Territorial Inequalities of Medicinal Waters, as Natural Healing Factors, in Hungary

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Abstract: The geographical occurrence of natural medicinal factors and their use in medical tourism, show differences in different countries and nations. The hydrogeological situation of Hungary is unique in Europe, thanks to the outstanding quantity and quality of medicinal waters. This natural healing factor provides the basis of the country's medical tourism and plays a prominent role in the spa treatment of musculoskeletal issues for patients. Due to the increasing value of health and the tourist importance of medicinal waters, the development of spa towns with a view to the sustainability of natural healing factors is becoming more and more important, for which it is important to reduce territorial inequalities. Accordingly, our research aims to map the territorial inequalities of Hungarian medicinal waters using the polarization and distribution indicators of territorial research. From our results, we concluded that the territorial inequality and concentration of medicinal waters, are relatively low in Hungary, which indicates a small territorial inequality. Among the country's NUTS3 areas, the counties of the Northern and Southern Great Plains region, Zala, Vas, and Heves County and Budapest, are the most developed, in terms of medicinal waters. On the one hand, these results provide guidelines for spa town decision-makers regarding the need to equalize territorial inequalities in the area of natural healing waters. On the other hand, our results can assist with the planning of further development of settlements along with the development of spa treatments, based on the local medicinal water. In addition, our results also highlight the need for further research on the topic, to ensure the optimal and sustainable use of medicinal waters, as well as to meet the needs of the public and the various service providers.

Keywords: medical tourism; medicinal water; natural healing factor; territorial inequality

1 Introduction

Only 0.6% of the Earth's water resources are groundwater resources [29, 43, 76]. The underground aquifer formations of different ages and properties resulted in diverse types of groundwater resources. In the use of underground water resources, the provision of drinking water [77], agricultural and industrial utilization (e.g., geothermal energy), and spa treatment (tourism and health care) are prominent in the world, in which the use of thermal and mineral waters plays a prominent role. [1, 11, 16, 26, 28, 53, 75]. The processing of the literature on the international data of thermal, mineral and medicinal plants is briefly summarized below. The occurrence of thermal waters exist in several countries (Japan, Israel, Iceland, New Zealand), but in Europe (France, Italy, Hungary, Spain, Germany, Austria, Romania, Czech Republic) availability is particularly outstanding [7] [20]. There are 480 thermal and mineral springs in Italy [30], more than 1000 in Turkey [66], and 8500 in Romania [54]. In terms of the natural healing factors, Germany ranks first in Europe [80], but thermal and mineral waters can also be found in Switzerland [17] and the Czech Republic [61]. In addition to the countries famous for their significant number of natural healing factors, these natural features also form the

basis of medical tourism in other countries. Slovakia is also relatively rich in thermal and mineral waters, whose spa tourism, according to Matlovičová et al., is based on the services of 31 spas located in the country's 21 spa towns [50]. According to the Tourism Organization of Serbia (TOS), Serbia has more than 1,000 thermal and mineral water sources, as well as many other natural healing factors (healing muds and healing gases), thanks to its geographical features [78]. In Vojvodina alone, 73 hydrothermal drillings were carried out until the end of 1998, the number of which continued to increase at a slower rate after that [44], with nature conservation and sustainable tourism aspects increasingly in mind nowadays [68]. This rate is 75% in several European countries, and more than 95% in Hungary [67, 73].

Based on the research of MUNTEANU et al. [55], the health use of natural medicinal agents has spread in many areas of the world. This is mainly manifested in the medicinal use of mineral and thermal waters in the Middle East, Southeast Europe, Asia, South America and North Africa. In the Middle East and North Africa, the recreational use of beach climate therapy is most typical, but medicinal use also appears in several countries (Israel, Tunisia, Turkey) [2] [69]. In Asia, spiritual, religious and recreational use is the most widespread in the spirit of holistic thinking [65], and in America the use of thermal and mineral waters can be linked to ancient sacred cults, which became part of the tourism system with the development of the wellness spa movement [66]. In many countries of Europe (Germany, France, the Czech Republic, Austria, Romania, Hungary) and in recent decades in America, the possibilities offered by spas have been integrated into the range of health services [33] [46].

In Hungary, underground aquifer formations of different ages and features resulted in diverse types of underground water resources [45]. As a result, there is a wide range of opportunities for the use of water measured in international terms [51].

