (table 3).

Table 3. **Peculiarities of the dietary habits of the population in areas of the Republic of Moldova with various boron concentrations in deep drinking water**

Area	District	Under one serving of fruit/day consumption, %	1-2 servings of fruit/day consumption, %	Over 2 servings of fruit/day consumption, %	Less than 2 servings of vegetables and greens/day consumption, %	2-3 servings of vegetables and greens/day consumption, %	Over 3 servings of vegetables and greens/day consumption, %	Consumption of fresh fruits and vegetables regardless of season, %	Consumption of dried fruits, %	Consumption of sunflower and pumpkin seeds, %
Above-the-limit	Ceadir-Lunga	64,4	30	5,6	77,8	18,9	3,3	28,9	26,7	41,1
Limit	Vulcanesti	13,1	29,5	57,4	13,1	31,1	55,8	67,2	27,9	37,7
	Comrat	63,6	36,4	-	54,5	45,5	-	50	36,4	54,5
Below-the-limit	Calarasi	28,8	64,4	6,8	42,4	56	1,6	35,6	55,9	54,2
	Briceni	3,4	86,2	10,4	13,8	75,9	10,3	20,7	69	62,1
	Drochia	27,5	62,5	10	43,8	52,5	3,7	42,5	23,7	70
	Cahul	23,8	67,8	8,4	53,6	41,7	4,7	38,1	58,3	78,6

The amount of alcohol consumed by respondents was assessed according to standard alcoholic drinks – 1 beer 330 ml/1 glass of wine 125 ml/1 serving of strong drink 40 ml. The majority of respondents included in the research consumed 0-1 standard drinks per week - 86.8% (CI_{95} 83.8-90.1).

3.4. Peculiarities of the clinical picture of people affected by osteoarthritis and rheumatoid arthritis

The present analysis reflects the particularities of the clinical picture, the risk factors for the occurrence of the disease, and the recommendations offered both to the patients with OA and RA investigated, as well as those reflected in the disease histories of patients in specialized departments.

Characteristics of the main risk factors for the occurrence of OA and RA

Patients in $B_{OA, RA}$ mostly showed unknown hereditary factors - 47.2% (CI_{95} 42.2-52.1). When asked about the support of osteoarticular pathologies by relatives, which indicates a genetic predisposition for the development of these conditions, most B_{BORON} respondents gave an affirmative answer - 45.4% (CI_{95} 40.7-50.1).

The majority of patients in $B_{OA, RA}$ rated their living and working conditions as satisfactory - 73.6% (CI_{95} 69.2-78.2), as did respondents to the questionnaire in B_{BORON} - 72.9% (CI_{95} 68.7-77.2).

For patients in $B_{OA, RA}$ for whom the age of onset of menopause was known, it most frequently occurred in the age range 46-55 years - 49.2% (CI_{95} 44.6-53.9), and almost half of the women surveyed in B_{BORON} were in menopause - 46.1% (CI_{95} 41.4-50.6).

The majority of the surveyed patients had not undergone surgical interventions on the osteoarticular system - 80.7% (CI_{95} 76.7-84.5) or osteoarticular trauma - 63.1% (CI_{95} 58.8-67.8).

In the case of patients with OA surveyed, in most cases their work did not involve physical effort - 29.8% (CI$_{95}$ 24.5-34.8) or involved moderate or light physical effort daily - 25.5% (CI$_{95}$ 21.1-30.1). In the case of those suffering from RA, the majority exercised intense physical effort daily as part of their work - 36.9% (CI$_{95}$ 27.2-46.4).

Both patients suffering from OA - 59.6% (CI$_{95}$ 54.3-65.2) and those suffering from RA - 35.9% (CI$_{95}$ 27.0-44.8) were occasionally exposed to cold, cold air currents and strong sunlight - risk factors for the development of osteoarticular diseases.

The majority of the surveyed patients from B$_{BORON}$ included in the research did not smoke - 93.4% (CI$_{95}$ 90.6-95.5).

Osteoarticular morbidity was statistically significantly associated with the respondents' living conditions, the age at which menopause occurred, physical exertion and exposure to cold, cold air currents and strong sunlight.

Description of the basic clinical signs of OA and RA

In the group of patients investigated, the most frequent symptom was osteoarticular pain - 84.7% (CI$_{95}$ 81.4-88.0). The following symptoms were statistically significantly associated with the osteoarticular diseases suffered by the subjects included in the B$_{BORON}$: joint pain in the morning and evening associated with limitation of movements and limitation of movement in the joint after inactivity.

The majority of patients in B$_{BORON}$ rated their general condition as bearable - 43.8% (CI$_{95}$ 38.5-49.1) of those suffering from OA and 54.4% (CI$_{95}$ 44.7-63.7) of those with RA.

Most frequently, patients with OA from L$_{OA, RA}$ experienced joint pain of mixed nature - 54.3% (CI$_{95}$ 49.4-59.2), and those with RA - of inflammatory nature - 62.5% (CI$_{95}$ 50.7-74.2). Most frequently, the intensification of pain at night or in cold, damp weather, during exertion was characteristic of patients with RA - 46.9% (CI$_{95}$ 33.9-59.1), and without intensification most often the evolution of OA passed - 79.8% (CI$_{95}$ 75.4-84.1).

Approximately half of the OA patients included in the L$_{OA, RA}$ did not experience morning stiffness - 46% (CI$_{95}$ 40.6-51.6). In the case of RA patients, morning stiffness was most frequently prolonged, lasting over 20 min - 64.1% (CI$_{95}$ 51.9-75.4).

Approximately half of the OA patients included in the L$_{OA,RA}$ did not experience morning stiffness - 46% (CI$_{95}$ 40.6-51.6). In the case of RA patients, morning stiffness was most frequently prolonged, lasting over 20 min - 64.1% (CI$_{95}$ 51.9-75.4). More frequently, increased values were observed in RA patients - 21.9% (CI$_{95}$ 12.3-32.4).

