



Solar Flux Exhibits a Negative Correlation with Suicide Rate

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Abstract

Aims & Methods: We re-examined the relationship between the sun's activity and suicide rates. Monthly data from Japan, covering the period from 1976 to 1994, were examined for this purpose. We calculated the correlations between the sunspot number, the solar flux and the male and female suicide rate using an ARIMA analysis.

Results: Significant negative correlations were found between solar flux and suicide rates in both sexes.

Clinical Implications: Artificially generated solar flux might be useful as a treatment for mental illness.

Introduction

Suicide is affected by psychiatric and psychological problems and depression is considered to be closely associated with suicide. It has been shown that depression is also strongly associated with suicidal ideation and, furthermore, an individual suffering from depression has a lowered serotonin level. Serotonin, a neurotransmitter manufactured in our brain, is metabolized to melatonin in the pineal gland, which is an organ that has been shown to be sensitive to electro-magnetic fields. Melatonin secretion in humans is increased at night and is inhibited by strong sun light in the morning. This cycle is one of the circadian rhythms that are apparently regulated by "clock" genes [1]. Thus, it is reasonable to suppose that sunlight affects the sleeping cycle of humans through the photo-biological reactions of melatonin. Sleeping disturbance can be caused by deficiency in melatonin secretion, which in turn leads to a deficiency in serotonin secretion and may increase the risk of depression. The sun emits not only visible light but also electro-magnetic radiation at other wavelengths. As a proxy for solar activity, we propose to use sunspots. The number of sunspots exhibits a marked cyclical behavior, with a period of about 11 years. It has been shown that the sunspot number is highly correlated with the strength of the magnetic field force that reaches the earth [2]. Wilson JW [3] reviewed the health problems posed by radiation, including extraterrestrial sources. Significant links between the monthly number of deaths due to cardiovascular disease and suicide and space proton flux larger than 90 MeV have been found [4].

Simply computing the correlation in observational data between variables can be dangerous, because it is quite common to find "nonsense correlations", a term coined by the statistician U. Yule in 1920. For data in the form of chronological series, additional pitfalls are the autocorrelations and seasonal effects, which by themselves could lead to nonsensical correlations unless we correct for their influence. The main purpose of statistical studies of observational data is exploratory. These kinds of studies can generate new hypotheses to be confirmed by more carefully designed studies later on.

Methods

This study is based on the following monthly data from 1976 to 1994 of the relative sunspot

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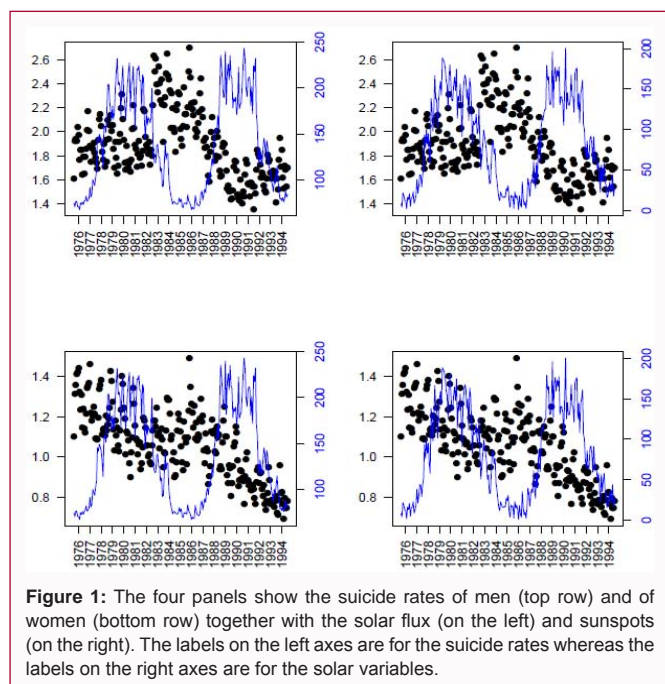
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number (ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/, September 30, 2001) [5], solar flux (f10.7cm) in Canada (<http://www.ngdc.noaa.gov/stp/SOLAR/getdata.html>, October 27, 2002) [6], and suicide rate in Japan. Suicide rates for men and women were adjusted to the sex and age distribution in the Japanese population in 1985 (Japan Ministry of Health and Welfare, 1976-1994) [7]. The f10.7 cm flux is the solar flux at 2800MHz and was recorded by radio telescope. In order to correct for autocorrelation and trend, an ARIMA (integrated auto-regressive moving average process) model was fitted to all series. In the case of the suicide rate, it turns out the differentiation of the series that is replacing the original x_1, x_2, x_3, \dots by $x_1 - x_2, x_2 - x_3, x_3 - x_4, \dots$, produces a new series that has a reasonably homogeneous appearance. In the case of sunspot numbers and solar flux, this difference step has to be repeated once more. These ARIMA models were fitted with the algorithms from the SPLUS statistical package (Version 4.5., Insightful Inc., 1998). As a result of such modelling, the original series is decomposed into a smoothed part and a residual part. We then calculated the correlations between the smoothed series and between the residual series.

