SOLAR ACTIVITY AND HOSPITALIZATIONS FOR DEPRESSIVE EPISODES IN CHILE

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INTRODUCTION: *This paper presents the relations between solar activity and the incidence of hospitalizations for depressive disorder found in the register of the Ministry of Health of Chile, where all the hospital discharges from 2001 to 2008 are kept.*
Solar activity is represented by the Wolf number, with the formula R= K (10g+f), where g refers to the group of sunspots and f is the total number of sunspots.
METHOD: *The databases of the Ministry of Health show all the hospital discharges, whether for psychiatric causes or other diagnoses, including data from public as well as private hospitals. For the sample analysis, two cases diagnosed as depressive disorder according to the classification CIE 10, ranging from F320 to F339, both included, were selected. The correlation between annual incidence of hospitalizations for depression and the average of the Wolf number for that particular year between the period spanning from 2001 to 2008, both included, which corresponds to approximately half of a solar cycle of 16 years.*
RESULTS: *Less intensity of solar activity correlates to a higher frequency of hospitalizations for depression in Chile.*
CONCLUSIONS: *Depressive disorders have a significant inverse correlation to solar activity.*
Key words: *Solar activity, Wolf number, Depression*

INTRODUCTION

Different mental disorders have been linked to the influence of the stars on human beings. Among these, mood disorders have been studied the most. A group of these disorders, the seasonal affective disorders, has been correlated to variables such as geographical latitude, time of acclimatization in migratory movements or journeys, ethnic and genetic characteristics, and the seasons of the year. Most research suggests that a percentage of individuals with unipolar as well as bipolar disorder are linked to seasonal rhythms [(1)]. Seasonal variations have also been linked to different psychiatric disorders, such as food disorder, anxiety, obsessive-compulsive disorder, premenstrual dysphoric disorders, as well as other such as alcoholism. Although it has been pointed out bulimia is most frequent during winter, we observe that those patients usually have comorbidity with mood disorders [(3)]. Research in this area shows that affective disorders are the ones most frequently associated to seasonal rhythms. It has been pointed out that those who suffer winter seasonal affective disorder (SAD) have as clinical characteristics atypical depressive symptoms[(4)]. The course of the illness is characterized by recurrent depressive episodes during the winter that tend to disappear during the

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summer, which would be explained by the lower amount of daily light during winter. This has been backed by papers that found a higher number of depressions in areas located at the latitudes closer to the North, where the common factor is the reception of less light (1, 5, 6). It has been mentioned that bipolar depressions with more access to light register shorter hospital stays (7).

Research carried out in six Japanese cities, located from latitude North 32 to 43, revealed the correlations between mood disorders and this variable (8). However, also in Japan, it was noted that the number of hours of daily sunlight during winter is a more influential predictor in the appearance of SAD than latitudes (9). Other authors have not found relations between latitude and prevalence of SAD, which is attributed to factors such as genetic vulnerability and sociocultural context (10,11). A higher genetic vulnerability for SAD in twins and close relatives has been suggested (12).

The effect of phototherapy as an effective treatment for depressive disorders is well known, in SAD as well as in those who do not follow this pattern (13). The higher the quantity of light applied, the stronger the answer to phototherapy (14). When following usual technical considerations, it does not present harmful side effects on the retina and the eye (15). It has been mentioned that melatonin, a hormone secreted by the pineal gland specially during the night, is a relevant factor (16). Phototherapy has an impact on its suppression, depending on the quantity of bright white light applied via lux units, modifying the human circadian patterns, effect that occurs to depressive individuals as well as to normal adults. It alters in constant ways the circadian pacemakers and the sleep patterns, thus influencing the levels of plasma melatonin, prolactin and cortisol (17-26). However, affective disorders do not necessarily go along with variations in melatonin levels, although the phototherapy that reduces these levels has therapeutic effects in the affective disorders (27).

Several drugs have demonstrated to be useful in SAD, such as the SSRI, reboxetine and mirtazapine. The most studied of these was the sertraline in controlled design with placebo, presenting a higher clinical action than tricycles and tetracycles (28). Thus, the serotonergic system as well as the catecholamines would be involved in seasonal affective disorders (29,30,31).

The energetic activity of the sun seems to be another variable correlated to the onset of affective illness. Already in 1610 Galileo Galilei observed sunspots from a telescope, although Chinese astronomers had recognized and registered them some 1000 years before. These spots have periodic variation through time. These stages were proven by Heinrich Schabe in 1843. Since 1894 measurements of these spots have been done, systematized by Wolf, who detected an increment and decrease of them in regular periods of 11 years. This was called “sun cycle”, and it repeats regularly. The spots are directly associated to solar energy activity, the latter being higher when there is a higher quantity of spots in the surface of the sun (32).

