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Moon/sun – suicide

Attempts to understand the complex mechanism of suicide

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Abstract

Introduction:

Findings concerning the effects of moon phases and sun activity on suicide are mixed in the international literature.

Aim:

Our aim was to examine the hypothesised effects according to gender and age on Hungarian data covering more than 30 years.

Methods:

Time series ARIMA models and dynamic regression models were applied in our analysis.

Results:

Among women aged 20–49 years, a significant increase in the risk of suicide has been observed during proton solar events. At the same time, among women aged 50–59 years a slight but significant decrease has been identified in the risk of suicide during magnetic storms and full moons.

Conclusion:

Proton solar events, geomagnetic storms and moon phases caused changes in the risk of suicide in certain age groups in the case of women only.

Keywords: geomagnetic storms; moon phases; proton solar events; suicide

Introduction

The fluctuation in the number of suicides committed in the course of a year is influenced by several factors. Besides the well-established seasonal [1], [2] and calendar [3] effects, studies have supported the protective effects of elections [4] and also that of big sports events [5].

In our study, we attempt to investigate the effects of moon phases, geomagnetic storms and solar proton events associated with solar flares.

The international literature has investigated the effects of moon cycles since the end of the 1960s. The effect of the sun, sunspots, solar flares and indirectly geomagnetic flares on health has also been researched although the time period covered in the literature is much more limited.

The effects of the moon and the sun are worth investigating because of two theoretical explanations. The first one is a biological factor. Here, we hypothesise that the observed phenomena may trigger certain physiological processes in humans that can potentially influence the likelihood of committing suicide. The other aspect is a possible social – cognitive factor. What we mean by social – cognitive factor is that due to their social-cultural embeddedness, people tend to associate certain phenomena (like the full moon) with such cognitive constructs that might lead to a higher rate of suicide.

Review of the literature

There have been several international studies examining the connection between moon phases and suicides since the 1960s.

The author of one of the earliest studies examined suicide attempts between 1960 and 1963 in Texas in relation to the full moon and new moon and apogee-perigee cycles in 2-week intervals [6]. Although the results of the statistical tests are not reported in the article, based on Pokorny’s tables and the calculations of the authors of a later article, there were no significant differences in the frequency of suicides over the periods examined [7]. Several small- sample studies arrived at the same conclusion although because of the low number of cases, results were not always unequivocal [8], [9], [10], [11].

Several studies focused on this topic in the 2000s. Biermann et al. [12] using German census data from 1998 to 2003 investigating the relationship between 5-day periods around the new moon and the full moon and the number of suicides according to gender, age and method of execution (violent vs. non-violent). Based on the samples deriving from this large dataset, neither the new moon nor the full moon exerted a significant effect on the number of suicides. Thus the only major conclusion that could be drawn was victims who were younger (than the median age) were less likely to choose non-violent methods within the 5-day periods around the new moon [12].

Voracek et al. [13] examined more than 65 thousand suicides in Austria broken down by moon cycles and found no significant relationships between committed suicide and moon phases. When examining sub-samples, the authors found only sporadic relationships without any clearly identifiable patterns. Based on this, they concluded that even though relationships can be found occasionally, these are most likely ascribable to type I errors (type 1 error is the incorrect rejection of a true null hypothesis).

Fewer scientific publications are devoted to analysing the relationship between the activity of the sun and violent behaviour, in particular suicide. In the following section, the methods and results of the study most closely related to our own investigations are presented.

Berk et al. [14] examined suicides committed between January 1968 and August 2002 in Australia. They found that on those autumn days when strong geomagnetic storms were detected, the average number of suicides committed by females was higher (1.86) than on other days (1.27). When investigating the 3-day periods starting with these days, they arrived at the same results (mean: 1.61 and 1.27 suicide cases). However, the examination of longer periods (4-day), other seasons, and males did not reveal any significant relationships [14].

Nishimura et al. [15] investigated the relationship between local geomagnetic field magnetic flux density and the standardised morbidity ratios (SMR) for suicide by each prefecture in Japan. They found the local geomagnetic field magnetic flux density was correlated with higher suicide rate, but only for males.