Almost half of the patients with OA - 41.9% (CI$_{95}$ 36.5-46.7) and more than half of those with RA - 57.8% (CI$_{95}$ 45.9-70.7) had C-reactive protein above 3 mg/dL in the blood, which indicated a high risk for the occurrence of inflammatory reactions in the body. Most patients with OA and RA included in L$_{OA,RA}$ had rheumatoid factor values within the normal range (below 14 IU/ml) - 58% (CI$_{95}$ 53.1-63.0). More often, it was increased in patients with RA - 21.9% (CI$_{95}$ 12.3-32.7) compared to those suffering from OA - 13.4% (CI$_{95}$ 9.7-17.1).

Most patients with OA and RA included in L$_{OA, RA}$ had normal blood erythrocyte values (4.2-5.6 * 106/µl for men and 3.8-5.3 * 106/µl for women) - 74.9% (CI$_{95}$ 70.5-78.8). The majority of the studied group of patients - 77.2% (CI$_{95}$ 73.1-81.3) had normal blood platelet levels (150-450 103/uL). More than half of the studied group had blood eosinophil values within the normal limits (0.5-5%) - 67.4% (CI$_{95}$ 63.0-72.0). Half of the patients included in L$_{OA,RA}$ had normal blood fibrinogen values (200-400 g/l) - 49% (CI$_{95}$ 44.3-53.6).

Synthesis of current recommendations for improving the clinical picture of OA and RA

The recommendations regarding the improvement of the condition of the osteoarticular system were collected, largely, from the medical histories of patients with OA and RA and meet the doctors' indications that were to be implemented by patients after leaving the specialized ward.

In terms of dietary recommendations, diet no. 5, for normalizing liver and biliary tract functions, was the most frequently recommended, especially for patients with RA - 84.4% (CI$_{95}$ 74.6-92.7). At the second place was diet no. 10, the purpose of which is to improve the activity of the cardiovascular system, prescribed more frequently for patients with OA - 19.3% (CI$_{95}$ 14.6-23.5). A statistically significant association was found between the recommended diet and morbidity from OA and RA (χ2 = 22.512, df=3, p<0.001).

The most frequently recommended dietary supplements were calcium and vitamin D3, both in the case of OA - 58.1% (CI$_{95}$ 52.8-63.7), and RA - 75% (CI$_{95}$ 63.2-85.2). A statistically significant association was detected between the recommended dietary supplements and the investigated morbidities (χ2 = 8.140, df=2, p=0.017).

The recommendation to exclude or limit physical exertion was more frequently offered to patients with RA - 93.8% (CI$_{95}$ 87.3-98.6), but also to the majority of patients with OA - 82% (CI$_{95}$ 77.7-86.0). A statistically significant association was established between the recommendation to exclude physical exertion and morbidity from OA and RA (χ2 = 5.479, df=1, p=0.019).

3.5. Comparative characteristics of boron intake and osteoarticular morbidity in various areas of the Republic of Moldova

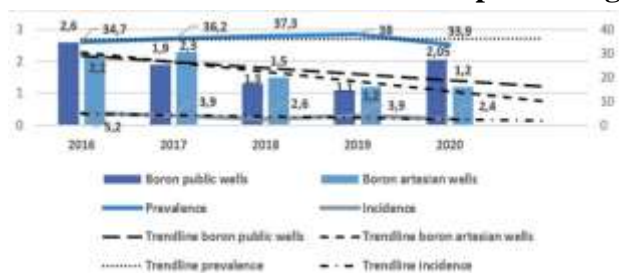**Boron above-the-limit area in deep drinking water**

Figure 7. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Ciadir-Lunga district, 2016-2020**

Detailed analysis of boron concentration in deep drinking water and morbidity indicators in the Ciadir-Lunga district shows that prevalence values for rheumatoid arthritis and inflammatory polyarthropathies increased during the period when boron concentration in deep waters was decreasing (2018-2019) (Figure 7).

The trend of decreasing boron concentration in water from public wells and artesian wells in the Ciadir-Lunga district, along with a slight increase in the prevalence and decrease in the incidence of rheumatoid arthritis and inflammatory polyarthropathies in adults from the same area during the period 2016-2020, is subject to the laws described by the equations:

$Y_{boron\ artesian\ wells} = -0,175x + 2,4429; R^2 = 0,6138; Y_{boron\ wells} = -0,1964x + 2,4643; R^2 = 0,4522$

$Y_{prevalence} = 0,02x + 35,94; R^2 = 0,0003; Y_{incidence} = -0,56x + 5,84; R^2 = 0,6054$

Boron limit area in deep drinking water
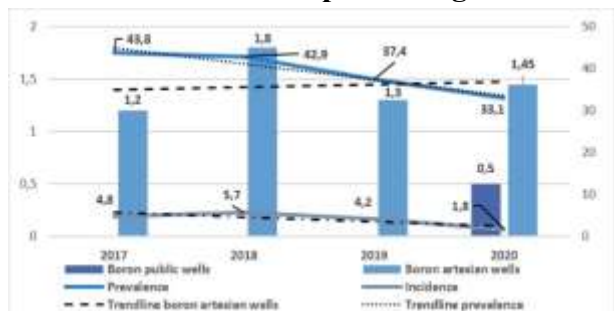
mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Comrat district, 2017-2020

In Comrat district, increasing concentrations of boron in deep drinking water overlapped with the trend of decreasing population morbidity indicators due to rheumatoid arthritis and inflammatory polyarthropathies (figure 8).

