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Original Article

Modeling the Spatial Distribution of Mood Disorders in Isfahan Province, Iran

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Abstract

Background and aims: Physical and social environments are effective on personality traits. What is in the framework of medical geography, is physical environment that can have positive effect on the human psyche. It can also have negative effects whose investigation is in the field of medical geographers.

Methods: The present study is a descriptive analytical research that discusses the modeling of the vulnerability of mood disorders (depression, bipolar) by using meta-ranking PROMETHEE, and ArcGIS software to study climatic parameters on the spatial distribution of these disorders in Isfahan Province from 2007 to 2011.

Results: The prevalence of mood disorders (depression and bipolar disorder) in all the province had a direct correlation with each other. Isfahan, Lenjan, and Shahin Shahr were very high-risk cities and Nain and Semirom were low-risk cities. The prevalence and incidence of these disorders have a direct correlation with temperature, precipitation and humidity. There was no significant correlation between sunshine hours and incidence of mood disorders in Isfahan province. The percentage of incidence of these disorders was almost twice higher in men than women.

Conclusion: Climatic parameters can be one of those factors that are effective in incidence and increasing of mood disorders (depression, bipolar). This issue highlights the need for more study and research in this field.

Keywords: Mood disorders, PROMETHEE, Isfahan

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Introduction

Several factors can be effective on the health of human psyche. One of the most important factors that influence personality traits is environment. In a public classification, the effective environment on personality is divided into physical environment and social environment and what is in the framework of medical geography, is physical environment. The physical environment is part of the natural environment that includes weather, climate, food and other material facilities.[1] In addition to positive effects on the human psyche, in some cases, environment has negative effects. For example, increase of the temperature in a period can increase irritability and irrational people and thus cause abnormal behavior and reactions of people, or when the weather is cloudy and rainy, some people feel angry, upset or sleepy, whereas when it is sunny, they become energetic For several important mental disorders whose cause is unknown and whose treatment is uncertain, when their map of incidence and spatial distribution is drawn, a significant difference can be seen from one point to another point that is not explicable only by genetic and social factors and it seems that the environmental interferences are the main factors in their etiology.[3] Therefore, it is necessary to investigate their distribution in the province and influencing factors, especially environmental factors for development of such diseases. There is an assumption that the geographical and climatic conditions can affect mood disorders. Therefore, it seems essential to study spatial distribution of mental illnesses in the province and the effect of climatic parameters and factors on the incidence and spread of these illnesses and also to draw the map of spatial distribution of mood disorders according to climate parameters.

PROMETHEE Methods

This method starts by expanding the scale measure for preference evaluation of one option compared

to other options by converting the product levels for options to scale of 0 to 1 (where 0 represents the worst and 1 the best).[4]

Intensity of preferences is represented in a form of matrix according to equation (1) within which all of decision-making options are compared to each other with respect to each target.

$$\begin{array}{c} a_1 \\ a_2 \\ \vdots \\ a_n \\ \\ \end{array} \begin{array}{c} \begin{bmatrix} g_1(a_1) & g_2(a_1) & \cdots & g_k(a_1) \\ . & . & . & . \\ . & . & . & . \\ g_1(a_n) & \cdots & \cdots & g_k(a_n) \end{bmatrix} \\ g_1(.) \quad \ldots \quad \ldots \quad g_k(.) \end{array} \tag{1}$$

In equation (1), $A=\{a_1,a_2,\ldots,a_n\}$ is a finite set of options and $\{g_1(.),g_2(.),\ldots,g_k(.)\}$ is a set of evaluation criteria.

In the next step, the utility function (F) is selected from Table 1 and the amount of $(P_{(a,b)})$ for all couples of options is compared with all of the criteria from equations (2) and (3) and calculated.

$$P_j(a,b) = F_j[d_j(a,b)]; \forall a,b \in A \tag{2}$$

$$\begin{cases} d_j(a,b) = g_j(a) - g_j(b) \\ 0 \le P_j(a,b) \le 1 \end{cases} \tag{3}$$

It should be noted that the above equations are for the criteria that they need to be maximized. For the criteria that should be minimized, the amount of $d_j(a,b)$ in the above equations will be symmetric.