Materials and methods

In our study, we examined the daily distribution of suicides from 1976 to 2010 (12784 days) from the perspective of moon cycles, protonic events and magnetic storms. The daily data on suicides were provided by the Hungarian Central Statistical Office (KSH). Besides the total sum of suicides committed (130,860 cases), we also examined the female (36,084 cases) and male (94,776 cases) occurrences, and age-specific patterns. In our analysis, instead of using raw numbers of suicide, we applied figures normalised for the whole population (the number of suicides per one million residents per day – normalisation for each day of the year was calculated using population figures for 1st of January, at every year).

Concerning the moon cycle, we treated the full moon and the new moon as having special significance with regard to our topic. Between 1976 and 2010, there were 433 days with a full moon and the same number of days with a new moon. In our study, we examined these special days with reference to suicide data.

As opposed to the moon cycle, protonic events do not follow set cyclical patterns, however, the frequency of protonic event is related to solar cycles (solar cycles last for 11 years on average, and the beginning of the cycle is characterised by increasing activity of the sun). The yearly average suicide rate (without the trend component) does not show any correlation with the solar cycle. In this paper, we focus on those protonic events which are associated with solar flares. The source of data concerning protonic events is available at: https://umbra.nascom.nasa.gov/SEP/. Based on the data we used, 179 protonic events associated with strong (M or X [16]) solar flares could be identified (overall lasting 292 days) between 1976 and 2010. We calculated with those protonic events which were associated with strong solar flares. It is possible that solar flares were observed different days than protonic events, but we always used the days of protonic events in our calculations.

Magnetic storms follow stronger solar flares, and they can be classified, among other things, based on the K-index [17]. To identify magnetic storms the Ap-index data reported for every third hour were averaged for each day, and if the mean exceeded 39 (which is the equivalent of a strength 5 K-index), then the given day was coded as 1 on the scale measuring magnetic storms; if the Ap-index was lower than 39, it was coded as 0. Over the period examined, there were 588 days on which a magnetic storm of some strength could be detected. The source of data used in our study is the "World Data Center for Geomagnetism" located in Kyoto, where data regarding magnetic storms are available from 1932. In this database, data originate from the Geophysical Institute of the University of Göttingen until 1996, and from 1997 from the GeoForschungsZentrum (GFZ) located in Potsdam. The mean values of suicide rates by the independent variables can be seen in Table 1.

Table 1:

Mean suicide rates (the number of suicides per one million residents per day) in the examined days.

		Suicide rate	Suicide rate – male	Suicide rate – female
Full moon	No	0.983	1.482	0.522
	Yes	0.961	1.478	0.484
New moon	No	0.982	1.482	0.521
	Yes	0.986	1.493	0.519
Protonic events	No	0.981	1.481	0.52
	Yes	1.037	1.556	0.557
Magnetic storm	No	0.987	1.487	0.525
	Yes	1.056	1.585	0.566

In our analysis, a dynamic regression model [18] was fitted to the daily suicide figures. In addition to the independent variables, ARIMA parameters, ensuring the stationarity of the time series, were applied in the dynamic regression model. For finding the suitable ARIMA parameters and for fitting the model, the auto.arima function of the forecast package [19] of programme R [20] was applied. Besides the AR and MA components (there could be a maximum of 2 AR and MA components), a second-degree polynomial trend component was also used in the model, as the trend of suicide was non-linear over the period examined. Moreover, dummy variables for the seasons, using autumn as the reference category, and continuous variables for days of the week (1=Monday, 7=Sunday) were applied (we tested our models with categorical weekday variables too, but the fit statistics (like BIC) was weaker with categorical variables, so we used the continuous weekday variables in our models). This model specification ensured the stationarity of the residuals.

The variables on which focused our attention (full moon, new moon, solar flares with protonic events, and magnetic storms) were introduced into the model as dichotomous independent variables. The above model was fitted to the total number of suicides, to the male and female measures separately, and also to the different age groups.