The trend of decreasing prevalence and incidence of adults with rheumatoid arthritis and inflammatory polyarthropathies and increasing boron concentration in

deep drinking water in Comrat district during 2017-2020 is represented by the equations:

$Y_{\text{boron artesian wells}} = 0,055x + 1,315; R^2 = 0,1245; Y_{\text{boron wells}} = 0,2x - 0,3; R^2 = 1$

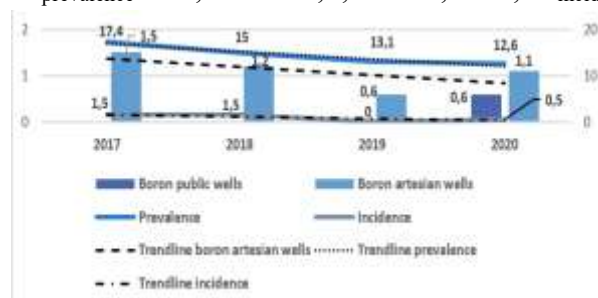$Y_{\text{prevalence}} = -3,76x + 48,7; R^2 = 0,9393; Y_{\text{incidence}} = -1,05x + 6,75; R^2 = 0,6604$

Figure 9. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Vulcanesti district, 2017-2020**

In the second district with the limit boron concentration in deep drinking water, Vulcanesti, the boron concentration in deep drinking water and the morbidity of adults with osteoarticular pathologies studied did not confirm the benefit of boron for osteoarticular health, since in the years with the highest boron concentration in artesian well water (2017-2018) both the prevalence and the incidence of adults with osteoarticular pathologies were the highest (figure 9).

At the same time, the trend of both boron concentration in deep drinking water and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies was decreasing, following the laws described by the equations:

$Y_{\text{boron artesian wells}} = -0,1086x + 1,3467; R^2 = 0,1524; Y_{\text{boron wells}} = -0,2x + 1,4; R^2 = 1$

$Y_{\text{prevalence}} = -1,63x + 18,6 ; R^2 = 0,9337; Y_{\text{incidence}} = -0,45x + 2 ; R^2 = 0,6$

Boron below-the-limit area in deep drinking water

Figure 10. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Cahul district, 2016-2020**

In the case of Cahul district, located in the below-the-limit area of boron in deep drinking water, in 2016, when the boron concentration in water from public wells and artesian wells recorded the highest values, although the prevalence of adults with rheumatoid arthritis and inflammatory polyarthropathies recorded maximum levels, the incidence is at the lower limit for the period 2016-2020 (figure 10).

For the period 2016-2020, the trend of both boron concentration in deep drinking water and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies was decreasing, determined by the equations below:

$Y_{\text{boron artesian wells}} = -0,0113x + 0,9446; R^2 = 0,0105; Y_{\text{boron wells}} = -0,1442x + 1,2144; R^2 = 0,8768$

$Y_{\text{prevalence}} = -0,14x + 11,9; R^2 = 0,054; Y_{\text{incidence}} = -0,12x + 3,42; R^2 = 0,0769$
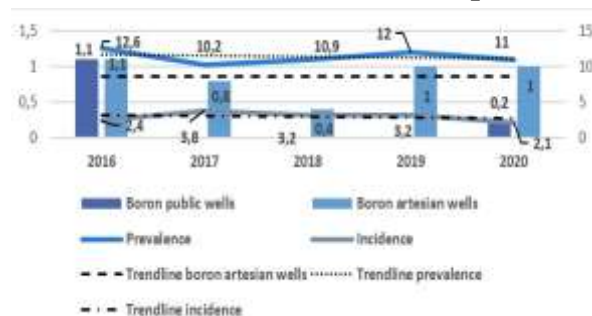

Figure 11. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Calarasi district, 2016-2020**

In Calarasi district, fluctuations in boron in public well and artesian well water and the prevalence of rheumatoid arthritis and inflammatory polyarthropathies in adults were consistent with the research theory. Thus, in 2020, when the boron concentration in public wells and artesian wells was the highest in the research period, the prevalence recorded minimum values (figure 11).

This fact is also reflected in the trend of increasing boron concentrations in deep drinking water and decreasing prevalence of adults with rheumatoid arthritis

and inflammatory polyarthropathies during the period 2016-2020, described by the equations:

$Y_{\text{boron artesian wells}} = 0{,}0516x + 0{,}4019; R^2 = 0{,}4651; Y_{\text{boron wells}} = 0{,}0442x + 0{,}0654; R^2 = 0{,}7825$

$Y_{\text{prevalence}} = -1{,}48x + 35{,}78 ; R^2 = 0{,}862; Y_{\text{incidence}} = 0{,}18x + 1{,}82 ; R^2 = 0{,}3894$
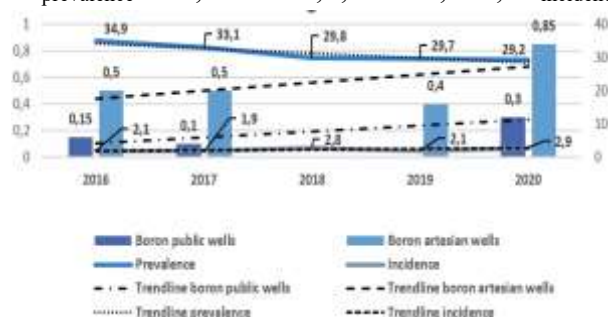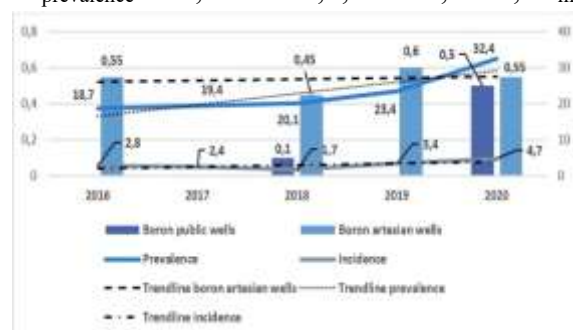

Figure 12. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Briceni district, 2016-2019**

$Y_{\text{boron wells}} = 0{,}0167x + 0{,}3667; R^2 = 0{,}0577$

$Y_{\text{prevalence}} = -2{,}35x + 29{,}2; R^2 = 0{,}3157; Y_{\text{incidence}} = -0{,}33x + 4{,}48; R^2 = 0{,}2321$

In Briceni district in 2018, both the prevalence and incidence of rheumatoid arthritis and inflammatory polyarthropathies in adults increased against the background of a decrease in boron concentration in water from public wells and artesian wells (figure 12).