Several facts have been observed related to the regularity of sun activity represented by sunspots, such as the modification of the temperature of the Earth, variations in rainfall, impact in the quality of the wines in certain areas, abundance of crops, electrocolloidal changes in blood and the growth of bacteriological crops. An interesting finding are the observations on the growth rings in trees, which reveal their age. This can be seen when doing a cross-section cut of the tree trunk, which shows a major extension in its rings in the years of higher sun activity. This phenomenon is attributed to sunspots, which present oscillations in 11-year periods (36). The aforementioned examples show the relation between the sun cycles and the highly diverse biological parameters, the rhythm of which would have a relation to solar activity (33).

To date, only the influence of sunlight and weather conditions have been considered in relation to certain psychiatric disorders, without much consideration given to this influence on human beings. In a previous report sun activity was correlated to the occurrence of affective disorders during a complete sun cycle (11 years) (34). A second report correlated these variables for a period longer than 16 years, finding that depressive disorders have an inverse correlation to sun activity, while manias were directly linked to energy coming from the sun (35).

MATERIALS AND METHOD

With the objective of studying the relation between sun energy and the frequency of hospitalizations for depressive episodes, the registers of the MINSAL (Ministry of Health) corresponding to admission for depressive episodes (CIE10 F32.0 to F33.9), in all public and private establishments in Chile during the period from 2001 to 2008, were examined. On the one hand, the intensity of monthly sun activity was registered through sunspots (sunspot number) according to the data published by the IPS Radio and Space Services, Australian Government (www.ips.gov.au) with the 52.731 cases identified.

The Wolf number varies daily, and it is the result of the formula R= K (l0g+f), where “K” is a constant depending on the observer, “g” is the number of sunspots, and “f” is the total number of spots. For the purposes of this research, the average Wolf number was considered for the months mentioned (32).

RESULTS

Characteristics of the sample

Databases of the Ministry of Health of the Government of Chile (MINSAL), which keeps a register of all the hospital discharges, whether psychiatric or other diagnoses, were examined. These databases include data related to age, gender, social security, hospitalization place, number of days in the hospital, and discharge diagnoses. These databases include hospitalizations in public hospitals as well as in private centers, as it is required from health providers to declare this data to the MINSAL. The registers from 2001 to 2008 were examined.

Table No 1. Characteristics of studied individuals

Demographics	Total	Women	Men
Number of patients (%)	52731	38939 (73,8)	13792 (26,2)
Age Mean Years (St dev)	38,1 (15,7)	38,2 (15,6)	37,8 (16,2)

For the sample analysis, cases that had as primary or secondary diagnosis a depressive episode were selected. The database does not allow to determine whether the episode evaluated is the first episode of the patient or a recurrence. On the other hand, methodological problems to properly identify the patients with depression diagnosis in the context of bipolar disorder were found. Thus, we decided to analyze exclusively CIE 10 diagnoses ranging from F320 to F339, both included; the frequencies of these CIE 10 diagnoses according to year can be seen in the table 2.

Table No 2. Number of cases according to the CIE 10 diagnosis

CIE 10 Diagnoses	Case Count	%
F320	2304	4,4
F321	1590	3
F322	11908	22,6
F323	3426	6,5
F328	545	1
F329	28862	54,7
F330	292	0,6
F331	308	0,6
F332	1360	2,6
F333	552	1
F334	213	0,4
F338	73	0,1
F339	1298	2,5
Total	52731	100

Table 3 shows the number of patients admitted by year. There are no significant differences between demographic variables by year.

Table No 3. Hospitalized individuals according to year of study

Year	Cases Count	%
2001	5037	9,6
2002	5887	11,2
2003	6308	12
2004	6709	12,7
2005	6113	11,6
2006	7520	14,3
2007	8060	15,3
2008	7097	13,5

Sample analysis

The number of hospitalizations for depressions was correlated to the Wolf number, and the correlation was negative. This means that the higher the Wolf number, the lesser the frequency of depression (Figure No 1).
An analysis of linear regression was performed, taking into account the number of monthly hospitalizations for depressive episodes as dependent variable and the intensity of monthly sun activity as the independent variable. A significant negative correlation for the model proposed was found (F 72.57,p 0.000,Beta -0.66). This means that whenever sun activity is reduced by 1 point, the number of cases increases by 0.66. (Figure No 2).