In each of the functions (Table 1), q is indifference threshold, p is strict superiority threshold and S is an amount between p and q. Threshold of minor differences, is the biggest difference that is not important for decision-maker and superiority threshold is the smallest difference for complete allocation of superiority between two options, and it is sufficient. It must be noted that the utility function is zero for negative d values.[6]

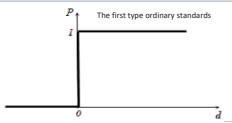
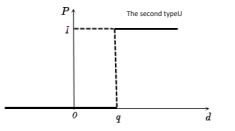
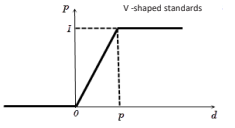
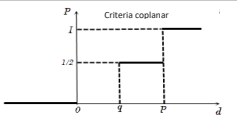
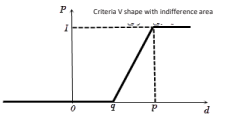
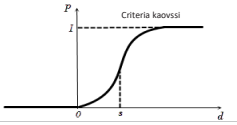
In the following, weight of criteria $(\{w_j;j=1,2,\ldots,k\})$ with proviso $\sum_{j=1}^{k} w_{j=1}$ is determined and the overcome degree of $\pi(a,b)$ or the same amount of superiority (a) to option (b) is calculated in comparison with all the criteria, for all couple options, according to equation (4).

$$\pi(a,b) = \sum_{j=1}^{k} p_j(a,b) w_j$$

Positive $(\Phi^+(a))$ and negative $(\Phi^-(a))$ outranking currents are calculated according to equations (5 & 6).

$$\phi^+(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a,x) \tag{5}$$

Table 1. Types of Generalized Criteria

Parameter	Equation	Generalized Criteria
-	$P(d) = \begin{cases} 0 & d \le 0 \\ 1 & d > 0 \end{cases}$	
q	$P(d) = \begin{cases} 0 & d \le q \\ 1 & d > q \end{cases}$	
p	$P(d) = \begin{cases} 0 & d \le 0 \\ \frac{d}{p} & 0 \le d \le p \\ 1 & d > p \end{cases}$	
p,q	$P(d) = \begin{cases} 0 & d \le q \\ \frac{1}{2} & q < d \le p \\ 1 & d > p \end{cases}$	
p, q	$P(d) = \begin{cases} 0 & d \le q \\ \frac{d-q}{p-q} & q < d \le p \\ 1 & d > p \end{cases}$	
s	$P(d) = \begin{cases} 0 & d \le q \\ 1 - e^{-\frac{d^2}{2s^2}} & d > q \end{cases}$	

Source: Tomic et al.[5]

$$\phi^{-}(a)=\frac{1}{n-1}\sum_{x\in A}\pi(x,a) \quad (6)$$

Thus, the pure outranking methods can be obtained according to equation (7).

$$\phi(a)=\phi^{+}(a)-\phi^{-}(a) \quad (7)$$

In this method, the full ranking of options, according to 2 mentioned terms in equation (8), and superiority relations (*P*) and minor differences (*I*) are obtained.

$$\begin{cases} aP^{II}b & if \quad \phi(a)>\phi(b) \\ aI^{II}b & if \quad \phi(a)=\phi(b) \end{cases} \quad (8)$$

Bayatani and Sadeghi concluded that prioritizing the causative agents of diseases and finding their local aggregation by using a combination of statistical analysis and local aggregation and modeling are possible in a GIS.[7]

