

## Research Article

# Perceived Influence of Weather Conditions on Rheumatic Pain in Romania

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The main objective of this study was to analyze the perception of the influence of various weather conditions on patients with rheumatic pathology. A group of 394 patients, aged between 39 and 87 years and diagnosed with degenerative rheumatic diseases, were interviewed individually by using a questionnaire created specifically for this study. Further on, to assess the relationship between pain intensity and weather conditions, a frequency analysis based on Pearson's correlation matrix was employed. The most important results are as follows: the great majority of the participants (more than 75%) believe that their rheumatic pain is definitely or to a great extent influenced by different weather conditions; most of the patients reported intensification of their pain with weather worsening, especially when cloudiness and humidity suddenly increase (83.8% and 82.0%, respectively), air temperature suddenly decreases (81.5%), and in fog or rain conditions (81.2%). In our research, alongside simple meteorological variables, we established that complex weather variables such as atmospheric fronts, in particular, the cold ones and winter anticyclonic conditions, greatly intensify the rheumatic pain, whereas summer anticyclonic conditions usually lead to a decrease in pain severity. In terms of relationships between pain intensity and weather conditions, we found the strongest correlations (ranging between 0.725 and 0.830) when temperature, relative humidity, and cloudiness are constantly high.

## 1. Introduction

At the international level, studies conducted in different regions focused on the relationship between weather conditions (WeCos) and the intensity of rheumatic pain. Most papers are retrospective, and many of them concluded that weather influences the intensity of rheumatic pain, but the mechanism that causes or intensifies the pain has not been fully elucidated so far [1–11].

Pain sensitivity to weather changes was reported for various rheumatic pathologies: rheumatoid arthritis [1, 2, 4, 5, 10, 12–18], inflammatory arthritis [2], fibromyalgia [2, 19], or degenerative pathologies, such as osteoarthritis [1, 2, 5, 9, 11, 14, 18, 20, 21] or spondylosis [1].

There are also studies conducted on patients with chronic pain and diagnosed with different rheumatic diseases [3, 4, 7]. Some previous studies pointed out that 62% of the subjects reported that their symptoms are influenced by the weather [22], 69% of the patients included in another interviewed group were sensitive to weather [1], and 97% of the patients questioned by Shutty et al. [3] were influenced by the weather; more than 50% of the subjects investigated by Hendler et al. [23] reported that their pain becomes more severe with changes recorded in some weather variables; 67.9% of the patients interviewed in another study [4] considered that meteorological conditions change affect their pain; 92% of the subjects who participated in a study based on a telephone questionnaire [5] reported that weather

influences their symptoms. A recent research paper on patients diagnosed with osteoarthritis showed that 67.2% of the investigated subjects reported that WeCos affect their pain [11].

Low atmospheric pressure and high relative humidity were found to be the meteorological variables that most influence the increase of pain intensity, stiffness, and inflammation in the joints [13, 16, 17, 20]. In the case of patients with arthritis, a decrease in pain severity and mean stiffness was reported when relative humidity was below 40% [5], whereas low atmospheric pressure was identified as the most influential atmospheric factor responsible for pain intensification in patients suffering from osteoarthritis [18]. A more recent study revealed that the combined effects of low pressure and high relative humidity could induce more severe pain generated by osteoarthritis [21]. Low temperature is associated with increased pain and stiffness of the joints, too [5], and enhances the risk of pain in patients diagnosed with rheumatoid arthritis [18].

On the other hand, stable atmospheric pressure, low humidity, a relatively high average temperature, and many hours of sunlight are considered beneficial for patients with rheumatism [1].

Several studies presented explanations supporting the mechanism of joint pain due to weather changes. Thus, changes in temperature, humidity, and especially air pressure may influence the expansion or contraction of various tissues in the affected joints causing pain [4, 20, 24–26].

In Romania, a few research papers focused on the influence of different WeCos on pain intensity in the case of patients suffering from chronic rheumatic diseases were previously developed. One of them confirmed that pain intensity is mostly influenced by atmospheric pressure [27]. Another one presented briefly some theoretical considerations [28].

This paper aims to analyze the perception of the influence of various WeCos on patients suffering from degenerative rheumatic pathology in a temperate climate such as that of Romania. Its main objective is to examine which of the meteorological variables are perceived by the sick persons to be the most influential for increasing the intensity of joint pain. We focused on pain intensification reported by the patients mentioned above during sudden changes in weather variables. Also, through this research, we examined the meteoropism in the case of the interviewed people.