The trend of increasing boron concentration in deep drinking water and decreasing prevalence and incidence of rheumatoid arthritis and inflammatory polyarthropathies in adults in Briceni district for the period 2016-2019 is determined by the equations:

$Y_{\text{boron artesian wells}} = 0{,}0118x + 0{,}2424; R^2 = 0{,}0535;$

At the same time, in Drochia district, the positive influence of boron on osteoarticular health is not confirmed, in 2020 both the boron values in deep drinking water and those of osteoarticular morbidity of adults in the area recorded maximum values for the researched period (figure 13).

The trend in boron concentration in artesian well water and the prevalence and incidence of rheumatoid arthritis and inflammatory polyarthropathies in adults has been increasing:

Figure 13. **Boron concentration in deep drinking water, mg/l and adult morbidity from rheumatoid arthritis and inflammatory polyarthropathies per 10 thousand inhabitants, Drochia district, 2016-2020**

$Y_{\text{boron artesian wells}} = 0{,}0244x + 0{,}4221; R^2 = 0{,}3798;$

$Y_{\text{prevalence}} = 3{,}14x + 10{,}24; R^2 = 0{,}7692;$

$Y_{\text{incidence}} = 0{,}48x + 1{,}08 ; R^2 = 0{,}4482.$

DISCUSSIONS

Daily boron intake in the boron above-the-limit area in deep drinking water

The specifics of drinking water consumption in the district classified as above-the-limit boron in deep drinking water (table 2) reveal that the population included in the research was mostly indigenous, the houses were connected to the aqueduct in over 96% of cases, and the water in them came from wells in 85% of cases. About half of the inhabitants consumed water from deep sources (from the water supply network or from public wells) for drinking purposes, for food preparation the share being over 50%. At the same time, in the Ciadir-Lunga district the largest number of people who consume bottled water both for drinking purposes and for food preparation is attested, their share among those who choose to consume bottled water for drinking purposes being 54.3%, and for food preparation – 78.3%.

Based on these observations, we can deduce that the population included in the research in this area was partially influenced by boron, as the water consumed for drinking purposes and for food preparation came in half of the cases from sources other than deep ones (bottled water).

The maximum daily intake of boron was below 2 mg, not reaching the level required for people in the risk group suffering from chronic osteoarticular diseases – 3 mg/day [6], but still higher than 0.4 mg/day – the minimum level that can contribute to osteoarticular health [4].

This area has the highest share of the population consuming less than one serving of fruit/day (64.4%), but also less than 2 servings of vegetables and greens/day (77.8%). At the same time, the consumption of boron-rich products, associated with osteoarticular morbidity, was also modest – around 26% for dried fruits and 40% for sunflower and pumpkin seeds (table 3).

The particularities of drinking water consumption and eating habits in the area, along with the fact that the southern districts of the country (including Ceadir-Lunga) record the highest values of fixed residue in drinking water, which influences osteoarticular morbidity [26], could represent, overall, the cause of the modest effects of boron on the osteoarticular system in the researched district.

Daily boron intake in the boron limit area in deep drinking water

In both selected districts, the majority of patients included in the research were natives (63.6% for Comrat and 73.7% for Vulcănești), the homes of over 95% of people in Comrat and over 81% in Vulcănești being connected to the local aqueduct. Water comes from artesian wells in over 68% of cases in Vulcănești and over 80% in Comrat (table 2). Thus, the majority of respondents in Comrat and Vulcănești districts were influenced by boron in deep drinking water for a long period of time.

The dietary habits in the boron limit area (table 3) confirm that in the Vulcanesti district the population was influenced to a greater extent by boron, as the share of the diet in the daily boron intake is 65%, delivering around 1.2 mg of boron daily. Thus, in Vulcanesti most respondents consumed more than 2 servings of fruit (57.4%) and more than 3 servings of vegetables and greens (55.8%). At the same time, this locality recorded the highest share of people consuming fresh fruits and vegetables regardless of the season (67.2%). However, in the Comrat district the consumption of products associated with osteoarticular morbidity was practically double compared to that in Vulcanesti (58.3% for dried fruits and 78.6% for seeds).

The maximum daily intake of boron in this area was 2 mg (table 2).

Daily boron intake in the boron below-the-limit area in deep drinking water

Of the four districts located in the below-the-limit area of boron in deep drinking water, in the Briceni district, where the idea of the positive influence of boron on osteoarticular morbidity was confirmed, the share of the indigenous population was the highest – over 93%, 100% of the homes of those included in the study being connected to the water supply network, where the water came in all cases from artesian wells. At the same time, in this locality the highest share of consumption of network water for drinking purposes (86.2%) and for food preparation (96.5%), but also the lowest share of consumption of well water for both purposes (0% for drinking purposes and 3.5% for food preparation) was recorded. In all four districts studied in the below-the-limit area, most respondents consumed between 1.5 and 2 l of water daily (table 2).

Cahul district was the only locality studied where in 13% of cases the water came from the river, the population being partially influenced by boron in deep drinking water.

The boron intake in the Briceni district was a maximum of 0.8 mg/day, less than in Calarasi, Cahul and Drochia, where the maximum figures reached 1-1.8 mg/day. Thus, we can deduce that in Briceni the influence of boron from deep drinking water (from artesian wells) was more pronounced due to the connection of all homes to the aqueduct that delivers water from the wells and its massive consumption by the population in the area.

Dietary habits in Briceni (table 3) – daily consumption of 1-2 servings of fruit (86.2% respondents) and 2-3 servings of vegetables and greens (75.9% respondents), along with a considerable consumption of boron-rich products, associated with osteoarticular morbidity (69% for dried fruits and 62.1% for sunflower seeds) confirm that a balanced and varied diet containing sufficient vegetables can positively influence the osteoarticular system.