In recent years, a number of methods were provided as outranking methods based on paired comparisons without using the excessive information, that focus on more accurate and realistic modeling decision-making issues. Among the various methods that are presented in the form of outranking methods, family of preference ranking organization method for enrichment evaluations (PROMETHEE) methods are widely used in the real world such as tourism, water resources management, priority in quality health centers, sewage facilities locating and vulnerability mapping watersheds with successful results.[8-12]

The strengths of this method compared to other methods of decision-making are ease of use for users, possibility of the parameters interpretation (classification of indices and options), sustainability of results compared to most of other methods, sensitivity analysis as simple and quick as possible, taking advantage of graphic design modeling, and possibility of considering different constraints in decision optimization.[8]

Given that this method alone cannot analyze the spatial multi-criteria problems, integration of PROMETHEE outranking methods with GIS is recommended for better and more efficient analysis of spatial issues.

Therefore, in this study, because of the necessity of studying the mood disorders, the vulnerability model with Promethee method of MCDA family models (multiple-criteria decision-making [MCDM] or multiple-criteria decision analysis [MCDA] is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making both in daily life and in settings such as business, government and medicine) was prepared. In the present study, this method is used to evaluate the climatic parameters (temperature, sunny hours, minimum and maximum humidity) effect on the incidence of mood disorders (bipolar and depression) in patients hospitalized in Farabi hospital of Isfahan and Kargrnezhad hospital of Kashan, in Isfahan province according to the location of patients.

The Geographical Location of the Study Area

Isfahan province has 107 044.6 km area and is located between 31 degrees 26 minutes to 34 degrees 30 minutes north latitude and 49 degrees 30 minutes 55 degrees 50 minutes east longitude meridian of origin (Figure 1).[13]

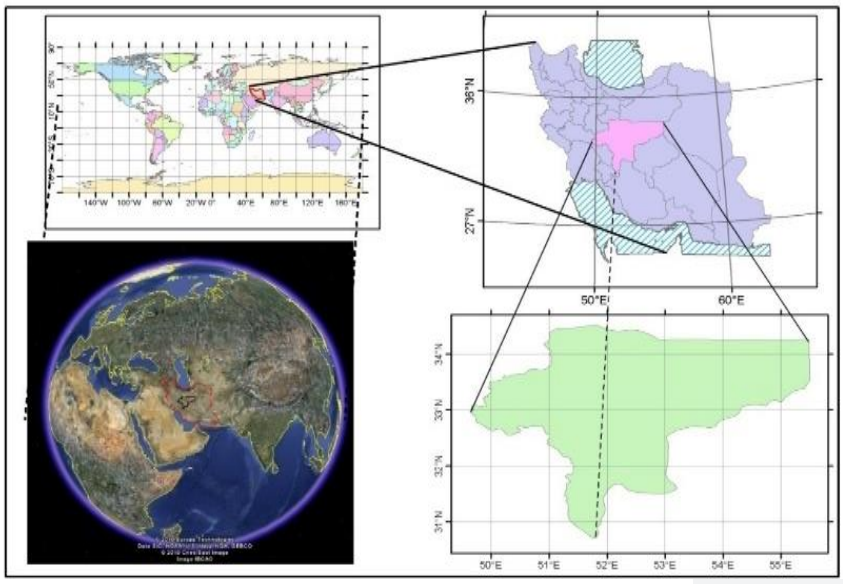


Figure 1. Location of Isfahan in Iran.

Methods

This descriptive analytical study evaluated the modeling of vulnerability to mood disorders (depression and bipolar). Because the mental illnesses are among those diseases on which environmental and climatic conditions can be effective, in this study, we evaluated the effect of climatic factors (temperature, rainfall, sunny hours, minimum and maximum humidity) on the incidence of depression and bipolar diseases and modeled the vulnerability to these diseases according to climatic factors.

Data of people that suffered from each disorder (depression and bipolar) were obtained by place of residence, age and sex from 2007 to 2011 (recorded data were obtained from psychiatric ward of Khorshid hospital, Farabi hospital of Isfahan city and Kargarnejad hospital of Kashan city).