## 2. Materials and Methods

*2.1. Design and Context.* The research was performed based on data collected from patients who were treated in Băile Tușnad medical resort, Romania. The field survey was conducted between October 1 and December 4, 2017.

The data for this study were collected in the form of a face-to-face questionnaire survey, which is a widely used technique [29]. The participants were interviewed individually. On the day of their arrival to the resort, immediately after the medical control, the patients were individually questioned for the present study. The procedure consisted of asking questions

and clarifying and explaining the specialized information to obtain as accurate as possible answers.

*2.2. Questionnaire and Instruments.* The questionnaire used was divided into three parts: one of them was established to obtain different investigation data from the subjects and the others contained questions related to medical and demographic data. The English version of the questionnaire is presented in Supplementary Material 1 (see SM\_1). Among the 21 questions, 14 were used to get medical information and to assess the perception of the subjects about the connections between their rheumatic pain and WeCos (Q1–Q14), while the last 7 questions allowed us to obtain demographic data (Q15–Q21).

The first 7 questions provided general information on medical data, such as the main diagnosis, associated pathology, intensity, and duration of rheumatic pain.

Subsequently, the investigation focused on the perceived impact of WeCos on pain reported by people suffering from degenerative rheumatic pathology. We considered two general WeCos:

- (i) “Bad weather” is characterized by high cloudiness, usually more than 4 oktas, variable wind velocity, and precipitation occurrence (cyclonic, convective, shower, continuous, intermittent), as well as by sudden change in temperature, pressure, or humidity; these features are specific mainly to cyclone central areas and generally connected with warm fronts (WFs) and cold fronts (CFs); also, the bad weather may be associated with summer thunderstorms generated by cumulonimbus clouds and developed in anticyclone (AC) conditions or inside the warm sector of the cyclones. At the periphery of cyclones, the weather improves.
- (ii) “Fine weather,” mainly characterized by clear sky or low cloudiness (less than 4 oktas), no precipitation, and no wind or light wind, is specific, in general, to AC central areas or the warm sector of the cyclones. An important difference can be identified between summer and winter anticyclone conditions (SACs and WACs), consisting mainly of temperature (high and very high temperatures during the warm season and low and very low temperatures during the cold season) and cloudiness (sometimes during WACs, fog or low clouds are present).

As was discussed above, the warm sector of a cyclone area, located between the two fronts, can generate both bad and fine weather. Thus, in general, precipitation stops and the cloudiness considerably decreases in the warm sector of a well-developed (mature stage) cyclone, especially during the cold season. This kind of weather is considered as “fine weather.” Sometimes, inside the warm air mass, due to the high temperature and water vapor content which is specific mainly during summer, high Cumulonimbus clouds develop, leading to thunderstorms, and thus, the WeCos are considered as “bad weather.”

For the assessment of the perceived rheumatic pain associated with WeCos, we used 5 questions (Q8–Q14) focusing on information related to day-to-day weather change as well as to seasonal change.

The general information was obtained from Q8–Q10 and Q12, while the specific conditions associated with pain intensification were investigated by using Q11. For Q11, first, the analysis was performed based on each item, considered separately. From previous discussions with the patients, we have got the information that most of them were not familiar with scientific terms such as “atmospheric (warm or cold) fronts,” “cyclones” or “anticyclones.” Thus, we decided not to use those terms in the questionnaire, but more simple ones, such as “temperature,” “light rain,” “shower rain,” and “wind speed.” After getting their answers for Q9–Q11, based on a detailed analysis of the subjects’ answers to individual items, we tried to “reconstruct” the complex WeCos (CF, WF, SAC, or WAC) and to identify which are the most influential for rheumatic pain. Under these circumstances, a few weather features characterizing them best were chosen from those listed in Q11 to assess their impact on joint pain intensity. Thus, the increase in cloudiness, relative humidity, and wind speed and the presence of light rain were considered specific for the WF, while the increase in relative humidity, cloudiness, and wind speed, as well as heavy rainfall or/and thunderstorm, were listed as CF conditions. We considered the temperature change irrelevant for this issue because during the winter, a frontal activity is associated sometimes with a warming process both in the case of the WF or CF compared to the previous days, especially when the cyclone is originated over the Mediterranean Sea and follows immediately after the WACs generated by the action of the Eastern European High extended westward. On the contrary, during the summer, the cyclonic WeCos may be associated with a cooling process, including the warm sector, especially when they occur after the SACs induced by the North-African high WeCos.

The “sudden change” was considered and explained accordingly to the questioned patients to have a temporal extension from less than one hour to one day.