In comparison, in Drochia district, where the positive influence of boron on osteoarticular health was not confirmed, deep drinking water (from the network and from the well) was used for drinking purposes by 55% of respondents, and for food preparation – by 69.9%. The indigenous population in Drochia made up 77.5% of respondents, the share of households connected to the water supply network being 70%, and water coming from artesian wells in 62.5% of cases (table 2). At the same time, in this locality the recommendation to consume 5 servings of fruits and vegetables/day was followed by fewer respondents, and the share of those who consumed dried fruits was the lowest (23.7%).

Based on these observations, we can deduce that the influence of boron in deep drinking water on osteoarticular morbidity depends both on the duration of water consumption (% of the native population) and on the connection of the dwelling to the water supply network where the water comes from an underground source (artesian well), as well as on the consumption of water for drinking purposes and for food preparation from underground sources (public wells or artesian wells). At the same time, the daily diet has a more pronounced contribution on the osteoarticular system if both the general WHO recommendation of consuming 5 servings of fruits and vegetables/day is followed and boron-rich products associated with osteoarticular morbidity are consumed in a considerable proportion.

Characteristics of morbidity due to osteoarthritis

According to the synthesis of the Chi-square test results, among the factors associated with morbidity from OA and RA, in both groups studied – age, duration of illness and living and working conditions. In the case of $B_{OA, RA}$ – gender and age of onset of menopause, and in the case of B_{BORON} – genetic predisposition, physical effort exerted at work, the district and locality of residence of the subjects and exposure to cold, cold air currents and strong sunlight.

Although a statistically insignificant association was established between BMI and morbidity from OA and RA, this parameter has a considerable influence on osteoarticular morbidity, a BMI located in the overweight area contributing to mechanical wear of the joints, especially the knee [27]. Considering that 44.7% of OA patients in B_{BORON} were obese, and the concentration of boron in the blood is inversely correlated with BMI values [28] and directly correlated with a balanced diet rich in boron [29], ensuring an adequate daily intake of this microelement from all sources is important for improving the condition of the osteoarticular system.

Patients included in B_{BORON} most frequently suffered from joint pain – on movement (86%) or in the morning and evening, with limited movement (54.3%). The nature of pain in the case of $B_{OA, RA}$ was most frequently mixed (54.3%), without intensification (79.8%), and was often not accompanied by morning stiffness (46%). Joint crepitations, another clinical sign for the diagnosis of OA [21], were encountered in 30.4% of cases.

Given that dietary boron supplements have the potential to improve OA symptoms [30], including reducing joint discomfort [11, 27] and decreasing C-reactive protein levels [11, 12, 13], and that boron supplements are at the top of the pyramid of healthy eating for OA patients [31], along with the fact that 37.3% of patients in $B_{OA, RA}$ did not receive dietary supplementation recommendations, we consider it appropriate to include boron supplements in the list of recommendations offered to OA patients. Of the dietary boron supplements, calcium fructoborate, which delivers 6 mg of boron/day for 8 weeks, has proven to be the most effective [4, 13, 14], including as an additional to classical therapy [11].

Considering that daily consumption of boron-rich water (containing over 1 mg boron/l) contributes to increasing osteocalcin levels in the blood of postmenopausal women [32], OA patients from areas of the country with varying boron concentrations in deep drinking water should adjust their daily drinking water consumption so as to ensure the minimum necessary amount of this microelement for maintaining bone mass.

Thus, if the population followed the general recommendations of daily consumption of 2 liters of water, and this contained 1 mg boron/l, around 2 mg of boron would be consumed daily through drinking water.

In the above-the-limit area of boron in deep drinking water, due to a consumption of mostly 0.5-1 l of water/day, the daily boron intake does not reach 2 mg/day. Increasing the consumption of drinking water to 1.5-2 l/day would ensure the necessary boron intake (2.55-3.4 mg/day). In the limit area, the intake of 2 mg boron/day is ensured both in Comrat and Vulcanesti districts due to the frequent consumption of more than 2 l of water/day. From the below-the-limit area, in Cahul district, an increase in the amount of water consumed daily to at least 2.5 l would ensure a maximum intake of 2.25 mg boron/day. In the other districts, to reach the daily dose of 2 mg boron taken from water, it is necessary to increase water consumption to over 3.5 l of water/day.

Considering that this consumption could be difficult for a large part of the population in the area, in this case it is useful to consider taking boron supplements to strengthen bone mass.

According to figures 2 and 3, most of the analyzed districts are located in the below-the-limit area of boron in deep drinking water. In localities where the boron concentration is above 0.7 mg/l, adjusting the daily consumption of drinking water from underground sources to 3 l/day would provide 2.1 mg boron/day, which may contribute to strengthening bone mass. If this concentration is below 0.7 mg/l, adjusting the daily water consumption will be difficult for the majority of the population, so the administration of boron supplements could be considered.

Among the dietary habits characteristic for B_{BORON}, those statistically significantly associated with OA and RA morbidity were the number of servings of fruits, vegetables and greens consumed per day, as well as the frequent consumption of dried fruits and sunflower and pumpkin seeds as a source of boron in the diet.

Dried fruits were consumed by 44.7% of OA patients, and sunflower and pumpkin seeds by 60.9% of respondents. Considering that the consumption of dried fruits (especially prunes), as a source of boron, contributes to the maintenance of bone mass [33], their inclusion in the daily diet of OA patients should be considered.

Characteristics of morbidity due to rheumatoid arthritis

Of the clinical features statistically significantly associated with morbidity from OA and RA in both groups studied, morning and evening joint pain associated with movement limitation was characteristic for 31.1% of RA patients, and movement limitation after inactivity for 18.4% of respondents. The most frequent qualification given to the state of the osteoarticular system was "tolerable" (54.4%). The nature of the pain experienced was most frequently of inflammatory origin (62.5%), predominantly without intensification (53.1%), and the duration of joint pain – over 20 minutes (64.1%).