Hungary’s hydrogeological properties are well-known worldwide, thanks to which it has an outstanding amount and quality of natural healing factors, including thermal and mineral water reserves. The use of this water resource is wide-ranging, but it is most prominent in medical tourism [39], during the use of certified medicinal waters for medicinal purposes [36].

The name of medicinal water in Hungary is regulated by EüM decree 74/1999. (XII. 25) [5]. The scope of the decree covers both the producers of medicinal water and those engaged in health service activities using this natural healing factor.

To be declared a medicinal water, mineral water has fulfilled several requirements. In addition to bacteriological, hydrogeological and public health tests, a medical study required, which clearly proves the healing effect of the water for external or internal use. The purpose of classification as medicinal water is that the thermal mineral water intended to be used as medicinal water by 74/1999. (XII. 25.) Based on one EüM decree, it must be proven to be medicinal water and thus, be chemically and bacteriologically flawless. In Hungary, the classification as medicinal water

was previously authorized by the National General Administration of Spas and Spas (OGYFI), then by the National Office of the Chief Medical Officer (OTH), and currently by the Government Office of the Capital City of Budapest, if the necessary criteria are met. During the procedure, it is necessary to carry out a comparative or follow-up medical examination, which significantly confirms the healing effect of the given water in the case of the examined disease [20, 37, 60]. From a medical point of view, the declaration as medicinal water is effective if the tested pathological symptom parameters show a significantly favorable result in at least 51% compared to the control group, and based on these results, on the recommendation of the competent Professional College, the tested water is declared as medicinal water [22, 60, 63]. In Europe, Hungary has the strictest process for declaring medicinal water [8].

74/1999. (XII. 25.) based on the wording of the EüM decree, we call those natural mineral waters that have a proven and verified medicinal effect "medicinal water". Medicinal waters can be classified into seven main groups according to their composition and are suitable for the treatment of different types of diseases (Table 1).

Table 1

Types and areas of use of medicinal waters in Hungary

The type of medicinal water (based on composition)	Disease or group of diseases
Salt water (calcium chloride, magnesium chloride)	- Gynecological diseases - Urological diseases - Dermatological inflammatory diseases
Carbonated (sour) **waters**	Cardiovascular diseases
Alkaline or calcareous waters (sodium bicarbonate, calcium bicarbonate, magnesium bicarbonate)	Musculoskeletal and rheumatological symptoms
Iron waters	Gynecological chronic inflammations
Iodine, bromine waters	- Hypothyroidism - Stress; sleep disorder - Peripheral joint diseases - Gynecological inflammations - Urological inflammations
Sulphate, sulphide (sulfur) **waters**	Dermatological symptoms
Radioactive waters	- Inflammatory rheumatological diseases - Hormonal diseases - Metabolic diseases

Source: [17]

The effectiveness of domestic medicinal waters is supported by numerous international and domestic publications in a meta-analysis [9], as well as in additional publications [6] [10]. Based on the research results of the past decades, it became possible to determine the applicability of domestic medicinal waters according to their chemical composition according to different diseases and disease groups [21] [31]. Based on several decades of empirical and evidence-based medicine (EBM) balneological research results, which are increasing nowadays, it can be concluded that domestic medicinal waters and other natural healing factors are a therapeutic option for many chronic health problems. Most of the medicinal waters are of outstanding importance in the treatment of locomotor diseases and are available in many settlements in Hungary.

In Hungary, the primary field of application of medicinal water treatments, or balneotherapy, is the treatment of musculoskeletal diseases, which, in addition to health care, also forms the basis of medical tourism. Thanks to this, the situation of our country is well known, according to which our country has an absolute advantage compared to other countries and a comparative advantage compared to the countries of the European Union in terms of tourism based on medicinal water [71].

The multifactorial system of medical tourism has a complex effect on social and economic processes, in which context it fits well into the diverse world of social geography. Accordingly, we consider it essential to emphasize the definition of regional differences in natural healing factors, including medicinal waters as health products [12, 62, 74]. Reducing growing regional inequalities in health and medical tourism can be an important part of the planning of spa town developments and the cooperation of those involved [4, 13, 14, 23, 38, 72]. In the globalized offer of medical tourism, Hungary can have a competitive advantage if it can provide special tourist services using medicinal waters as natural healing factors [49]. This is especially relevant in the period after the COVID-19 pandemic [24] [41].