**2.3. Sample Selection.** The participants in this survey were selected, based on their diagnosis, from the patients admitted to the treatment facility of Baile Tusnad medical resort. The survey included a group of 394 patients aged between 39 and 87 years. All subjects interviewed for this study had been diagnosed with degenerative rheumatic pathology: primary coxarthrosis, primary gonarthrosis, cervical dorsal and lumbar spondylarthrosis, omarthrosis and cervical and/or lumbar discopathy, posthip and/or knee arthroplasty after coxarthrosis, and advanced gonarthrosis. The demographic features of the focus group are presented in Section 3.1.

**2.4. Study Area.** This study was developed based on a transversal research approach (one assessment) in Băile Tuşnad resort, which is one of the top medical tourism resorts in Romania, according to the ranking carried out by

the Romanian Balneology Association [30]. We have chosen this resort because people suffering from cardiovascular and rheumatic pathologies from all regions of Romania use these treatment facilities due to the long tradition of the resort in treating such diseases. Recently, a few studies demonstrating the efficacy of treatments in Băile Tuşnad resort for patients suffering from the pathologies mentioned above have been carried out [31–33].

The temperate continental climate of Romania is characterized by cold winters and hot summers, as well as sudden changes in day-to-day WeCos generated by the extratropical cyclones crossing Romania, through their warm and cold fronts.

Băile Tuşnad medical resort is located in central Romania, at an average altitude of 650 m above the sea mean level, in an intermountain depression of the Eastern Carpathians, with a tonic climate characterized by cool summers and cold winters [34]. Among the natural therapeutic factors of the resort, the most important are sedative bioclimate, which stimulates the human body functions, numerous therapeutic mineral water springs, and natural therapeutic gases (mofettas) [35–37]. Usually, during the winter, the treatment facilities of the resort are not used.

**2.5. Data Sources and Analysis.** All the analyses were performed based on data collected through face-to-face questionnaires. The entire database is available as Supplementary Material 2 (see SM\_2). For the assessment of rheumatic pain intensity that patients feel, we used a simplified scale, with only 3 steps, from 1 to 3 with the variants: mild pain, moderate pain, and severe pain. This could be the easiest way for sick persons to remember and score the intensity of their pain as close as possible to reality.

To analyze the patients’ responses, we first calculated the frequencies for each question/item. The results and graphical representations were obtained by using the Excel application available from MS Office 2016.

To explore the potential relationships between variables describing the intensity and changes of perceived rheumatic pain and WeCos, a Pearson’s correlation matrix was established between the items/questions and the results are available in Supplementary Material 3, (see SM\_3). The statistical significance was established at  $\alpha=0.01$ . The Shapiro–Wilk test of normality was applied to assess the data distribution using a reference value  $\alpha=0.05$ . The same method has been successfully used in a previous study [5]. The correlation analysis and descriptive statistics were performed by employing SPSS version 22.

### 3. Results and Discussion

**3.1. Demographics.** The sample group consisted of 232 women (58.9%) and 162 men (41.1%) (Q17). Among the respondents, 56.1% were from urban areas and 43.9% were from rural areas. Regarding geographical distribution, the patients came from all regions of Romania but those living in central Romania were dominant (40.6%) (Q15). The great majority of the participants in this survey were retired for

age (85.3%) or medical reasons (10.7%), and only a small proportion was still employed (3.5%). The difference of 0.5% did not answer this question (Q20).

Among the interviewed subjects, those graduating from vocational/professional education and secondary schools were dominant (30.7% and, respectively, 24.4%). High-school graduation was reported by 19.3% of the respondents, technical posthigh-school graduation covered 16.2% of them, and only a small share got a bachelor's and master's degree (8.9%). The remaining share of 0.5% did not answer (Q21).

All subjects interviewed for this study had been suffering from rheumatic pain between 1 and 65 years before participating in this survey (Q3).

Also, most of the participants (81.5%) had associated chronic pathologies such as hypertension, ischemic heart disease, insulin-dependent diabetes mellitus and noninsulin-dependent diabetes mellitus, and stroke or a history of myocardial infarction, chronic obliterative arteriopathy, hepatic steatosis, gastritis, and a chronic ulcer (Q4).

For the accuracy in interpreting the results, we considered it necessary to account some characteristics related to body weight fluctuations and daily lifestyle (routine behavior) (Q18 and Q19).

Similar studies revealed a correlation between rheumatic pain and body weight [11, 38–40], and we decided to investigate this issue, too. Thus, for the question regarding body weight fluctuations during the previous year, most of the patients (63.71%) answered that their weight maintained, whilst about 27% reported an increase in weight: 16.24% experienced an insignificant increase of about 1–2 kg and 10.15% of the patients reported a significant increase, by more than 2 kg. About 10% of the subjects reported they had lost weight over the previous year.