Given that some phytochemicals, including boron compounds, have the ability to reduce oxidative damage induced by inflammation [17] and to reduce serum levels of C-reactive protein [9], combining classical therapy with dietary supplements containing calcium fructoborate would be a solution to reduce the symptoms, including those described above, experienced by patients [17]. In this regard, the dose of calcium fructoborate that has shown results is 108 mg 2 times/day or 216 mg in a single dose/day [27], including in combination with Etanercept [17].

The majority of respondents consumed tap water, both for drinking purposes (43.7%) and for food preparation (59.2%). This came in most cases from artesian wells (79.6%), and was assessed as satisfactory (64.1%).

Dried fruits were consumed by 26% of patients with RA, while sunflower and pumpkin seeds by 48%. Given that a Mediterranean diet rich in plant products can contribute to reducing RA symptomatology [34],

maintaining the consumption of five servings of fruits and vegetables, along with the more frequent consumption of dried fruits and sunflower and pumpkin seeds that are significantly associated with the osteoarticular morbidity studied, is welcome.

Preventive measures for osteoarticular morbidity studied, conditioned by the boron concentrations in the drinking water consumed

Osteoarthritis prevention measures

Taking into account the results obtained in this research, for patients with OA, including in the National Clinical Protocol NCP-86, to the usual recommendations for the treatment of the condition with medication, by opting for an active lifestyle, reducing body weight and using joint support means [21], we consider it appropriate to add the following:

- adjusting the amount of water consumed/day, from deep sources, depending on the boron concentration in it – 1.5-2 l/day in regions with above the boron limit, over 2 l/day in those with the boron at the limit and between 2.5 and 3.5 l/day in those below the boron limit;

- in areas where the boron concentration in deep drinking water (public wells and artesian wells) is below 0.7 mg/l – supplementing the diet with boron products, preferably calcium fructoborate with a daily boron intake of 6 mg. The duration of a course of treatment will be at least 8 weeks. The periods of administration of boron supplements should not overlap with those of administration of vitamin D.

- following a balanced diet, mainly plant-based by consuming 5 daily portions of fruits, vegetables and greens, especially dried fruits, sunflower seeds and pumpkin.

Rheumatoid arthritis prevention measures

In order to reduce the symptoms experienced by patients with rheumatoid arthritis, in addition to those of medication, weight loss and physical exercise [22], in the National Clinical Protocol NCP-75, we consider it appropriate to introduce additional recommendations:

- to increase the daily intake of boron, drinking water from deep sources (artesian wells or public wells) in quantities of over 2 l/day;

- combining the administration of Etanercept with calcium fructoborate in doses of 108 mg 2 times/day or 216 mg in a single dose/day, especially in the case of patients from areas below the boron limit in deep drinking water;

- following a Mediterranean diet with daily consumption of five servings of fruits and vegetables, dried fruits and sunflower and pumpkin seeds.

GENERAL CONCLUSIONS

1. Mapping the territory of the Republic of Moldova based on the multiannual average concentrations of boron in deep drinking water shows that during the research period in water from public wells, the figures were practically in all cases in the sub-limit area of boron concentration (0-1 mg/l), with the exception of Vulcanesti district, which was ranked in the above-the-limit area (1.7 mg/l). In the case of water from artesian wells, although for most regions the below-the-limit boron concentration was obtained, in Comrat and Taraclia districts it was at the limit (1.5 and 1.4 mg/l respectively), and in Ceadâr-Lunga district – at the above-the-limit (1.7 mg/l). The lowest concentration of boron in deep drinking water was recorded in the districts of Cimislia (0.01 mg/l in artesian wells) and Basarabeasca (0.02 mg/l in artesian wells), and the highest – in the district of Ceadâr-Lunga (1.7 mg/l in both public wells and artesian wells).

2. Morbidity from OA and RA was statistically associated with factors such as age, sex, duration of illness, age of onset of menopause, genetic predisposition, physical exertion, place of residence, exposure to cold, cold air currents and strong sunlight, and living and working conditions.

3. A weak positive correlation was established between the average boron concentrations in the water from artesian wells and the average values of the incidence and prevalence of adults with rheumatoid arthritis and inflammatory polyarthropathies during the research period.

4. To strengthen the osteoarticular system and prevent the occurrence of OA and RA, it is recommended to consume deep drinking water in quantities that would deliver at least 2 mg of boron daily. For residents of the boron-limit area, this amount can be ensured by 1.5-2 l of water/day, in the limit area of 2.5 liters, and in the below-the-limit area – over 3.5 liters. In regions where the boron concentration in deep drinking water is less than 0.7 mg/l, the necessary boron intake can be obtained from adequate water consumption and a diet supplemented with boron preparations, preferably calcium fructoborate.

5. Although at the population level, following the analysis of multiannual averages of boron concentrations in deep drinking water and morbidity from RA and inflammatory polyarthropathies, the benefits of boron for osteoarticular health have not been confirmed, the separate analysis of osteoarticular morbidity in the below-the-limit, limit and above-the-limit areas of boron in deep drinking water attests to trends that confirm the positive impact of boron on the osteoarticular system. The manifestation of the positive effects of boron on osteoarticular morbidity, reflected in the reduction of the incidence and prevalence figures of RA and inflammatory polyarthropathies, is possible following the frequent consumption of deep water both for drinking purposes and for food preparation, even if the boron concentration is in the below-the-limit area.

PRACTICAL RECOMMENDATIONS

- **Recommendations for decision-makers (Ministry of Health, Ministry of Environment):**

1. Addressing, in normative documents, practical guides and population-oriented recommendations, the microelement boron naturally present in the environment as a fortifier of osteoarticular health and abandoning its status as an element dangerous to human health.

2. Ensuring improved water quality by maintaining the natural concentration of boron in deep drinking water and abandoning water treatment methods that have the potential to reduce the presence of this mineral.