Figure No. 1. Frequency of depression cases in relation to Wolf number

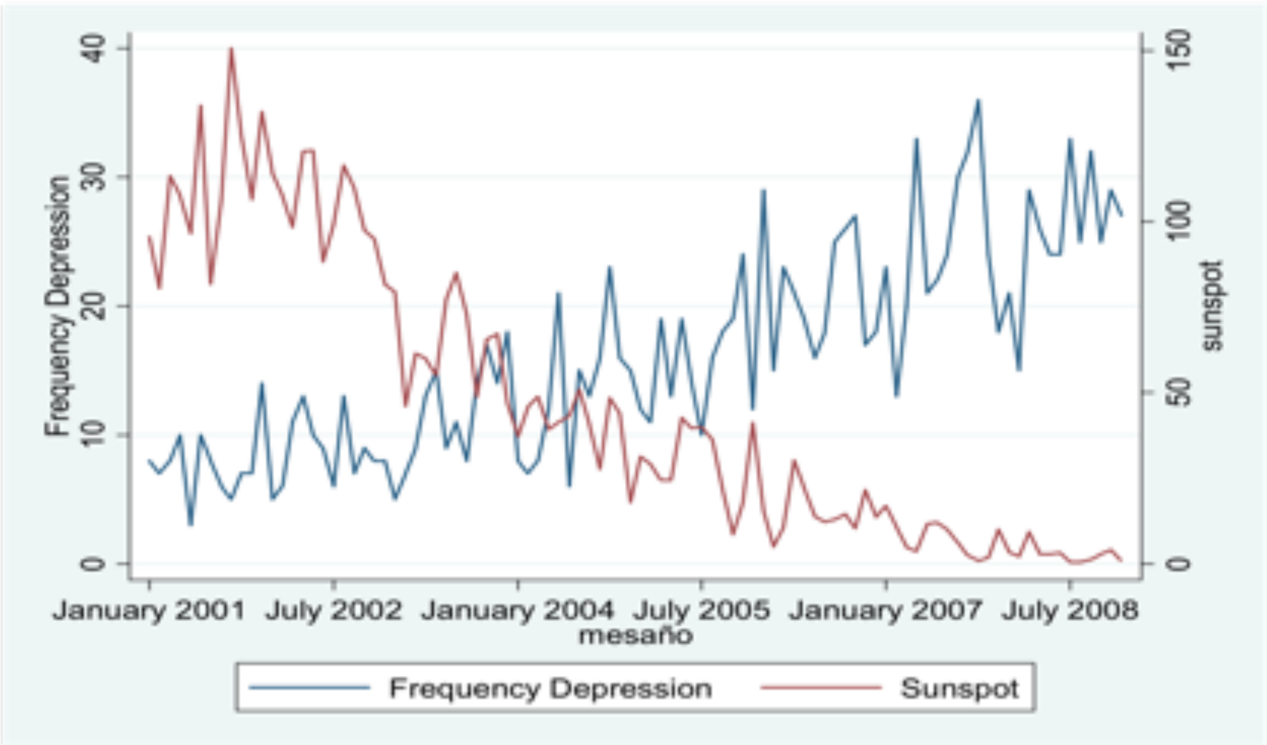
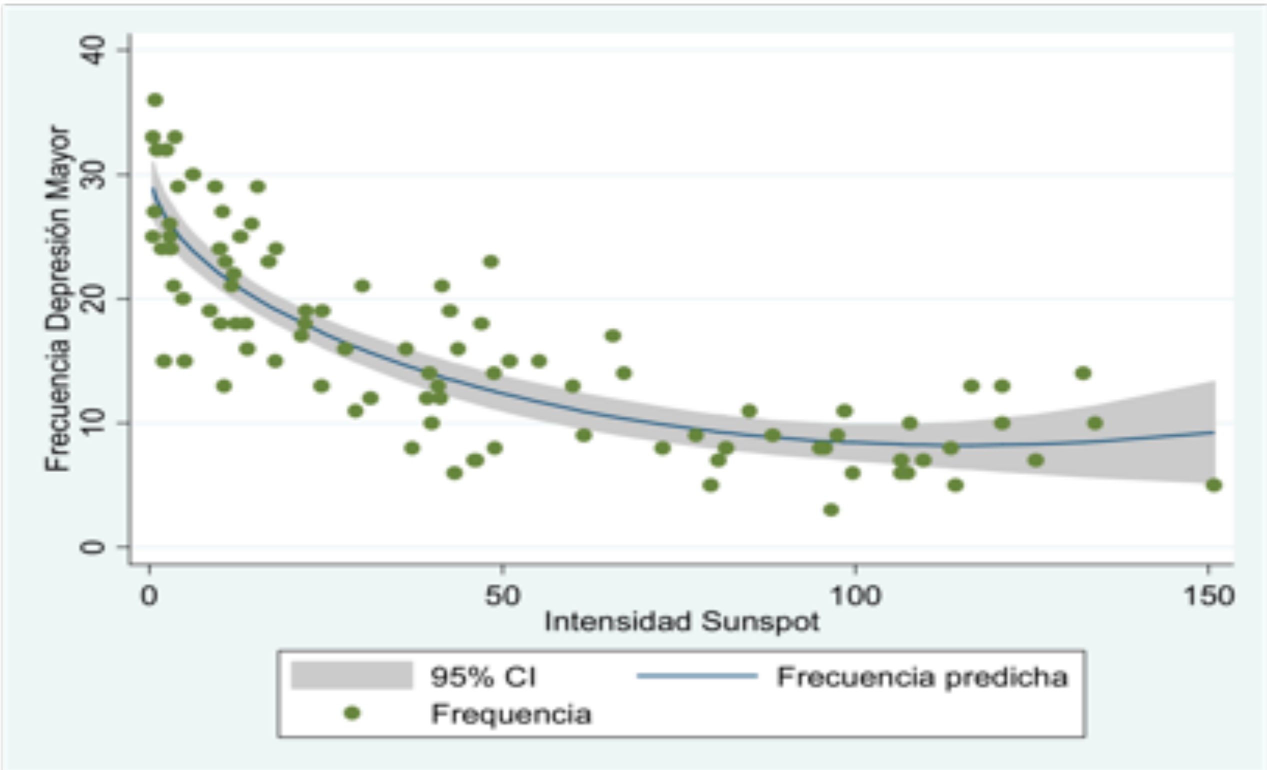