Basic map including topography, isorain and isothermal maps and so on was drawn using GIS and to run the PROMETHEE outranking methods, we used Visual PROMETHEE software and the layers were analyzed in ArcGIS version 10.1.

In order to prepare maps of each climatic parameters, first, data of synoptic stations were interpolated by using the IDW tool in the ArcGIS and then by the Zonal statistics tool. Average of each of climatic factors was calculated and applied to each city. Finally, according to obtained maps and data and overlapping of them, the effect of climatic parameters on spatial distribution of mood disorders (depression and bipolar) in Isfahan province was studied.

Results

Among hospitalized mental patients in Khorshid and Farabi hospitals in Isfahan city and Kargarnejad hospital in Kashan city from 2007 to 2011, 9567 patient suffered from bipolar and 6195 patient suffered from depression. Among patient with bipolar, 3609 patients (37.7%) were women and 5958 patients (62.2%) were men. And in patients that suffered from depression, 1949 patients (31.45 %) were women and 4246 patients (68.5%) were men. The youngest patient of this statistical population was 11 years old and the oldest one was 93 years old. For this reason, age classification was done from 11 years old to older ages and based on the classification in the study of Davasaz et al[14] by a ten-year interval. Thus, in terms of age distribution, the patients were classified into 8 classes. Among these classes in bipolar disorders in the age class of 21-30 years old, about 3322 patients were assigned and to the same class among depression patients about 2018 patients were assigned as the largest classes. Charts show age distribution in both illnesses (Figures 2 and 3).

In order to assess the environmental factors, first of all, the map of vulnerability to mood disorders was prepared. Evaluating the diseases shows that the incidence of bipolar disorder and depression is significantly correlated in the cities of Isfahan province; it means that each city which has a greater incidence of bipolar disorder, the depression is also more frequent there and vice versa. Therefore, for these two diseases, we prepared a risk map and analyzed with the map of climatic parameters.

As it is seen in Figure 4, the differences between these two diseases are different in every city; so, to prepare a risk map, we should combine these two diseases in a way that the incidence of both diseases is considered. To achieve this purpose, the PROMETHEE method was used. This method starts with extension of incidence rate of each disease to evaluate priority of one city over another city by converting the product levels for cities to a scale from 0 to 1 (where 0 represents the worst and 1 does the best).[4]

Higher priorities reported in the form of a matrix according to equation (1) in which all cities will be compared together according to each disease.

At this stage, the diseases in the form of ordinary priority of function (Table 2) entered to PROMETHEE

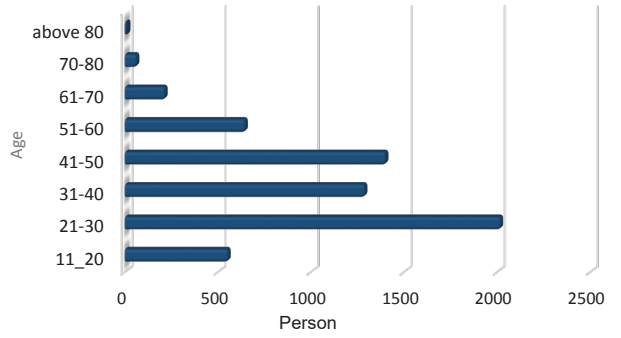


Figure 2. Bipolar Patients in Isfahan Province According to Age Classification from 2007 to 2011.