It was documented that smoking both in the past and present is associated with the severity of rheumatoid arthritis [41, 42]. In terms of routine behavior, an overwhelming proportion of the patients mentioned that they regularly drink coffee (84.7%) and about a quarter reported occasional alcohol consumption (24.3%); 17.0% of them answered that they used to smoke in the past, but they quit in the recent years.

No significant correlation was found between changes in weight or routine behavior and the intensity of the most frequently perceived pain reported by the investigated group.

**3.2. Perception of Rheumatic Pain and Its Connection with Weather Conditions.** Since all subjects who participated in our study had been previously diagnosed with chronic degenerative pathology, first, we investigated the frequency of their pain in the previous year (Q5). An overwhelming majority of the patients responded that they felt pain every day or almost every day (64.7%), 15.7% reported pain several times per week, and 15.7% declared that they experienced pain a few times per month. Only 3.1% felt the pain less than once per month, and 0.8% did not answer this question.

In terms of intensity, more than half of the subjects rated pain felt before their admission to the Băile Tușnad

treatment facilities (Q6) as moderate, followed by those feeling high-intensity pain (see Figure 1(a)). Regarding the intensity of the most frequently felt rheumatic pain (Q7), patients also reported moderate pain as dominant (see Figure 1(b)).

The similarity between the answers to these questions revealed the fact that pain assessment referred to the regular manifestation of pain intensity.

The great majority of the participants in this survey believe that their pain is influenced by weather (Q8). Thus, more than 75% of them consider that rheumatic pain is definitely or to a great extent influenced by the weather and some others (5.0%) reported pain intensification to some extent due to WeCos (see Figure 2(a)). The analysis by social genders indicated that although male and female responses were not very different, women seem to be more weather sensitive than men since the number of those declaring that their pain is definitely or to a great extent influenced by WeCos was 10% higher compared to that of men. In the groups perceiving the influence of WeCos on pain as “to some extent,” “did not notice,” or “no influence,” men were dominant (see Figure 2(b)).

For further analysis, we excluded the subjects who considered that the weather had nothing to do with their pain (43 people, representing 10.9% of the subjects).

Next, our investigation focused on the impact perceived during various WeCos. The analysis of the answers regarding joint pain intensification under changing WeCos (Q9) indicates that the great majority of the respondents (about 62%) feel that fine weather never aggravates their rheumatic pain, whereas during bad weather, 66.9% of the patients reported an intensification of pain whenever it occurs (see Figure 3(a)).

Analyzing the patients' perception of pain intensity during SACs (Q10), we found that 72.9% of them always or most often feel a decrease in pain intensity, whereas 26.5% of them have never experienced pain during warm and sunny weather. Also, the great majority of the patients (almost 90%) reported that their pain does not change or increase in intensity when the weather is warm and sunny, and about 75% never or very rarely feel pain during SAC (see Figure 3(b)).

The severity of rheumatic pain varies widely from patient to patient and from time to time in any one patient [43]. In order to identify which WeCos cause most frequently changes in the rheumatic pain intensity, we assessed the participants' perception on the influence of some simple meteorological parameters such as air temperature, relative humidity, cloudiness (sudden increase or decrease, as well as unchanged conditions in these variables), the presence of fog, rain showers and/or thunderstorms, light and continuous rain, and wind speed on their pain (see Figure 4) (Q11).

For most of the interviewed patients, pain becomes severe when cloudiness and relative humidity suddenly increase (83.8% and 82.0%, respectively), when air temperature sharply decreases (81.5%), and in fog or mist conditions (81.2%). Also, severe pain was reported during rain showers or thunderstorms (68.9% of the patients), when wind speed increases (67.2%), and during light and continuous (cyclonic) rain (45.9%) (see Figure 4).



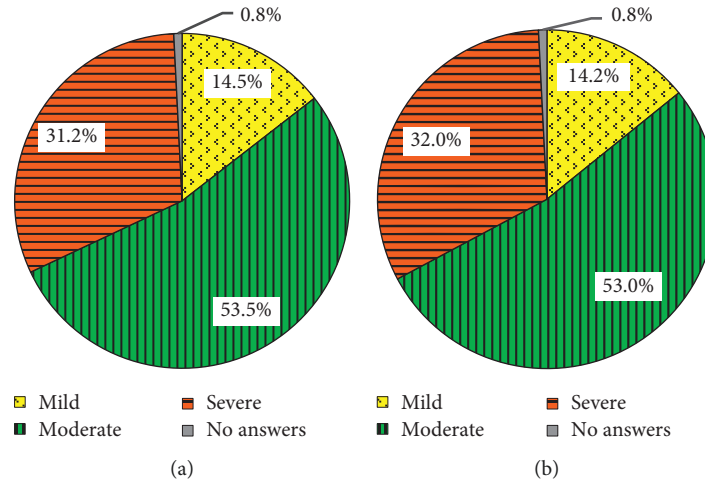


FIGURE 1: Intensity of rheumatic pain: on the day before admission (Q6) (a); most frequently felt (Q7) (b).