Results

Both in the case of the time series for all the suicides and for males and females separately, first-order autoregressive and first- and second-order moving average processes fitted the data best. The days of the week and season variables displayed the expected patterns: from Monday to Sunday the likelihood of committing suicide decreased, the fewest suicides were committed in the winter months and the most in the summer (although the number in the spring is not much lower than that in the summer). These temporal trends can also be identified in the case of male and female suicides. The fit of all three models was acceptable, and based on the Augmented Dicky-Fuller (ADF) test [21], the residuals of the models were stationary.

None of the key variables proved to be significant in any of the models of suicide (significance level of main independent variables with bold), so neither the full moon, nor the new moon, nor protonic events, nor magnetic storms resulted in higher or lower incidents of suicides (see Table 2). The results were the same for males. In the case of females only one variable, the full moon, proved to be significant. This result, however, is contrary to our expectations, as a lower number of female suicides can be identified at full moon.

We hypothesised that people with different age might have different sensitivity to the examined effects. We tested our models using different age groups and present the summary of our results concerning moon phases, solar protonic events and geomagnetic storms in Table 3 (significant effects with bold). In the regression models, all the background variables presented in Table 2 have been introduced. However, for lack of space, this table presents figures for our target variables only. We omitted the 0–19 age group from this table, as the incidence rate is very low in the group.

Table 2:

Dynamic regression models.

	All		Male		Female	
		Sig	**B**	**Sig**	**B**	**Sig**
Intercept	[illegible]	0.000^{c}	1.863	0.000^{c}	0.817	0.000^{c}

	All		Male		Female	
	B	Sig	B	Sig	B	Sig
AR(1)	0.985	0.000[c]	0.980	0.000[c]	0.995	0.000[c]
MA(1)	−0.909	0.000[c]	−0.908	0.000[c]	−0.962	0.000[c]
MA(2)	−0.031	0.001[c]	−0.032	0.000[c]	−0.019	0.048[a]
Trend linear component	−0.002	0.693	0.008	0.189	−0.010	0.01[b]
Trend squared component	−0.001	0.000[c]	−0.001	0.000[c]	0.000	0.128
Days of week (1=Monday, 7=Sunday)	−0.034	0.000[c]	−0.057	0.000[c]	−0.013	0.000[c]
Winter	−0.083	0.000[c]	−0.130	0.000[c]	−0.067	0.000[c]
Spring	0.100	0.000[c]	0.180	0.000[c]	0.047	0.000[c]
Summer	0.107	0.000[c]	0.195	0.000[c]	0.061	0.000[c]
Full moon	−0.020	**0.220**	0.003	**0.912**	−0.041	**0.009**[a]
New moon	0.002	**0.923**	0.007	**0.802**	−0.004	**0.854**
Protonic events	0.015	**0.466**	0.020	**0.572**	0.012	**0.544**
Magnetic storm	−0.018	**0.221**	−0.020	**0.435**	−0.014	**0.296**
BIC		7668		21,646		6902
ADF test (residuals) – p-value		0.00		0.00		0.00

[a]p<0.05; [b]p<0.01; [c]p<0.001

Table 3:

Dynamic regression models by different age groups.

		Full moon	New moon	Protonic events	Magn. storm
Male 20–49 years old n=44,964	B	−0.013	−0.101	0.126	−0.016
	S.E.	0.096	0.096	0.119	0.085
	Sig	0.896	0.293	0.290	0.851
Male 50–59 years old n=18,496	B	0.023	−0.043	−0.033	−0.011
	S.E.	0.061	0.061	0.074	0.053
	Sig	0.700	0.482	0.659	0.832
Male 60+ n=29,205	B	−0.003	0.181	−0.054	−0.040
	S.E.	0.077	0.077	0.096	0.068
	Sig	0.972	**0.020**[a]	0.573	0.557
Female 20–49 years old n=11,768	B	−0.094	−0.002	0.122	−0.046
	S.E.	0.048	0.048	0.058	0.042
	Sig	0.051	0.961	**0.036**[a]	0.272

		Full moon	New moon	Protonic events	Magn. storm
Female 50–59 years old n=6466	B	−0.078	−0.017	0.011	−0.086
	S.E.	0.035	0.035	0.043	0.031
	Sig	**0.027**[a]	0.628	0.803	**0.005**[b]
Female 60+ n=17,176	B	−0.035	−0.001	−0.057	0.046
	S.E.	0.059	0.059	0.071	0.051
	Sig	0.553	0.993	0.422	0.367

[a] $p<0.05$; [b] $p<0.01$; [c] $p<0.001$.