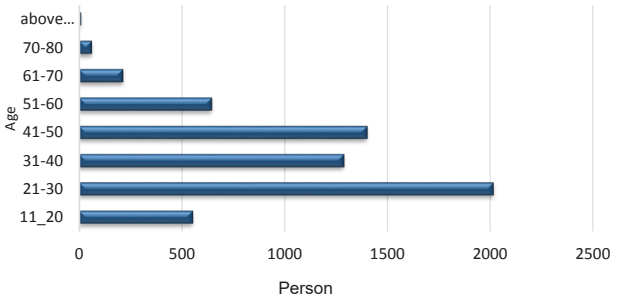


Figure 3. Depression Patients in Isfahan Province According to Age Classification from 2007 to 2011

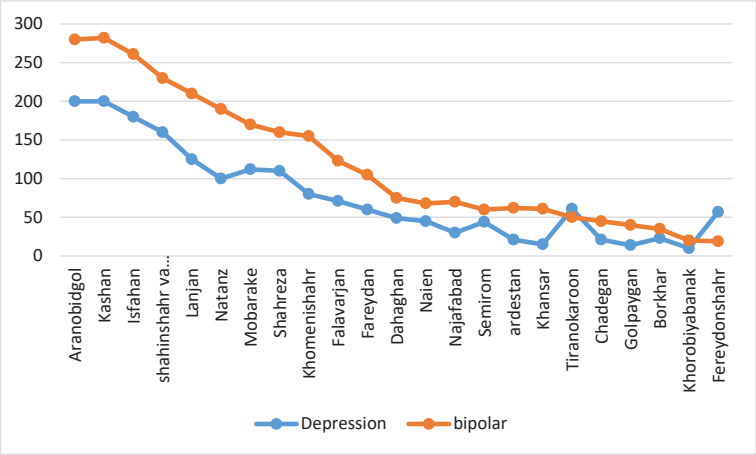


Figure 4. The Incidence of Mood Disorders in Hundreds of Thousands.

model.

PROMETHEE method output has 3 types of data:

- Output flow (Φ^+) that is average of Intensity of priorities of one city than other cities (Equation 7).
- Input flow (Φ^-) which is average of Intensity of priorities of all cities than one city (equation 6).
- Pure flow (Φ) that is achieved from the difference between the output and input flows (equation 7), and based on the pure flow the priority rate of cities to each other is measured.

Pure flows resulting from the PROMETHEE model were entered into the describing information table of each city, and according to this field, the risk maps were drawn. Finally, based on the difference between the standard deviation, the pure flows (Φ^+) were classified into three classes (Figure 5).

For preparing each map of the climatic factors, first, the synoptic stations data were interpolated by using IDW tool in ArcGIS software, and then by the Zonal Statistics tool, the average of each climatic factor was calculated and applied to each city. Comparing the temperature map with the risk map of province shows that the risk of incidence of mood disorders corresponded mostly to temperature range of 14.69 to 17.37°C (Figure 6).

According to Figure 7 the majority of very high and high risk cities have precipitation in the range of 117.76

Table 2. Output PROMETHEE Method

Rank	Township	Input Current	Output Current	Net Output	Score
1	Arano bidgol	0	0.955	0.955	100
1	Kashan	0	0.955	0.955	100
2	Isfahan	0.091	0.909	0.818	23.26
3	Shahinomeymeh	0.136	0.864	0.727	14.73
4	Lanjan	0.182	0.818	0.636	10.47
5	Shahreza	0.273	0.727	0.455	6.20
5	Mobarakeh	0.273	0.727	0.455	6.20
5	Natanz	0.273	0.727	0.455	6.20
6	Khomeynishahr	0.364	0.636	0.273	4.07
7	Falavarjan	0.409	0.591	0.182	3.36
8	Fareydan	0.477	0.523	0.046	2.55
9	Dahaghan	0.568	0.432	- 0.136	1.77
11	Tirano karon	0.614	0.386	- 0.227	1.46
11	Semirom	0.614	0.386	- 0.227	1.46
12	Naieen	0.614	0.386	- 0.227	1.46
13	Najafabad	0.659	0.341	- 0.318	1.20
14	Ardestan	0.727	0.273	- 0.455	0.87
15	Fereydonshahr	0.773	0.227	- 0.546	0.68
16	Khansar	0.818	0.182	-0.646	0.52
17	Chadegan	0.841	0.159	- 0.682	0.44
18	Borkhar	0.864	0.136	-0.727	0.37
19	Golpaygan	0.909	0.091	- 0.818	0.23
20	Khorobiyabanak	0.977	0.023	-0.955	0.05