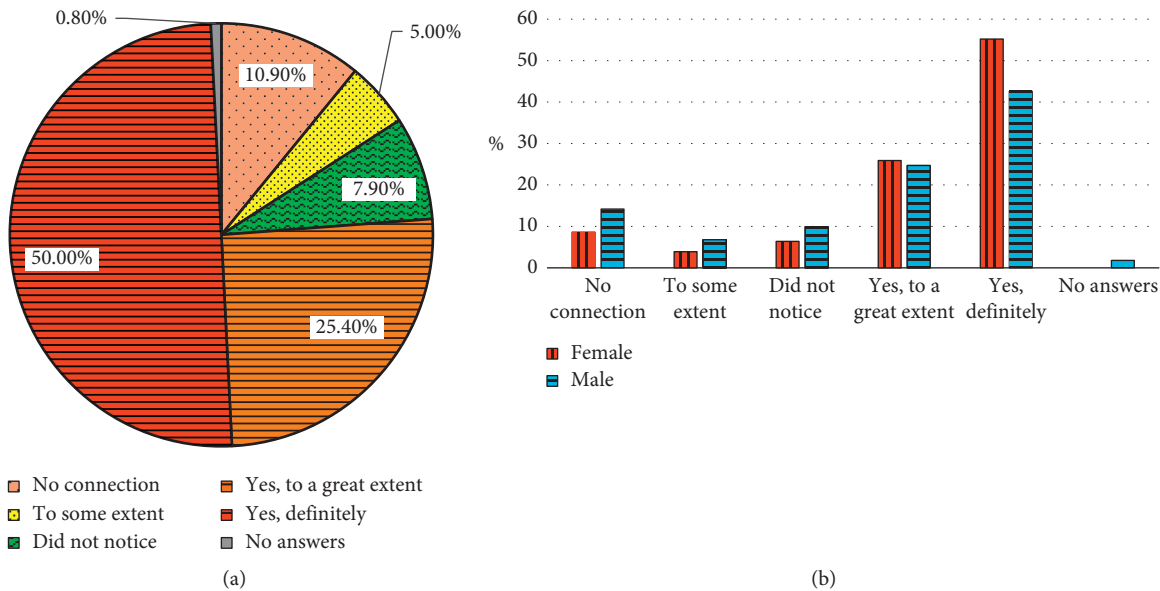


FIGURE 2: Perception of the influence of WeCos on rheumatic pain: all participants (a); by social gender (b) (Q8).

In the opposite conditions, more than half of the subjects responded that their symptoms improve; they feel mild intensity pain when air temperature suddenly increases (50.4%) or remains constantly high (51.9%), when humidity suddenly drops (61.5%), and when cloudiness decreases sharply (61.5%) (see Figure 4).

We can conclude that bad weather, especially that specific to CFs and WFs, is responsible for intensification of the rheumatic pain, whereas fine weather, characterizing mainly the SACs or the warm sector of the cyclonic systems, has a great contribution to diminishing pain intensity, which becomes mild for most of the patients (see Figure 4).

The majority of the interviewed subjects (67.8%) reported that their most intense pain associated with changing weather usually occurs during transition seasons (spring and/or autumn). This fact could be explained by the main features of the weather during these periods of the year,

which are characterized by more intense and rapid changes due to the circulation of different air masses over the considered region. Only 11.4% of the subjects feel the most intense pain during summer and/or winter, and less than 10% experience the constant intensity of the pain all over the year (9.4%). A share of 11.4% did not answer this question (Q12).

Regarding meteo-tropism, most of the subjects (68.1%) feel an intensification of their pain before the weather worsening. Thus, 68.1% of them can always or most often “predict” or “forecast” weather worsening. About 13.0% reported more severe pain sometimes (7.1%) or rarely (6%), and less than 7.7% reported no change in pain intensity before weather changes. The remaining share of 11.1% did not answer this question (Q13).