3. Supplementing the National Clinical Protocols NCP-75 and NCP-86 with recommendations aimed at adjusting boron intake through diet and drinking water consumed.

- **Recommendations for the executing and implementing authorities (Environmental Agency, "Apele Moldovei" Agency, National Agency for Public Health):**

1. Preventing contamination of surface drinking water with borates from household cleaning products following the discharge of domestic wastewater through the appropriate design and construction of drinking water supply and sewage systems.

2. Prioritizing the construction of drinking water supply systems from underground sources and increasing the coverage of localities with aqueducts.

3. Ensuring permanent monitoring of the microelement boron in groundwater and mapping of areas of the country with various concentrations of it in the drinking water consumed.

4. Collection of data on population morbidity due to various conditions, including osteoarticular pathologies, by age category (not just separately – adults and children) to ensure standardization of morbidity rates in order to exclude variations in the age structure of the population during data interpretation in subsequent scientific studies.

5. Participation in the implementation of the provisions of international policy documents and the harmonization of national legislation with community legislation regarding the concentration of boron in drinking water.

6. Assess the impact of boron from drinking water on health and the functioning of other human organ systems and disease states.

7. Promoting the consumption of drinking water rich in boron to strengthen the osteoarticular system.

- **Recommendations for specialists of the Primary Medical Care Service and Specialized Medical Care (arthrology, orthopedics and rheumatology):**

1. Encouraging patients with OA and RA to consume deep drinking water from the area of residence and providing recommendations for its consumption in accordance with the qualification assigned to the locality of residence – above-the-limit/limit/below-the-limit boron in deep drinking water.

2. Recommending dietary supplementation with boron preparations for patients with OA and RA from areas where the concentration of this microelement in the drinking water consumed is below 0.7 mg/l. Indicating vitamin D supplementation separately from calcium fructoborate.

3. Inclusion of the recommendation to adopt a Mediterranean diet, based predominantly on plant products, especially dried fruits and sunflower and pumpkin seeds, by patients with OA and RA.

- **Recommendations for patients with OA and RA:**

1. Consuming water from the centralized water supply network if it comes from artesian wells and giving up bottled drinking water, both for drinking purposes and for food preparation.

2. Adjusting daily water consumption to 1.5-2 l/day in districts with above-the-limit boron , to 2.5 l/day in those with boron at limit, and to 3.5 l/day in those below-the-limit of boron in deep drinking water.

3. Adopting a diet rich in fruits, vegetables and greens throughout the year and including dried fruits of all types and sunflower and pumpkin seeds in the daily menu.

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INFORMATION ABOUT THE VALORISATION OF THE RESEARCH RESULTS
LIST OF PUBLICATIONS AND PARTICIPATIONS IN SCIENTIFIC FORUMS
of Ms. **Racu Maria-Victoria**, completed for the doctoral thesis in medical sciences,
on the topic „Hygienic assessment of the impact of boron from drinking water on morbidity due to osteoarticular diseases"
Doctoral program 331.02. Hygiene,
doctoral supervisor Pînzaru Iurie, dr. hab. şt. med., assoc. univ.
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- **Articles in international scientific journals:**

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✓ **international**

12. **Racu M-V.** «Влияние бора на костно-суставную систему». *Международная научно-практическая конференция «Здоровье и окружающая среда»,* посвященной 95-летию республиканского унитарного предприятия «Научно-практический центр гигиены», г. Минск, 24–25 ноября 2022 года.

13. **Racu M-V.** „The association between the consumption of boron-rich food and water with above-the-limit boron concentration and osteoarticular morbidity, *XI International Medical and Pharmaceutical Congress of Students and Young Scientists*, Chernivtsi, Ukraine, 2-5 april 2024, III Degree Diploma in section „Medicine online”.

14. **Racu M-V.** „Boron intake of the population from different regions of the Republic of Moldova”, *10th edition of MedEspera International Congress for Students and Young Doctors*, Chisinau, 24-27 April 2024.

15. **Racu M-V.** „Evaluarea igienică a impactului borului din apa potabilă asupra sănătății osteoarticulare”, *Conferința Științifică Internațională, secția Starea mediului ambiant și dezvoltarea durabilă, cu prilejul aniversării a 30 de ani ULIM*, Chișinău, 17-20 octombrie 2022.

✓ **national**

16. **Racu M-V.,** Scorei IR, Pînzaru I. „Influența compușilor borului asupra sănătății cardiovasculare – reviul literaturii”, *Conferința națională cu participare internațională „Un mediu sigur – sănătate protejată”*, Chișinău, 12-13 noiembrie 2020.

17. **Racu M-V.,** Scorei IR. „The role of boron and its compounds in prevention of osteoarticular diseases”. *National Conference with international participation „One health approach in a changing world”*, Chișinău, 4-5 noiembrie 2021.

18. **Racu M-V.,** „Rolul borului în funcționarea sistemului osteoarticular”. *Conferința Științifică anuală a USMF „Nicolae Testemițanu”, „Cercetarea în biomedicină și sănătate: calitate, excelență, performanță”,* Chișinău, 20-22 octombrie 2021.

19. **Racu M-V.** „Rolul borului pentru corpul uman”. *Conferința Națională cu participare Internațională „Apa și sănătatea: realizări și provocări”,* Chișinău, 22 martie 2022.

20. **Racu M-V.** „Estimarea influenței unei diete bogate în bor asupra pacienților cu boli osteoarticulare cronice”, *Conferința științifica pentru tinerii cercetători „Abordări moderne de cercetare în Igienă”.* Chișinău, 19 februarie 2025.

ADNOTARE
Racu Maria-Victoria
„Evaluarea igienică a impactului borului din apa potabilă asupra morbidității prin bolile osteoarticulare”
Teză de doctor în științe medicale, Chișinău, 2026

Actualitatea cercetării: Apa potabilă de profunzime este una din sursele principale de bor în dietă, având potențialul de a influența sănătatea osteoarticulară, ceea ce impune evaluarea impactului acestui microelement asupra bolilor cu tendință în creștere, precum osteoartroza și artrita reumatoidă, și formularea recomandărilor de prevenire specifice.