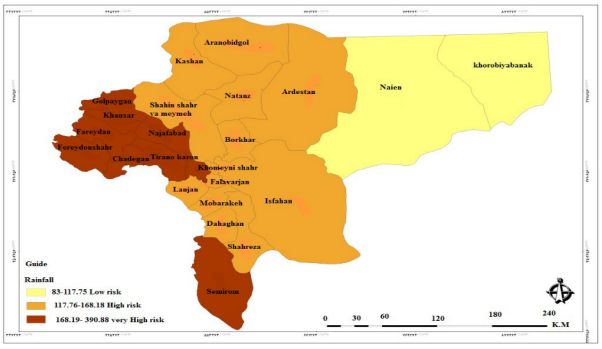


Figure 5. Map of Vulnerability to Mood Disorders in Isfahan Province.

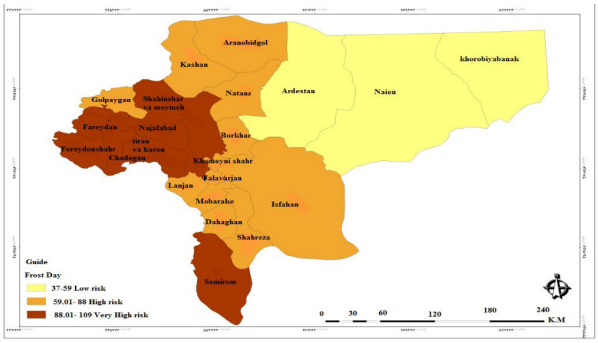


Figure 8. Map of Frost Days in Isfahan Province.

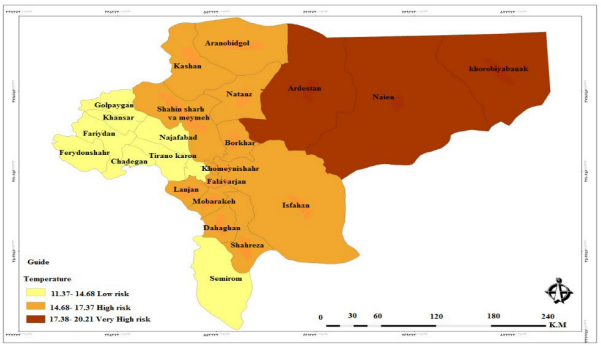


Figure 6. Temperature Map of Isfahan Province.

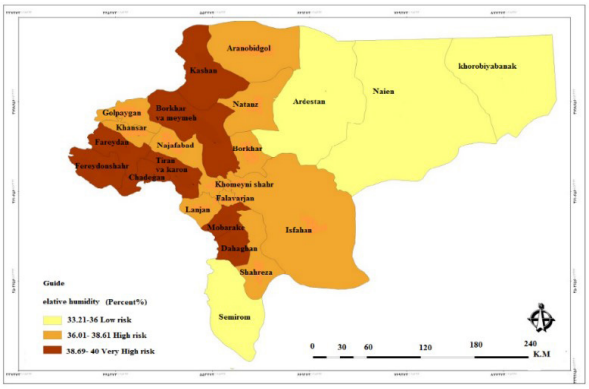


Figure 9. Map Moisture Isfahan Province.

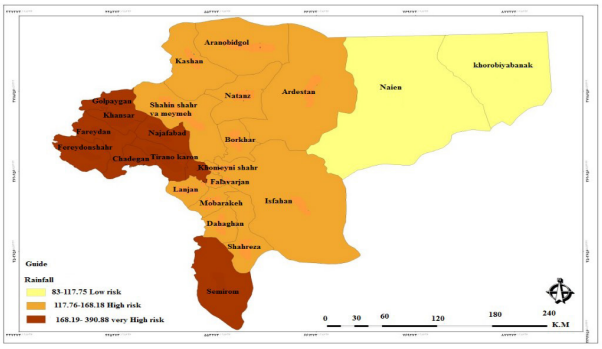


Figure 7. Precipitation Map of Isfahan Province.

