

Climate and Prevalence of Mood Disorders: A Cross-National Correlation Study

To the Editor: Seasonal climate variations are notably known to affect mood in both individuals with and individuals without mental disorders.^{1,2} Intriguingly, the prevalence of mood disorders differs greatly from one country to another. For example, lifetime prevalence has been measured at 21% in France and the United States, compared with under 5% in Nigeria.³ Since seasonal variations could affect the mood, we conducted the following study to examine whether some climate characteristics could, at least in part, explain the worldwide distribution of lifetime prevalence of mood disorders.

Method. The lifetime prevalences of mood disorders from 17 countries belonging to each continent in both the Northern and Southern hemispheres in 2001–2005 were extracted from the World Health Organization World Mental Health Survey (see eAppendix 1 at Psychiatrist.com).³ For each country, the population size, the gross domestic product (GDP) per habitant, and climate characteristics for the period 1990–2009 were obtained from the World Bank Group (www.worldbank.org).

The differences between the highest and lowest monthly values of rainfall and temperature were calculated to serve as estimates of the amplitude of the seasonal variations. Four independent variables were thus obtained: the annual averages of rainfall and temperature and the amplitudes of monthly differences in rainfall and temperature. The lifetime prevalence of mood disorders was the dependent variable of the model. The selection of the best multiple regression model was based on the significance of *F* tests and the highest *R*² values. The model was further tested with the inclusion of population size or GDP per habitant as a control variable to assess their possible influence on the relationship between climate and prevalence of mood disorders. Finally, leave-one-out sensitivity analyses were conducted by repeating analyses with the consecutive exclusion of each data point to ensure that the overall results were not influenced by outlier data.

Results. The best multiple regression model included the 4 independent variables ($F = 4.78$, $R^2 = 0.62$, $P = .015$). The β values, indicative of the direction and the strength of the relationship between each independent variable and the lifetime prevalence of mood disorders, were -1.30 ($P = .02$) for the amplitude of monthly rainfall differences, 0.81 ($P = .003$) for the average annual rainfall, 0.23 ($P = .64$) for the amplitude of monthly temperature differences, and 0.53 ($P = .40$) for the average annual temperature. The inclusion of the population size ($F = 16.84$, $R^2 = 0.86$, $P < .0001$) or the GDP per habitant ($F = 4.33$, $R^2 = 0.59$, $P = .021$) as a control variable did not affect the present results. Finally, leave-one-out sensitivity analyses identified no outlier data.

Some limitations should be taken into account when interpreting the present results. First, the data did not take into account the regional variability within a given country of both climate

characteristics and lifetime prevalences of mood disorders. Climate properties were measured in the capitals of the included countries, and lifetime prevalences corresponded to the national prevalences. Second, although the years of data collection for lifetime mood disorder prevalences and climate characteristics could not perfectly fit, their overlap (2001–2005 for lifetime prevalences and 1990–2009 for climate characteristics) seems reasonable and should not affect our results and conclusions, given the velocity of climate change. Finally, we were unable to consider the different subtypes of mood disorders, and we cannot specifically conclude whether climate characteristics may affect the lifetime prevalence of major depressive disorder, bipolar disorder, or both.

However, this study is the first to describe the relationship between the climate of a country and its lifetime prevalence of mood disorders (see eAppendix 1). Specifically, the highest prevalences of mood disorders are observed in countries characterized by small variations across monthly rainfall and high levels of rainfall, independently of the countries' wealth.

The present findings extend previous results by highlighting the critical importance of the weather in mood disorders through a cross-national dimension and offer new perspectives regarding the discrepancies across national lifetime prevalences of mood disorders. It remains to be determined, for example, whether the relationship between climate and prevalence of mood disorders could be mediated by light exposure or barometric pressures and whether climate changes to come may affect the occurrence of mood disorders.

REFERENCES

- Schlager D, Schwartz JE, Bromet EJ. Seasonal variations of current symptoms in a healthy population. *Br J Psychiatry*. 1993;163(3):322–326.
- Magnusson A, Partonen T. The diagnosis, symptomatology, and epidemiology of seasonal affective disorder. *CNS Spectr*. 2005;10(8):625–634, quiz 1–14.
- Kessler RC, Angermeyer M, Anthony JC, et al. Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry*. 2007;6(3):168–176.

Jean-Yves Rotgé, MD, PhD
jeanyves.rotge@mac.com
Philippe Fossati, MD, PhD
Cedric Lemogne, MD, PhD

Author affiliations: INSERM (French Institute of Health and Medical Research) UMR 894, Psychiatry & Neurosciences Center, Paris Descartes University, Sorbonne, Paris Cité, Faculty of Medicine (Drs Rotgé and Lemogne); Pierre and Marie Curie University; INSERM U 1127, CNRS (National Center for Scientific Research) UMR 7225; Brain and Spine Institute; and AP-HP (Paris Hospitals Public Assistance), Department of Psychiatry, Pitie-Salpetriere Hospital (Dr Fossati); and AP-HP, Department of Old Age Psychiatry, University Hospital Paris West (Dr Lemogne), Paris, France.

Author contributions: All authors were involved in the research and writing of this letter.

Potential conflicts of interest: None reported.

Funding/support: None reported.

Supplementary material: Available at PSYCHIATRIST.COM.

J Clin Psychiatry 2014;75(4):408 (doi:10.4088/JCP.13108810).

© Copyright 2014 Physicians Postgraduate Press, Inc.

See supplementary material for this letter at PSYCHIATRIST.COM.