For a more detailed analysis, especially related to the complex WeCos (WF and CF), we investigated when exactly

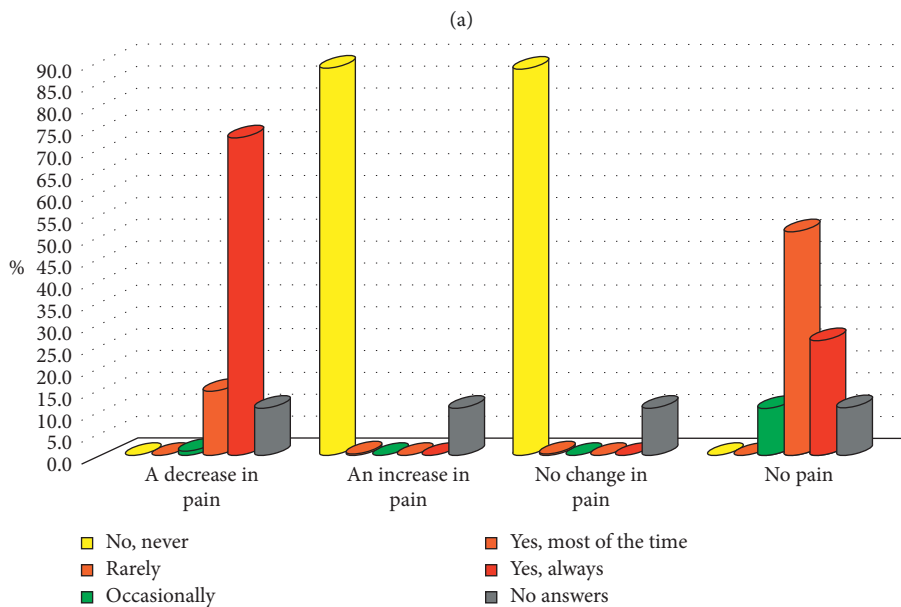
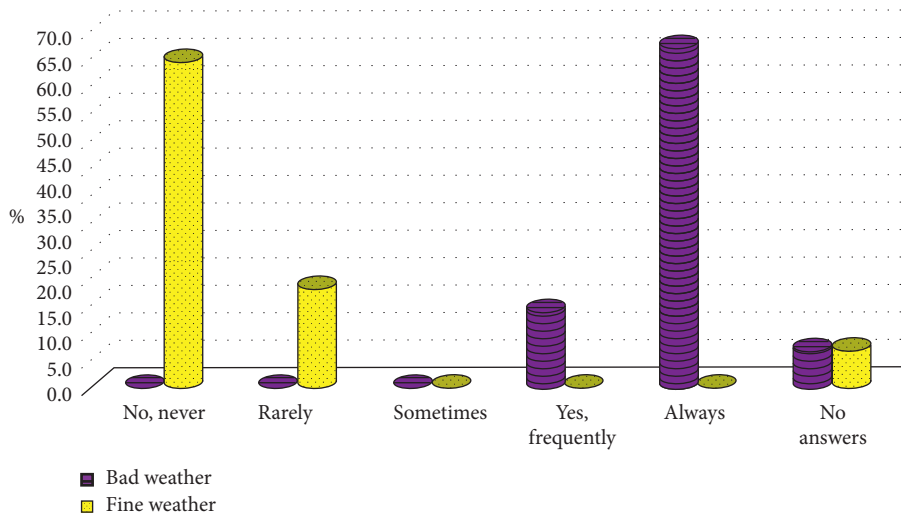


FIGURE 3: Frequency of pain intensification in WeCos in general (Q9) (a) and in fine weather (Q10) (b).

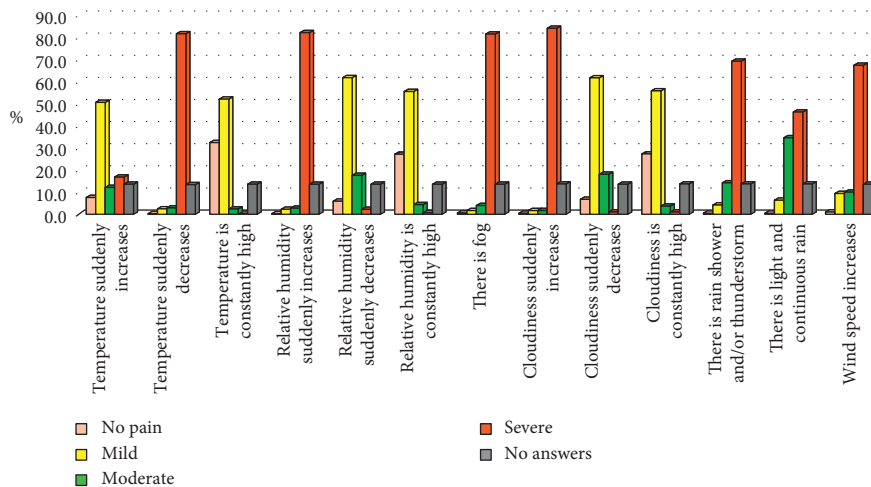


FIGURE 4: Fluctuations in pain intensity during sudden changes in WeCos (Q11).