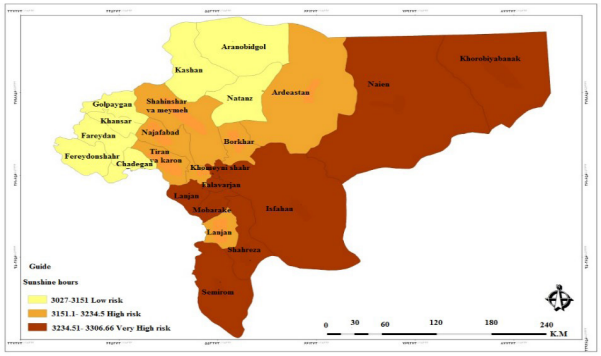


Figure 10. Map of Sunshine in Isfahan Province.

to 168.18 mm, respectively. Thus, it can be concluded that this rate of rainfall makes the environment more vulnerable to mood disorders.

According to the map of frost days in Isfahan province (Figure 8), in cities with a high incidence of mood disorders, the number of frost days is about 59 to 88 days.

Based on the results and Figure 9, the relative humidity that is above 36% makes the conditions more vulnerable to mood disorders. The sunny hours is also one of the analyzed factors in vulnerability to mood disorder. As Figure 10 shows, the incidence of mood disorders in cities has no significant relationship with the sunny hours factor.

Discussion

Reviews of mental illness that in many cases lead to physical illness, can provide conditions from next adverse consequences for the individual, family and community. The climate change in different regions can have a great impact on mental health, which proposes the medical geography discussion.

Medical geography is a modern and growing science in Iran. However, in European countries for many years it was considered based on geography regions and impact of climate on incidence of diseases. But this has a slow process in Iran.

So far, different studies were done about the impact of climatic factors on the incidence of mental illness

in the world and also in Iran that we referred to a few of them:

Howarth[15] and Guilmette et al[16] studied anxiety, aggression, depression, drowsiness, optimism and succulence in association with meteorology parameters such as sunny , rainy, snowy, moderate and humid days. They found that humid, moderate and sunny weather conditions have the most effects on moods. Humid weather leads to focus reducing and drowsiness increases. In moderate conditions anxiety decreases.

Results of Reid et al[17] and Madden et al[18] study is one of the possible mechanism in emotional disorder of seasonal mood changing. It is a fairly stable characteristic seen in this people. Change of mood is associated with emotional response. People who have more mood changeability may have more emotional reactivity against strong external changes. It seems that the emotional reaction is one of the characteristics of seasonal mood, since people with higher seasonal mood gain relatively high scores in neuroticism and often have more emotional response to the weather conditions.

Rohan and Sigmon in a study asked students to complete the Seasonal Pattern Assessment Questionnaire and also Beck Depression Inventory (BDI) in fall, winter and spring. More than half of these students based on seasonal pattern assessment questionnaire, showed a winter mood significant pattern, that was associated with low mood, a decrease in energy levels and social activity and weight gain, appetite and sleep in the winter months. Sixteen percent of students showed sub symptoms of seasonal emotional disorders and 5% of them showed the symptoms of seasonal emotional disorders. Finally, the students reported "relatively bad" feeling in December and also "relatively good" feeling in April.[19]

Hardt and Gerbershagen in a survey study on patients with coronary heart disease reported that, in November, December, January and February 19% of women and 14% of men responded in terms of difficulty in sleeping. Difficulty in sleeping increased in December and decreased in February. Lack of bright days in December and January, was associated with a prevalence of psychological distress.[20]