THE JOURNAL OF
CLINICAL PSYCHIATRY
THE OFFICIAL JOURNAL OF THE AMERICAN SOCIETY OF CLINICAL PSYCHOPHARMACOLOGY

Supplementary Material

Letter Title: Climate and Prevalence of Mood Disorders: A Cross-National Correlation Study

Author(s): Jean-Yves Rotge, MD, PhD; Philippe Fossati, MD, PhD; and Cedric Lemogne, MD, PhD

DOI Number: 10.4088/JCP.13l08810

List of Supplementary Material for the letter

1. [eAppendix 1](#) Supplementary Methods and Discussion

Disclaimer

This Supplementary Material has been provided by the author(s) as an enhancement to the published letter. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

Climate and prevalence of mood disorders: a cross-national correlation study

Jean-Yves Rotge, Philippe Fossati, Cedric Lemogne

Supplementary Methods

In the present study, we have included all countries (n=17) for which the WHO World Mental Health Survey reported the lifetime prevalence of mood disorders, namely Belgium, Colombia, France, Germany, Israel, Italy, Japan, Lebanon, Mexico, Netherlands, New Zealand, Nigeria, PR China, South Africa, Spain, Ukraine, United States (Kessler et al., 2007).

Supplementary Discussion

To account for the relationship between climate and prevalence of mood disorders, many hypotheses, not mutually exclusive, could be posited. First of all, sun exposure is likely to be related to the climate characteristics described in the present study. Many studies have reported the efficacy of bright light therapy and dawn simulation in seasonal affective disorder and in nonseasonal mood disorders (Terman and Terman, 2005; Golden et al., 2005; Lieveise et al., 2011). Activation of the suprachiasmatic nucleus of the hypothalamus, which regulates circadian rhythms (Bunney and Bunney, 2000; Zhou et al., 2001), through the glutamatergic retinohypothalamic tract (Berson et al., 2002) may account for the effects of bright light treatment on mood and hypothalamic-pituitary axis activity. Light may also activate the raphe nucleus through subcortical projections of retinal neurons (Frazao et al., 2008). The raphe nucleus is the main source of the serotonergic inputs to limbic structures, which contributes to the pathophysiology of mood disorders (Owens and Nemeroff, 1994), but it is also involved in the

regulation of circadian systems (Ciarleglio et al., 2011). Second, high levels of rainfall and its everyday life consequences may constitute a chronic and repetitive stress factor, susceptible to affect the mood. Finally, rainfalls are usually associated with low barometric pressure, which could account for the association between rainfalls and mood disorders. Indeed, low barometric pressure could affect the human sympathetic-parasympathetic balance (Hansen and Sandner, 2003), which has been shown to be altered in mood disorders (Grippe and Johnson, 2002). Obviously, the hypothesis of such a pathophysiological mechanism requires to be properly assessed.

Conclusions

Worldwide climate types may partially explain the worldwide distribution of mood disorders. Our findings suggest that chronic exposition to a cat-and-dog weather with poor seasonal variations represents a risk factor of mood disorders. It remains to be determined whether the relationship between climate characteristics and lifetime prevalence of mood disorders could be mediated by light exposure or barometric pressures and whether climate changes to come may affect the occurrence of mood disorders.

Supplementary References

Berson DM, Dunn FA, Takao M. Phototransduction by retinal ganglion cells that set the circadian clock. *Science*. 2002;295:1070-1073.

Bunney WE, Bunney BG. Molecular clock genes in man and lower animals: possible implications for circadian abnormalities in depression. *Neuropsychopharmacology*. 2000;22:335-345.

Ciarleglio CM, Resuehr EH, McMahon DG. Interactions of the serotonin and circadian systems: nature and nurture in rhythms and blues. *Neuroscience*. 2011;197:8-16.

Frazao R, Pinato L, da Silva AV, Britto LR, Oliveira JA, Nogueira MI. Evidence of reciprocal connections between the dorsal raphe nucleus and the retina in the monkey *Cebus apella*. *Neurosci Lett*. 2008;430:119-123.

Golden RN, Gaynes BN, Ekstrom RD, et al. The efficacy of light therapy in the treatment of mood disorders: a review and meta-analysis of the evidence. *Am J Psychiatry*. 2005;162:656-662.

Grippe AJ, Johnson AK. Biological mechanisms in the relationship between depression and heart disease. *Neurosci Biobehav Rev*. 2002;26:941-962.

Hansen J, Sander M. Sympathetic neural overactivity in healthy humans after prolonged exposure to hypobaric hypoxia. *J Physiol*. 2003;546:921-929.

Kessler RC, Angermeyer M, Anthony JC, et al. Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry*. 2007;6:168-176.

Lieverse R, Van Someren EJ, Nielen MM, Uitdehaag BM, Smit JH, Hoogendijk WJ. Bright light treatment in elderly patients with nonseasonal major depressive disorder: a randomized placebo-controlled trial. *Arch Gen Psychiatry*. 2011;68:61-70.

Owens MJ, Nemeroff CB. Role of serotonin in the pathophysiology of depression: focus on the serotonin transporter. *Clin Chem*. 1994;40:288-295.

Terman M, Terman JS. Light therapy for seasonal and nonseasonal depression: efficacy, protocol, safety, and side effects. *CNS Spectr*. 2005;10:647-663.

Zhou JN, Riemersma RF, Unmehopa UA, et al. Alterations in arginine vasopressin neurons in the suprachiasmatic nucleus in depression. *Arch Gen Psychiatry*. 2001;58:655-662.