Our research aims to explore and define the territorial inequalities of medicinal waters as natural healing factors in Hungary to promote the development of spa towns.

2 Materials and Methods

To achieve our research goal, we used the Hungarian database of natural healing factors for our secondary research. The examined data were collected and processed from the 2019 National Public Health and Medical Officer Service (ÁNTSZ) database. We included this year's data in our analysis because after the COVID-19 pandemic [18], which also appeared in Hungary in March 2020, due to the changes in medical tourism, only significantly distorted data are available to spa medical data, which could have significantly influenced our research results. We examined

the data on medicinal waters in Hungary at the NUTS3 division level (territorial middle level), so the sample of the analysis consists of 20 areas (Budapest and 19 counties) [1].

The data analysis, we used the extent-ratio, the extent of dispersion, the relative extent and the dual indicator (Éltető – Frigyes index) to measure territorial polarization. And the Gini index, the Hirschman – Herfindahl index and the Hoover index to measure the deviation of the territorial distributions was used [27] [32]. The relationship between the Gini index and the Hoover index was depicted using the Lorenz curve [24] [31].

Among the measures of regional polarization, the extent-ratio is used to determine the number of times the difference between the two extreme values of the medicinal waters examined per area: $K = X_{max}/X_{min}$ [29]. As a second polarization indicator, we use the extent of dispersion, which determines the difference between the largest and smallest value of the investigated natural healing factor: $R = x_{max} - x_{min}$ [33]. In our studies, this indicator shows the biggest differences in the number of medicinal waters by area. The relative extent is already suitable for a more detailed comparison of the data series, so in our research we use this indicator to determine how the average of the medicinal water number in the examined area compares to the difference between the largest and smallest values of the same factors: $Q = \frac{X_{max} - X_{min}}{\overline{X}}$ [29]. As a fourth polarization indicator, we use the Éltető – Frigyes index [15]. With this indicator, we examine the development and supply of medicinal waters in the examined areas (as the ratio of the average of the values above the average of the entire distribution and the average of the values below the average of the entire distribution): $D = \frac{\overline{X_m}}{\overline{X_a}}$ [26] [30]

Based on the literature, several methods are available for the more complex measurement of regional research, which are described in various aspects by foreign [46, 10, 9] and domestic authors [14, 29, 31]. To measure the deviation of territorial distributions, we first use the Gini index, which is one of the most frequently used territorial index. It is primarily used to examine income inequalities [24], but its use is increasingly spreading during health inequality studies as well: $G = \frac{\Sigma_{i=1}^{n}\Sigma_{i=1}^{n}|y_i - y_j|}{2 * \bar{y} * n^2}$ [8, 14, 16, 29, 33]. In our research, we use this indicator to determine the average difference in the number of medicinal waters per area, that is, the difference in their territorial distribution. When applying the Gini index, researchers accept a value of around 0.4 as a relatively significant inequality. Using another indicator for measuring territorial distributions, the Hoover index, we examine what percentage of the medicinal waters would need to be regrouped between the territories for the distribution to be the same: $h = \frac{\Sigma_{i=1}^{n}|x_i - f_i|}{2}$ [14, 23, 33]. The relationship between the Gini index and the Hoover index can be clearly illustrated using the Lorenz curve, which also helps describe inequality [24] [31].

In the present research, the Lorenz curve illustrates medicinal waters' proportion (inequality) per territorial unit. In the figures, the blue line indicates the cumulative distribution of the ratio of medicinal water as a medicinal tourism characteristic in increasing order (Lorenz curve), and the arrow indicates the maximum vertical distance between the Lorenz curve and the diagonal (largest difference), which corresponds to the Hoover index. The ratio of the area between the diagonal and the Lorenz curve to the area of the half square gives the Gini index. The Hirschman – Herfindahl index is used to measure the sectoral concentration in our study, which is based on the concept of the distribution ratio and shows the degree of concentration of a given neutral characteristic between territorial units: $HI = \Sigma_{i=1}^{n}(x_i /\Sigma x_i)^2$ [33]. With this index, we examine the differences in the territorial distribution of medicinal waters in Hungary. The indicator compares the distribution of the examined factors to a completely uniform one, a value above 0.6 indicates a strong concentration [29].