Talaie et al discussed the relationship between homicide, suicide and hospitalization of psychiatric patients in Mashhad according to climatic factors, and they found a strong relationship between violence and hospitalization of mental patients with a daily average temperature, minimum and maximum relative humidity, and minimum and maximum daily atmospheric pressure.[21]

Rosenthal et al reported that clinical depression occurs regularly during the winter months and decrease during spring and summer. They also noticed some related high range of changes in behavioral and physiological of people, including decreased physical activity, change in appetite, increased drowsiness, reducing of social interactions and increased excitability to winter.[22]

Anderson in a study investigated the effects of heat on human assaults. He said at least five different types of aggression were increased by heat.[23]

Postolache et al recognize the Suicides peak in the spring and believes that mood disorders increased in the spring.[24] Biometeorologists have found that biological behavior, mood and health were associated with climate change.[25]

Cyr found that people in different weather conditions (such as sunny, rainy, cloudy, windy, snowy and foggy) immediately respond to conditions..[26]

Khoshhal and Arman in a study, investigated the relationship between environmental temperature and aggression in two cities with different climates, hot and cold. The results of this research showed that the aggression is more common in cold climates.[27] In another study, with the amount of pharmaceutical suicide in Isfahan, In a five-year period from 1989 to 2004, he linked the number of daily, weekly, two weeks, monthly and seasonal suicides with variables such as temperature (min - max - average), sunshine hours and day length.[28]

Ghias et al in their study on the effects of climate on psycho-behavioral disorders in children between 4 to 7 years old in Isfahan, Iran found that the mental disorders in cold regions were mostly nocturnal enuresis and depression and in tropical regions were stuttering and nail-biting.[29]

Most studies in the field of seasonal changes and psychiatric disorders have emphasized on mood disorders, however, other psychiatric disorders may also have seasonal features such as bulimia whose symptoms increase during the winter. Seasonal changes in anxiety disorders, dipsomania and obsession have also been reported. A number of studies were done on the impact of season on suicide which showed that a number of suicides occurred after the very bad weather. Some studies have indicated the relationship between light and suicide.[30]

Therefore, it can be said that the number of the people who are sensitive to atmospheric changes, increases day by day. Although sensitivity to atmospheric changes is not a disease by itself but it can have severe side effects. In order to study climatic

factors on mood disorders (bipolar and depression) the climatic factors including temperature, precipitation, sunny hours, minimum and maximum humidity were evaluated. Data analysis showed that these mood disorders in all listed cities has a significant correlation together. For risk mapping, two diseases data (bipolar and depression), were combined together by using the PROMETHEE method. Finally, according to criteria that differ from the average of pure flow (Φ) all cities of Isfahan province were classified into three groups to study the incidence and risk of these disorders, that Isfahan city is in high risk and Nain city is at low risk. Comparing the distribution of mood disorders and climatic factors (temperature, precipitation, frost days, sunny hours, minimum and maximum humidity) showed that this mood disorders is more common in 14.69 to 17.37°C of temperature, 168.18-117.76 mm of precipitation, 88-59 frost days, and above 36% of humidity. Also significant correlations were not found between the sunny hours and incidence of mood disorders.

Another variable that must be controlled in future studies is individual differences. Some studies [16] showed that features of Neuroticism is associated with sensitivity to climate change; this means that people who have high score on the personality trait of Neuroticism, more quickly respond to climate change.

Therefore, we can use the results of the above researches in preparing the maps of spatial distribution of different diseases by considering the geographical factors affecting them (so far less attention has been paid to them) including mental illness. Spatial and temporal changes can be predicted and side-effects of diseases can be reduced by planning and making appropriate decisions by health policy makers.

For more accurate and more practical this study recommends using more limited scale of research and more precise evaluation criteria. To select the appropriate method for analyzing the more accurate data other multi-criteria decision-making methods should also be evaluated

Conflict of Interest Disxclosures

The authors declare no conflict of interest.

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