patients' symptoms occur/aggravate compared to the weather change at the ground level (Q14). Our results showed that 42.7% of the interviewed patients can predict the weather change, through the intensification of their pain, between one and three days before, and 34.2% feel more severe pain during the previous day or on the day when the weather changes. We did not record any answer about pain intensification after WeCos changes. However, 23.1% of the interviewed did not answer this question.

**3.3. Correlation Analysis.** Based on the Shapiro–Wilk test, a normal distribution of data was found. Further, correlation indices between the main variables characterizing pain intensity and WeCos and the other relevant variables were calculated. All indices are presented in Supplementary Material 3 (see SM\_3). Many significant correlations were found, but some of them indicate a quite fable connection between different items (less than 0.200). In this chapter, we present shortly only the strongest correlations found.

The results confirmed several methodological choices made in this study. First, some correlations between clinical and demographic data were tested. We found a strong relationships (0.976) between the pain intensity reported before admission (Q6) and the most frequent level of pain intensity in general (Q7), leading to the conclusion that the moment of the study assessment was not a pain peak (or an unusual situation), but a regular level of perceived pain, which was of paramount importance for this study. Under these circumstances, we assumed that the answers to the following questions were not altered by unusual pain severity. Also, acceptable direct correlations (0.326; 0.327) were found between the frequency of rheumatic pain (Q5) and its intensity (Q6, Q7); it revealed that those patients with more severe pain feel it more frequent, too.

In terms of relationships between pain intensity and WeCos, we found the strongest correlations (between 0.725 and 0.830) when temperature, humidity, and cloudiness are constantly high. Those WeCos could be associated with summer cyclonic conditions. Similarly, when relative humidity and cloudiness suddenly decrease, corresponding mainly to SACs, the pain becomes milder.

During fine weather (Q10), the high coefficient of 0.706 between patients reporting “no improvement” and those answering “no change” in their pain intensity is explained by the high rate of people feeling pain every day or almost every day (Q5).

Two correlation coefficients of 0.500–0.600 were detected for pain intensification (i) when relative humidity and cloudiness increase sharply, and (ii) during rain showers and/or thunderstorms and wind speed increase. The latest correlation indicates a sensitivity also associated with unstable atmosphere WeCos, especially related to cumulonimbus clouds, which are more specific during the warm season.

Increasing pain severity indicated good connections (0.400–0.500) with high relative humidity, cloudiness, or wind speed, as well as with the presence of rain showers and/or thunderstorms or fog. People reporting more intense pain

with increasing frequency during worsening weather associated usually with instability of the atmosphere and specific to frontal areas or to locally developed thunderstorms (Q9\_bw) also considered that the frequency of their pain decreases when the weather becomes fine, such as clear sky or low cloudiness and no precipitation, specific mainly to SACs (characterized by stable atmospheric conditions), but sometimes also to the warm sector of a cyclone (Q9\_fw) (–0.453).

Weaker correlations, but still statistically significant (0.300–0.400), were found between the declared sensitivity (Q8) and the frequency of pain intensification when the weather becomes bad (Q9\_bw). Also, a significant correlation was found between answers given to questions Q9\_bw and Q10q1, denoting consistency in the formulated responses: decreasing pain intensity when the weather is fine correlated directly (0.353) with an increasing frequency of more severe rheumatic pain with worsening WeCos.

The connection between the pain duration reported by patients (in years) (Q3) and age (Q16), as well as between the associated pathologies (Q4) and age (Q16), was quite weak (less than 0.300).

The low values of the most indices, yet statistically significant, could be explained by the fact that pain is not generated, but intensified by WeCos. They cannot explain more because the mechanism generating pain is much more complex and implies a multitude of variables. Under these circumstances, we consider that correlation indices of 0.300 or higher are relevant, especially when the correlation matrix is combined with good results of frequency analysis.