3 Results

The data of the Hungarian medicinal waters examined in our research (270) were collected from the ÁNTSZ database at the settlement level, and we generated a database aggregated at the district level and then at the regional level. Our results show that the number of registered medicinal waters varies between 0 and 20 in the districts of Hungary. This result is illustrated on a map in Figure 1.

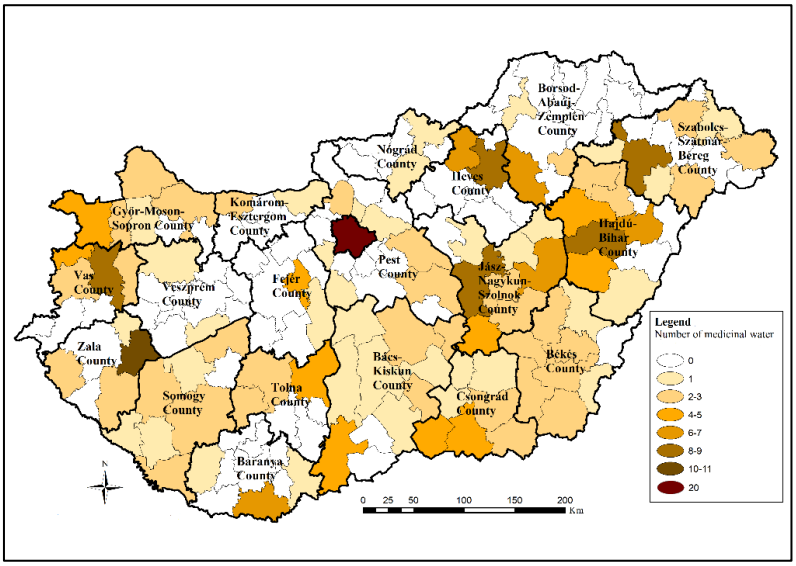

Figure 1
Number of medicinal waters in Hungary in 2019
Source: Based on ÁNTSZ 2019, own calculation and editing

Based on the settlement data of the ÁNTSZ, we determined the number of medicinal waters at the regional average level, based on which data we performed the territorial calculations (Figure 2).

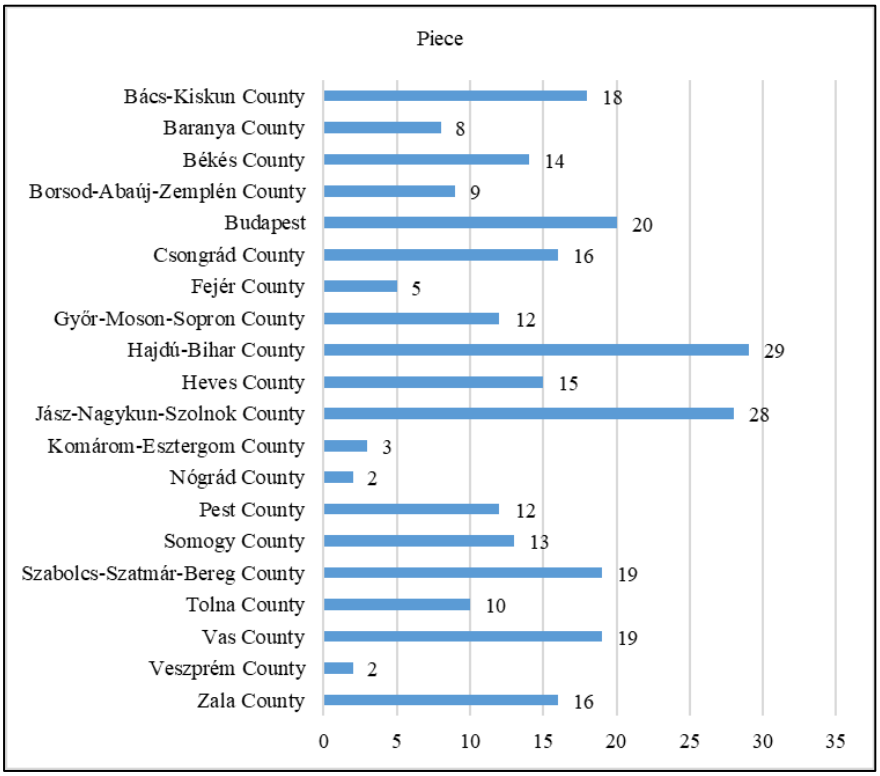

Figure 2

Number of medicinal waters in Hungary's NUTS areas

Source: Based on ÁNTSZ 2019, own calculation and editing

Based on the data, we found that the number of medicinal waters in Hungary is the fewest in Veszprém and Nógrád County (two each), and the most in Hajdú-Bihar (29) and Jász-Nagykun-Szolnok (28) County.