Scopul cercetării: evaluarea igienică a impactului borului din apa potabilă de profunzime asupra morbidității populației prin osteoartroză și artrită reumatoidă, și elaborarea măsurilor de prevenție.

Obiectivele cercetării: Evaluarea distribuției teritoriale a concentrațiilor borului în apele de profunzime utilizate în scop potabil și efectuarea cartografierii teritoriului Republicii Moldova în baza concentrațiilor determinate; Estimarea morbidității populației prin osteoartroză și artrită reumatoidă; Determinarea

asocierii statistice dintre concentrația borului în apa potabilă de profunzime și morbiditatea prin osteoartroză și artrită reumatoidă; Elaborarea măsurilor de prevenție a osteoartrozei și a artritei reumatoide condiționate de concentrația borului în apa potabilă de profunzime.

Noutatea și originalitatea științifică se rezumă la abordarea borului ca un fortifiant al sănătății osteoarticulare, aportul zilnic al căruia urmează a fi ajustat prin intermediul apei potabile consumate.

Rezultatele noi obținute constau în cercetarea în premieră a influenței borului asupra sănătății osteoarticulare, realizarea cartografierii teritoriului Republicii Moldova în conformitate cu concentrațiile borului în apa potabilă de profunzime, ceea ce va permite identificarea regiunilor în care localnicii sunt mai vulnerabili la patologiile osteoarticulare cronice, iar măsurile de profilaxie elaborate vor contribui la gestionarea eficientă a acestora.

Semnificația teoretică se rezumă la faptul că prezenta cercetare face parte din politicile naționale de sănătate publică care vizează calitatea apei potabile și impactul acesteia asupra sănătății populației.

Valoarea aplicativă constă în elaborarea măsurilor de prevenire a bolilor osteoarticulare în raport cu concentrația borului în apa potabilă de profunzime, a metodei de evaluare a aportului de bor din diferite surse care poate fi aplicată de specialiștii din instituțiile competente pentru a influența concentrațiile borului în apa potabilă consumată.

Implementarea rezultatelor științifice s-a efectuat prin validarea lor la saloane naționale și internaționale de invenții, la conferințe naționale și internaționale, cu valorificarea acestora atât în mediul academic și în formarea specialiștilor, cât și în activitatea practică a specialiștilor din domeniul evaluării riscurilor de mediu și a cercetării științifice în domeniul biochimiei.

Structura tezei: introducere, 3 capitole, discuții, concluzii generale și recomandări practice, bibliografie din 134 surse, 14 anexe, 177 pagini de text de bază, 22 tabele și 83 figuri, 11 lucrări științifice, un certificat de inovator și două materiale la saloane de invenții.

Cuvinte-cheie: bor, apă potabilă de profunzime cu diverse concentrații de bor, artrită reumatoidă, osteoartroză, boli osteoarticulare, cartografiere bor, prevenție.

ANNOTATION
Racu Maria-Victoria
„Hygienic assessment of the impact of boron from drinking water on morbidity due to osteoarticular diseases"
PhD Thesis in Medical Sciences, Chisinau, 2026

The actuality of the research: Deep drinking water is one of the main sources of boron in the diet, having the potential to influence osteoarticular health, which requires the assessment of the impact of this microelement on diseases with a growing trend, such as osteoarthritis and rheumatoid arthritis, and the formulation of specific prevention recommendations.

Research purpose: hygienic assessment of the impact of boron in deep drinking water on the morbidity of the population due to osteoarthritis and rheumatoid arthritis, and the development of prevention measures.

Research objectives: Assessment of the territorial distribution of boron concentrations in deep waters used for drinking purposes and mapping the territory of the Republic of Moldova based on the determined concentrations; Estimation of the population morbidity due to osteoarthritis and rheumatoid arthritis; Determination of the statistical association between the boron concentration in deep drinking water and the morbidity due to osteoarthritis and rheumatoid arthritis; Development of measures to prevent osteoarthritis and rheumatoid arthritis included in the boron concentration in deep drinking water.

The scientific novelty and originality are summarized in the approach of boron as a fortifier of osteoarticular health, the daily intake of the following course to be adjusted through the consumed drinking water.

The new results obtained consist in the premiere research of the influence of boron on osteoarticular health, the mapping of the territory of the Republic of Moldova according to boron concentrations in deep drinking water, which will allow the identification of regions where local residents are more vulnerable to chronic osteoarticular pathologies, and profiling measures of the effective contribution to management will be developed.

The theoretical significance is that the research is part of the national public health policy aimed at the quality of drinking water and the impact on the health of the population.

The applied value consists in the development of measures to prevent osteoarticular diseases in relation to boron concentrations in deep drinking water, of methods for assessing boron intake from different sources that can be applied by specialists from competent institutions to influence boron concentrations in consumed drinking water.

The implementation of the scientific results was carried out by validating them at national and international invention salons, at national and international conferences, with the use of these both in the academic environment and in the training of specialists, as well as in the activity of specialists in the field of environmental risk assessment and scientific research in the field of biochemistry.

Thesis structure: introduction, 3 chapters, discussions, general conclusions and practical recommendations, bibliography from 134 sources, 14 appendices, 177 pages of basic text, 22 tables and 83 figures, 11 scientific papers, an innovator's certificate and two materials at invention salons.

Keywords: boron, deep drinking water with various boron concentrations, rheumatoid arthritis, osteoarthritis, osteoarticular diseases, boron mapping, prevention.

RACU, **Maria-Victoria**

HYGIENIC ASSESSMENT OF THE IMPACT OF BORON FROM DRINKING WATER ON MORBIDITY DUE TO OSTEOARTICULAR DISEASES

331.02 – HYGIENE

Summary of the thesis of doctor in medical sciences