## 4. Conclusions

The findings of our study are, in general, in line with those previously reported, stating that WeCos influence the intensity of rheumatic pain [2, 11, 44] and that low air temperature and high relative humidity are the most influential meteorological variables for pain intensity in the case of different rheumatic diseases [4, 5]. Our results show that the great majority of the interviewed people (more than 75%) consider that their pain is influenced by the weather, which is in agreement with other results revealing that 92% of the respondents consider that their symptoms are influenced by the weather [5]. Moreover, high cloudiness and the presence of fog or rain (be it rain shower or cyclonic rain) were reported, by the interviewed patients in our study, as having a great influence on pain intensification, with the same frequency as relative humidity and low temperature.

We also found that women are more sensitive than men to WeCos change in terms of pain intensity, which is consistent with the results reported in some previous studies on this topic [2, 11, 44].

Alongside simple meteorological variables, we could establish that complex weather variables such as atmospheric fronts, in particular, the CF, as well as WACs greatly influence the pain intensification, whereas SACs usually lead to a decrease in pain severity.

One of the most important findings is that, in general, worsening WeCos responsible for pain intensification were

associated by our respondents with the presence of water in the atmosphere rather than temperature. The state of the water (liquid or water vapors) did not seem to be so important since, from direct discussions with the respondents, all forms of water (relative humidity, cloudiness, precipitation, or fog) were simply considered as “humidity.”

In terms of seasonality, our results did not overlap with other research studies that reported the maximum frequency of pain intensification during winter [4]; we found that the most severe pain occurs during transition seasons (spring and/or autumn). This difference can be explained by the features of the local and regional climate in the analyzed regions. In Romania, during winter and most of the summer, ACs are dominant and the weather is fine, especially during midsummer and late summer, whereas during spring, autumn, and early summer, the weather changes very rapidly due to numerous extratropical cyclones originated in the Atlantic Ocean or over the Mediterranean Sea [45].

The analysis of meteo-tropism for our group revealed a much higher share of the patients feeling an intensification of their joint pain before the weather worsening: more than 68% compared to values of 48–52% previously reported [4, 5]. Also, more than 40% of the participants in our study indicated more intense pain at least 24 hours before weather worsening (between 1 and 3 days), whereas some other research papers found that most of the interviewed people experienced more intense pain at least 12 hours before the changing weather [20, 46]. A possible explanation for the increase in pain severity between 1 and 3 days before weather worsening in the case of people reporting meteo-tropism could be the delay of 24–72 hours between changes (air temperature, relative humidity, air pressure, cloudiness, and wind speed) in the higher and middle troposphere and those at the ground level. This situation is specific to the WFs, while in the case of the CFs, changes in the upper levels usually occur 24 hours or less before changes at the ground level.

Based on these results, we consider that a detailed biometeorological forecast would be of great importance for people suffering from degenerative rheumatic pathologies.

### Data Availability

The data used to develop this study are available as Supplementary Materials (see SM\_1 and SM\_2) associated to this paper.

### Conflicts of Interest

The authors declare that they have no conflicts of interest.

### Authors' Contributions

All authors contributed equally to this research paper.

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### Supplementary Materials

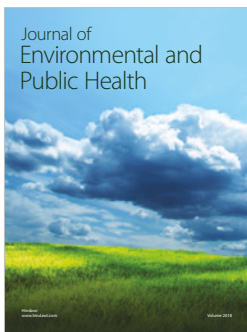
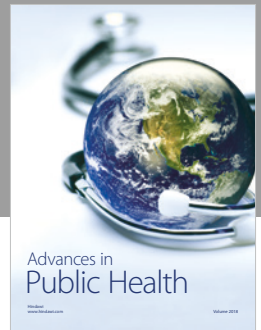
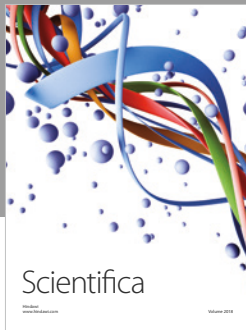
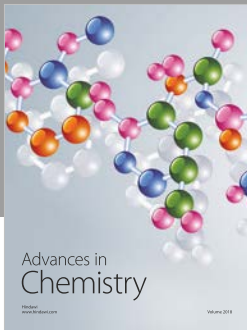
Three Supplementary Materials are provided together with this article. The first Supplementary Material (SM\_1) consists of the English version of the questionnaire used to collect the data. The second Supplementary Material (SM\_2) contains the data used for this analysis (responses to the questionnaire). The third Supplementary Material (SM\_3) contains the results of the correlation matrix discussed in this paper. The statistically significant correlation indices are highlighted in red. Each supplementary material is cited in the manuscript. (*Supplementary Materials*)

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