3.1 Territorial Water Inequalities

Territorial differences (inequality, development, concentration) of medicinal waters were examined with the help of metrics of territorial polarization and indices showing differences in territorial distributions at the regional average level in Hungary.

3.1.1 Examination Results of Territorial Polarization

To examine territorial polarization, we used the methods of extent-ratio, dispersion extent, relative extent, and the Éltető – Frigyes index (dual indicator).

Calculating the extent-ratio: $K = 29/2 = 14.5$, was obtained. This result shows a fourteen-and-a-half times difference between the areas with the most (29) and the least (two) medicinal water.

As a result of the examination of the extent of the dispersion: $R = 29 – 2 = 27$ was obtained, with which we were able to determine the significant difference in the number of medicinal water elements of the territorial unit with the highest (29) and lowest (two) medicinal water numbers.

When calculating the relative extent: The result was $Q = (29-2)/13.5 = 2$, which shows a two-fold difference between the average (13.5) number of medicinal waters in the area with the most (29) and the least (two) medicinal waters.

After that, one of the most commonly used metrics, the Éltetlő – Frigyes index (dual indicator), was calculated based on the data in Table 2.

Table 2

Éltető – Frigyes index of medicinal waters

	Undeveloped areas										Developed areas												
NUTS3 areas	Nógrád County	Veszprém County	Komárom-Esztergom County	Fejér megye County	Baranya County	Borsod-Abaúj-Zemplén County	Tolna County	Győr-Moson-Sopron County	Pest County	Somogy County	Békés County	Heves County	Csongrád County	Zala County	Bács-Kiskun County	Szabolcs-Szatmár-Bereg County	Vas County	Budapest	Jász-Nagykun-Szolnok County	Hajdú-Bihar County	**Below-average average**	**Above-average average**	**Average**
pcs	2	2	3	5	8	9	10	12	12	13	14	15	16	16	18	19	19	20	28	29	**7.6**	**19.4**	**13.5**

Source: Based on ÁNTSZ 2019, own calculation and editing

The result of the Éltető – Frigyes index of the medicinal waters is $D = 19.4/7.9 = 2.5$, which value shows a difference of two and a half times between the medicinal water supply of the territorial units. Based on these data, we determined the developed and underdeveloped areas of Hungary in terms of medicinal water supply (Figure 2).

Based on the data, we determined that in Hungary, on average, there are 13.5 medicinal waters in one area. Budapest and nine counties have an above-average medicinal water number, which is why we assessed this as a developed regional average level. Among the developed areas, Hajdú-Bihar County (29 units) and Jász-Nagykun-Szolnok County (28 units) stand out. Ten counties lag behind the national average, in terms of the number of medicinal waters. The fewest medicinal waters are found in Nógrád and Veszprém County (two each). The areas with an above-average medicinal water number are located in the eastern and central parts of the country, as well as in Heves, Zala, Vas County, and Budapest.