Figure No 2: Linear regression between Wolf number and the frequency of cases of depression



It can be concluded that less intensity of solar activity correlates to a higher frequency of hospitalizations for depression in Chile.

DISCUSSION

Some remarks can be made in relation to sun activity. The Wolf number represents an index of the energy that comes from the sun to the Earth. Sun activity includes not only the quantity of visible light that reaches the Earth at any given time, but also the energy contained in gamma rays, x-rays, and ultraviolet light, the last two being the main sources responsible for sun energy, which is what Wolf number ultimately shows. Visible light is only a tiny fraction of the realm of solar electromagnetic radiations. The visible light spectrum is limited by the infrared zone, which has a longer wavelength, and by ultraviolet light, followed by x-rays and gamma rays of even lower wavelength (36).

The behavior of sunspots is not uniform, but, on the contrary, their presence and activity vary daily for months and years, presenting several dimensions and, at times, they can be observed on the surface of the sun disc.

A sunspot refers to a depression of hundreds of kilometers under the general visible surface of the sun. Its center has a temperature of 3900 degrees Kelvin, compared to the 5600 degrees Kelvin of the rest of the sun surface (37). The surface of the spots can reach diameters from 50.000 to 90.000 kms. (seven times the diameter of the Earth) (32). The temperature of the inner area of the spots represents cooler zones and thus they radiate less light (33). In this way, the higher the number of sunspots, the lesser quantity of sunlight in the form of photons coming from that area is observed, but at the same time a rise in the magnetic solar energy and of energy as such can be observed.

The spots are surrounded by brighter areas called faculae, which are separated from each other by dark spaces. These are reliefs that protrude from the sun surface, and that are more brilliant than the photosphere, as they are made of huge light clouds that form chromospheric eruptions or flares. These faculae have a hot central area, and emit energy in the form of light, which can be observed at plain sight especially at the edges of the sun, because the luminosity of the photosphere is lower in those areas. After an intense activity, they are reduced until they disappear, so that in a period of 11 years, variations of the general total area of the spots as well as of the faculae (32) can be observed.

The regular rise and reduction of sunspots is accompanied by a resulting variation of faculae, because, as spots increase, bright areas in their edges appear, so that the decrease of the quantity of light coming from the spots is linked simultaneously to a higher quantity of light coming from the faculae.

Total sun luminosity is a consequence of the irradiation coming from the photosphere as well as from the faculae. The movement of the axis of the Earth around the sun determines the luminosity received by this planet, which in turn determines the temperature and its changes in weather.

In other words, when the number of sunspots increase, there is a slightly lower production of visible light coming from these less bright areas of the sun surface, because of their lower temperature. However, both magnetism and sun energy increase, represented by ultraviolet rays, x-rays and gamma rays, which are invisible, highly energetic elements of the solar spectrum as they represent solar emissions of lower wavelength. Ultraviolet light could play a relevant role, because this area of the solar spectrum has more non-visible energy, but of a higher intensity due to a higher frequency of sunspots.