Results

Table 1 shows the correlation coefficients between suicide rate, sunspot number and solar flux, both for the smoothed values and the residuals. The residuals show a strong correlation only within the pairs of related series, namely male and female suicide rates as well as the two solar series. In the smoothed series, additional negative correlations are found between solar flux and suicide rate in both sexes and also between the relative sunspot number and the suicide rate in males. The adjusted data are shown in Figure 1.

Discussion

Even though we found a surprisingly strong negative association between solar flux and suicide rates, our findings have to be taken with a grain of salt. The solar cycle lasts about 11 years and our data only spans 19 years, i.e. not even two cycles. To clarify the effect we found in these data, further studies, either elucidating the physiological effects, or using longer chronological series will be needed.

Table 1: Correlation matrix of the smoothed values (above the diagonal) and residuals (below the diagonal) after fitting ARIMA model.

| | sunspot number | male suicide rate | female suicide rate | f10.7 cm flux |
|---------------------|----------------|-------------------|---------------------|---------------|
| sunspot number | | -0.389** | -0.058 | 0.981** |
| male suicide rate | 0.025 | | 0.611** | -0.405** |
| female suicide rate | -0.050 | 0.531** | | -0.083** |
| f10.7 cm flux | 0.82** | -0.063 | -0.077 | |

* $p < 0.05$, ** $p < 0.01$

In Figure 1, we observe two peaks with a central dip in the suicide rate for men, perfectly mimicking the behavior of the sunspot numbers. This is not true or at least very much weaker in the suicide rates for women.

Our data demonstrate that in the period from 1976 to 1994 suicide rates for men tended to increase when the number of sunspots decreased. A possible explanation of this phenomenon lies in the fact that the decrease of sunlight energy (in proportion to sunspot number) causes a decrease in the melatonin secretion in men, and may thus lead to affective disorders such as depression, which in turn might increase the suicide rate. Melatonin, or 5-methoxy-N-acetyltryptamine, is a hormone produced by pinealocytes in the pineal gland, located in the center of the brain. It is a derivative of the amino acid tryptophan. Melatonin helps regulate the sleep-wake rhythm. Normally, production of melatonin by the pineal gland is stimulated by darkness and inhibited by light. To synthesize melatonin, serotonin is converted to N-acetylserotonin by the enzyme 5-HT N-acetyltransferase. N-acetylserotonin is then converted to melatonin by the enzyme 5-hydroxyindole-O-methyltransferase. Melatonin has been shown to increase the lifespan of mice by 20% in some studies [8]. The melatonin levels in the serum of suicide victims are prominently lowered in comparison with that of comparable subjects that did not commit suicide [9]. On the other hand, the melatonin level is generally higher in women than in men [10]. Therefore, the effect of a decrease in melatonin secretion by decreasing sunspot is thus considered to be lessened in women.

A wide range of mortalities that are associated with Melatonin reduction, are found to be significantly correlated with sunspot number, including cancer, cardiac and neurological mortality [11]. Reiter R et al. [11] postulates that the Schumann Resonance, and low frequency electromagnetic wave surrounding the earth, might play a role in causing health problems and in increasing mortality rates.

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