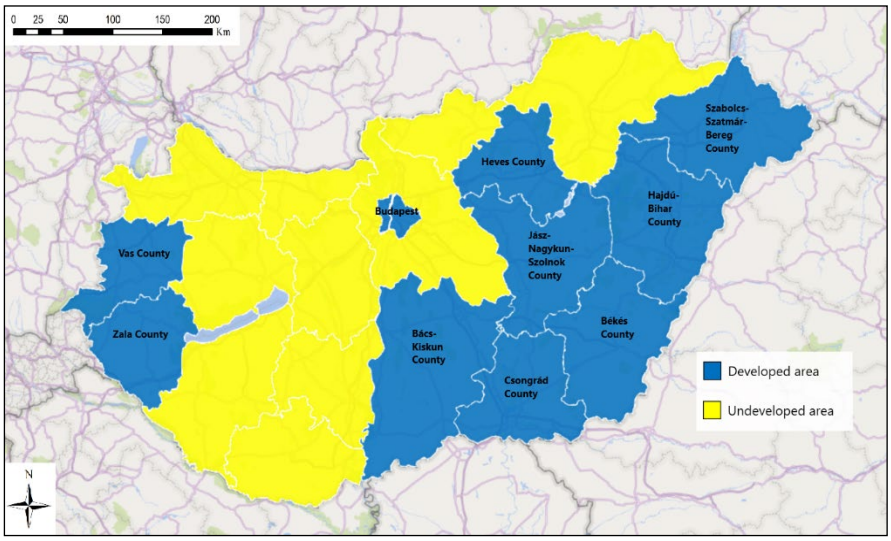

Figure 2
In terms of medicinal waters, developed and underdeveloped areas in Hungary
Source: Based on ÁNTSZ 2019, own calculation and editing

While the location of the areas with below-average (underdeveloped regional average) medicinal water numbers is typical for the western and northern parts of the country, with the exception of Zala, Vas, Heves, Szabolcs-Szatmár-Bereg County and Budapest.

3.1.1 Examination Results of Territorial Distributions

The Gini index, the Hoover index, and the Hirschman – Herfindahl index were used to analyze the territorial distributions, that is, the concentration and the combinations of the Gini index and the Hoover index were also plotted on the Lorenz curve.

Examining the Gini index of medicinal waters, we found a difference in the territorial distribution of the medicinal factor:

$G = \frac{\Sigma_{i=1}^{n}\Sigma_{i=1}^{n}|y_i - y_j|}{2 * \bar{y} * n^2} = \frac{1666}{2*13{,}5*400} = \frac{1666}{10800} = 0.15$. This means that the average difference between the medicinal waters at the average domestic level is 0.15. This result shows significant regional equality for medicinal waters. The data are also illustrated using the Lorenz curve (Figure 3).

In the figure, the blue line indicates the cumulative distribution of the ratio of medicinal waters in ascending order, and the arrow indicates the maximum difference between the Lorenz curve and the diagonal (0.15). Since the Lorenz curve is close to the diagonal, we conclude that the result shows significant territorial equality.

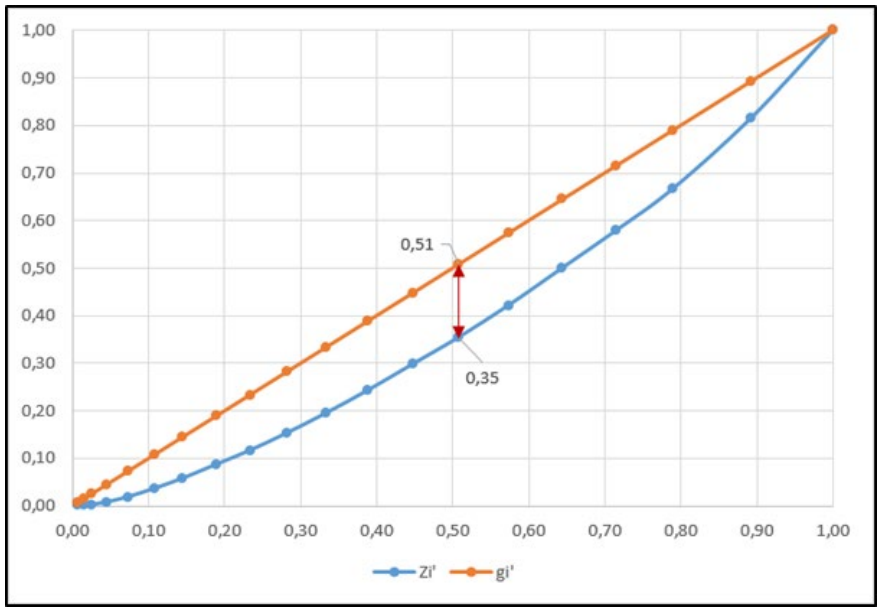

Figure 3
The Lorenz curve of Hungarian medicinal waters
Source: Based on ÁNTSZ 2019, own calculation and editing