The data shows that the risk-decreasing effect of the full moon identified in the case of females is only significant within the 50–59 age group; however, the analysis of the different age groups resulted in a significant increase factor at new moon in the case of males over 60.

It is also an interesting finding that protonic events seem to have a weak increasing effect on the risk of suicide in the case of females between the ages of 20–49. Geomagnetic storms, however, appear to have a significant decreasing effect on women aged between 50 and 59.

Discussion

The aim of our study was to investigate changes in suicide rates over unique periods of solar and lunar activities. In our analysis, we focused on the full moon, new moon, protonic events and magnetic storms, and we examined how these related to suicide rates in the case of the whole population and also separately for males and females.

Based on dynamic regression models, when no breakdown by age groups was applied, the variables were not related to the temporal distribution of the suicide measures. A significant relationship was identified in one case only.

On the day of the full moon, females commit fewer suicides than could be expected. Although the effect is small and this result is counterintuitive, it would be a mistake to ascribe it to statistical error right away.

Upon examining different age groups, we found that this tendency is only significant in the case of females aged between 50 and 59 years old. In addition, within this narrower age group, the effect is stronger.

At the same time, a significant and positive new moon effect could be identified in the case of males over 60 years old. Therefore, we can argue with caution that moon phases seem to exert an effect on both genders in the older age groups but in very different ways. Since these effects were only identified in certain narrow age groups, the cognitive symbolic explanation of their effect has to be rejected. It seems more likely that it is either the separate or the combined effects of those social and biological changes related to old age that might be responsible for the observed effects of moon phases.

A significant but weak increase in the risk of suicide during protonic events has been identified in the case of women aged between 20 and 49 years old. As this effect does not characterise women below 20 and over 50 years old, it can be said to be related to the socially and biologically most active phase of women’s lives. It is possible that this phenomenon results from either particular social roles (motherhood, partnership) or biological background (giving birth, natural hormonal background, contraception) or from a combined effect of these two.

Geomagnetic storms demonstrated a weak but significant risk decreasing the effect of suicide in the case of women aged between 50 and 59 years old.

On the whole, regarding the full moon and the new moon, our model complements the results of earlier studies reporting a lack of relationships. We have found significant effects in the case of old-age suicides. These results do not completely contradict what we found in the newest literature [12], [13], but it underlines the importance of future investigation of the topic using larger datasets, and using age and gender specific sub-samples.

With regard to solar activities, there was relatively little literature available, but is seemed to support the hypothesis that there might be a relationship between sun activity and the number of committed suicides. Regression analysis of the Hungarian data refuted the relationship of these variables in the case of males. Overall this does not support the results of Nishimura et al. [15] as they found relationship only in the subsample of males. In certain age groups of women, this relationship was firmly supported, but not the same way regarding protonic events, and magnetic storms. Berk et al. [14] found a significantly higher rate of female suicide during geomagnetic storms, but we found a decrease (but in a narrower age-group). There are more and more results available about the impact of magnetic storm to health-related issues (see Feigin et al. [22] investigating the correlation between stroke and geomagnetic storms), so it seems important to understand the possible causal mechanism behind this phenomenon.

When evaluating the findings of our study, it is important to take into account those limitations that have to be observed when interpreting our data. Obviously, ecological analyses cannot be used to draw conclusions with regard to causality, as in these aggregate analyses, neither the micro-environment nor the individu[illegible]pear, which further undermines the validity of the results. The fact that we examined relatively rare events is also considered a restriction: protonic events and magnetic storms are not very frequent occurrences. Although many days are covered by the entire period of investigation, the days which are important in this study are relatively rare. Thus, our estimates must be assigned wide confidence intervals.

The specific relationships identified in the case of females suggest that the biological factors we consider contributing to suicides might be operating differently in the case of the male and female populations. This also suggests that in understanding this extremely complex phenomenon social and biological explanations should not be considered as rivals but as working in a complementary fashion.

Author Statement

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