This paper analyzed the sun activity as measured by the Wolf number, which also indicates the number of spots. This also indirectly includes the presence of faculae that emit luminous energy, whose appearance follow a pattern similar to sunspots.

The limitations of the study arise from the application of the diagnosis criteria of the MINSAL, which identifies the cases of depression already mentioned. Bipolarity cases are not included, as this is a cross-sectional study, including depressions for the years indicated without any subsequent monitoring to check the evolution of these individuals in relation to an eventual manic or hypomanic episode. It includes the results found during the years 2001 and 2008, which correspond to only a part of the sun cycle. Studies with a higher number of years can show results with complete sun cycles. Moreover, definite conclusions could be reached as long as the findings here presented are observed in other parts of the Earth, in different latitudes or in different continents.

Taking into account the limitations of the present study, there are some remarks than can be made in relation to the link between sun activity and the incidence of mood disorders.

Several hypotheses could be proposed from these results. Part of the sun energy reaches the Earth in the form of light, but there are also the forms of emission of sun activity of lower wavelength mentioned above. Both phenomena occur concurrently during a sun cycle, so the total energy emitted by the sun would be related to a lower incidence of depressions in years of less sun activity.

Exposition to daily sunlight has been pointed out as a pathogenic factor in seasonal depressions (29). On the other hand, phototherapy has a recognized effect on certain depressions, as it extends the photoperiod (38,39,40). When applied especially during the mornings, it produces an antidepressive effect over endogenous circadian systems in seasonal affective disorders, conditions on which most research in relation to the variations of human behavior dependent on the human clock has focused.

The clinical answer to phototherapy includes individuals who suffer a seasonal pattern of the symptom as those who do not, based on the idea that its therapeutic action would be linked to the intensity of the photons that reach the retina, because the human eye has the ability to perceive only a range of the solar spectrum, in this case, photons emitted by a luminous source. These facts could be compared to the higher activity of the faculae that accompanies the appearance of sunspots.

It has also been proposed that the retina varies in its light perceptive-adaptive capacity during the winter months in individuals with seasonal depression, a factor that could be added to the lower quantity of luminous light during that season of the year. These factors alter the serotoninergic transmission in the SNC (42).

The unit to measure light in phototherapy is lux, which represents the brightness with which the human eye perceives the light. Light is formed by wavelengths expressed in the different color tonalities of the luminous source. Some studies state that white light is superior to blue or red light (43). Other studies show that green light has a stronger therapeutic effect than red light, because the rhodopsin in the eye can better absorb the green light and modify the levels of melatonin. This would be linked to the antidepressive response mediated by rhodopsin (44,45).

Ultraviolet light could have antidepressive effects, but its use is not viable as it may cause skin cancer or eye cataracts (46). Infrared light has also been used in the treatment of seasonal depression, but its superiority over white light has not been demonstrated (47).

Non-visual systems have been proposed in the modification of circadian rhythms in rats and presumably in humans (49, 49). Extraocular application of light modifies phase patterns of circadian rhythms, which affects the levels of melatonin and body temperature. These events are not observed when using placebos instead of bright light in non-ocular body areas, which allows for the conclusion that vertebrate species, including humans, would have a sort of extraocular light receptor, or else that this light causes modifications in biological clocks as well as in the receptors contained in the retina (50). Modifications in the biological clocks have been observed through the application of a new source of luminosity even in sleeping individuals (51).

Where melatonin acts is a matter of debate, because, when administered to rats, it modifies their circadian rhythms (52), which leads to propose that it would affect the suprachiasmatic nucleus in rats as well as in humans. This would produce synchronizing or asynchronous effects in these areas (53). In a similar way, these areas could be linked to the modifications caused in humans by the sun energy, which could act as receptors of this energy.

Thus, we can propose the existence of other areas that work as reception sources of solar energy apart from the human eye, which until now only includes white light over the retina as capable of creating antidepressive effects. Still, it is necessary to elucidate if the SNC has other mechanisms that would be responsible of future molecular changes from energy coming from the sun in the form of ultraviolet rays, gamma rays and x-rays, and in this way manner, circadian rhythms. According to the findings of this paper, besides the presence of photons in the visible spectrum, the sun energy variable must be considered, both concurrent phenomena which would play a role in the higher or lower annual incidences of depression.

CONCLUSIONS

A relationship between sun energy and frequency of hospitalizations for depressive episodes can be observed according to the registers of the MINSAL during the 2001-2008 period. A higher intensity of monthly sun activity means a lower incidence of hospital discharges in the 52.731 cases identified. This paper establishes a link between these two parameters seemingly related to this group of depressive individuals.

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