Analyzing the data further, using the Hoover index, we examined what percentage of Hungarian medicinal waters would need to be regrouped between areas to ensure that their territorial distribution is the same with the number of musculoskeletal diseases registered in the country and the medicinal water treatment utilization. Calculated with the musculoskeletal disease number:

$h = \frac{\Sigma_{i=1}^{n}|x_i - f_i|}{2} = 53/2 = 26.5$, and the Hoover index of medicinal waters: $h = \frac{\Sigma_{i=1}^{n}|x_i - f_i|}{2} = 36/2 = 18.0$, calculated with the medicinal water treatment utilization. Based on the results obtained in this way, we conclude that in the case of medicinal waters, the territorial distribution would be the same in the case of regrouping with the number of musculoskeletal diseases at 26.5%, and the medicinal water treatment utilization at 18.0%.

The territorial concentration of the medicinal waters was also examined using the Hirschman – Herfindahl index. As a result: $HI = \Sigma_{i=1}^{n}(x_i/\Sigma x_i)^2 = (0.007^2 + 0.007^2 + 0.011^2 + 0.019^2 + 0.030^2 + 0.033^2 + 0.037^2 + 0.044^2 + 0.044^2 + 0.048^2 + 0.052^2 + 0.056^2 + 0.059^2 + 0.059^2 + 0.067^2 + 0.070^2 + 0.070^2 + 0.074^2 + 0.104^2 + 0.107^2) = 0.065$. This value indicates a relatively low concentration of medicinal water and therefore a small regional inequality.

The results of our research are summarized in Table 3.

Table 3
Territorial indices of medicinal waters

Extent-ratio (K)	Extent of dispersion (R)	Relative extent (Q)	Dual indicator (D) (Éltető-Frigyes index)	Gini index (G)	Hirschman-Herfindahl index (HI)	Hoover index (h) (%)	
						Musculosceletal disorders number	Number of medicinal water treatment utilization
14,5	27,0	2,0	2,5	0,15	0,065	26,5	18,0

Based on medium-level studies of medicinal waters as natural healing factors in Hungary, it can be concluded that they show relatively low (small) regional inequality and concentration. In other words, Hungary's medicinal water supply is relatively uniform from a territorial point of view.

Conclusions

Our study aimed to map the territorial inequalities of Hungarian medicinal waters, as natural healing factors and to present the obtained results, to promote the tourism and health industry development, for Spa towns.

Thanks to its significant hydrogeological features, Hungary is in a privileged position, in Europe, thanks to the quantitative and quality indicators of its medicinal waters. This natural healing factor, is not only prominent in its natural geography but also has a significant social and economic role as a result of its use in medical tourism and health care. Environmental and nature conservation efforts that have become increasingly important in recent years [39], as well as the tourism [37] and health changes caused by the COVID-19 pandemic, also justify the fact that the field tests of this unique natural healing factor are carried out in Hungary. We did all this to promote the planning of tourism and health developments [40] related to medicinal water, which is becoming necessary in spa towns.

In our research, we used the extent-ratio, extent of dispersion, relative extent and the Éltető – Frigyes index (dual indicator) methods to examine territorial polarization [15, 29, 33], while we used the Gini index, the Lorenz curve, the Hoover index and the Hirschman – Herfindahl index to measure the deviation of the territorial distributions [16, 23, 29, 33].

Based on he calculated regional average results, we have come to the overall conclusion that Hungarian medicinal waters show relatively low (small) regional inequality and concentration. According to this, the country's medical water supply as a whole is relatively uniform from a territorial point of view. According to the results of the most informative and reliable indicator, the Éltető – Frigyes index, i.e., the dual indicator, nine counties of Hungary and Budapest can be called developed areas, in terms of medicinal water supply. Among the developed areas, Hajdú-Bihar County (29 units) and Jász-Nagykun-Szolnok County (28 units) stand out. However, we consider it important to point out that the aggregated data are not

sufficient in themselves and provide adequate guidelines for the planning of spa town developments. It is necessary to pay special attention to the partial results, which draw attention to the peripheral areas that are underdeveloped in terms of medicinal water supply. Also, further research is needed in the fields of tourism and healthcare, in order to reveal populations, service providers and based on this information, develop the optimal and sustainable use of medicinal water, in addition to the realization of the interests in supply and demand.

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