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Research report

Analysis of the seasonal pattern in suicide

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Abstract

Background: Suicide has been attributed to social and psychological factors but also to geophysical effects. Of the latter, changes in solar radiation and geomagnetic activities may contribute to the frequency and the seasonal pattern of suicides. *Methods:* We studied with a population-based, nationwide analysis all the individuals who committed suicide ($n = 27{,}469$) in Finland during the period of 1979 to 1999. The daily data on the number of suicides, and the mean and maximum levels of geomagnetic activity were compiled and modelled with Poisson regression using the number of inhabitants in each province as the denominator. Time series analysis of monthly numbers of suicides was carried out using a seasonal-trend decomposition procedure. *Results:* There was a strong seasonal effect on suicide occurrence ($P < 0.00001$), the risk of suicide being greatest in spring. The seasonal effect was most pronounced when the number of suicides was relatively low. High levels of solar radiation activity were associated with the increased risk of suicide ($P = 0.00001$), but the effect of geomagnetic activity was weak. *Limitations:* No individual data on alcohol consumption or mental disorders were available. *Conclusions:* Suicide occurrence varies markedly by season and needs attention where prevention is concerned.

Keywords: Population; Seasons; Suicide

1. Introduction

Most studies have found that suicide rates tend to peak during spring and summer (Petridou et al., 2002). Suicides are not evenly distributed over particular periods of time, since social or psychological factors have immediate or long-term influence on the individual's decision to commit suicide. In addition to social and endogenous time-givers, the physical ones such as changes in local weather conditions can modify human behaviour and influence the occurrence of death from suicide, possibly by interacting with social factors (Preti, 1997; Salib and Gray, 1997). However, changes in aerospace weather conditions (Russell and McPherron, 1973) are beyond this interaction and open up a possibility to test the hypothesis of physical factors having a direct effect on the risk of suicide, and to estimate the magnitude of the effect, if any.

Changes in the geomagnetic activity have been suggested to influence the human circulation, as measured with blood pressure and heart rate (Watanabe et al., 1994), and the onset of depressive episodes in male patients with bipolar disorder (Kay,

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1994). A link between circulation and mood may well exist, since there are decreases in cerebral blood flow in the prefrontal cortex, limbic systems and paralimbic areas that may account for impaired attention as well as cognitive and emotional responses in patients with affective disorder (Ito et al., 1996).

1.1. Aims

Since geophysical factors may affect daily behaviour patterns, it is important in terms of prevention to study whether they can affect the occurrence of death from suicide. An individual's failure to adjust to stimuli from the natural habitat may lead to death from suicide during certain periods of the year more frequently than by chance. We therefore set out to study the time series of death from suicide in the population of a northern region where extreme changes in the intensity of geophysical factors such as the daylight and ambient temperature routinely take place. Specifically, we aimed at studying the seasonal effect on suicide, and the effects of solar radiation and of geomagnetic activity on the frequency of suicides.

2. Methods

The material consisted of all suicides ($n = 27{,}469$) committed from 1 January 1979 to 31 December 1999 in Finland, a northern European country with ~ 5 million inhabitants. Data derived from the official death certificates were obtained from Statistics Finland and contained the following information for each case: the date of death, date of birth, sex, residence, birthplace, and marital status. The detailed content of the Finnish death certificate provides excellent accuracy and reliability of information on the cause of death.

2.1. Solar radiation and geomagnetic activity

Changes in the activity of solar radiation can be observed as changes in the number of sunspots. Geomagnetic field variations routinely arise from current systems that are caused by regular changes in solar radiation, and the interactions of the solar wind with the magnetosphere induce irregular current systems and geomagnetic field changes (Gorney, 1990). Geomagnetic activity indices have been

Table 1
Number of suicides (n), incidence per 1000 person-years, and risk ratio (RR) with 95% confidence interval (CI) from the Poisson regression model

Variable		n	Incidence	RR	95% CI
Sex	Male	21 622	42.56	1.00	Reference
	Female	5847	10.86	0.26	0.25–0.26
Month	Jan	2138	24.07	1.00	Reference
	Feb	1875	23.16	0.96	0.90–1.02
	Mar	2214	24.92	1.04	0.98–1.10
	Apr	2342	27.24	1.13	1.07–1.20
	May	2669	30.04	1.25	1.18–1.32
	Jun	2481	28.86	1.20	1.13–1.27
	Jul	2472	27.83	1.16	1.09–1.23
	Aug	2348	26.43	1.10	1.04–1.16
	Sep	2264	26.34	1.09	1.03–1.16
	Oct	2393	26.94	1.12	1.06–1.19
	Nov	2215	25.77	1.07	1.01–1.14
	Dec	2058	23.17	0.96	0.91–1.02
Wolf number	< 50	10 462	26.05	1.00	Reference
	50–100	6467	25.53	0.98	0.95–1.01
	>100	10 540	26.91	1.03	1.01–1.06
Ak value	<9.5	7021	25.42	1.00	Reference
	9.5–11.8	7024	25.93	1.02	0.99–1.05
	11.8–17.0	6900	26.23	1.03	1.00–1.07
	>17.0	6524	27.58	1.08	1.05–1.12

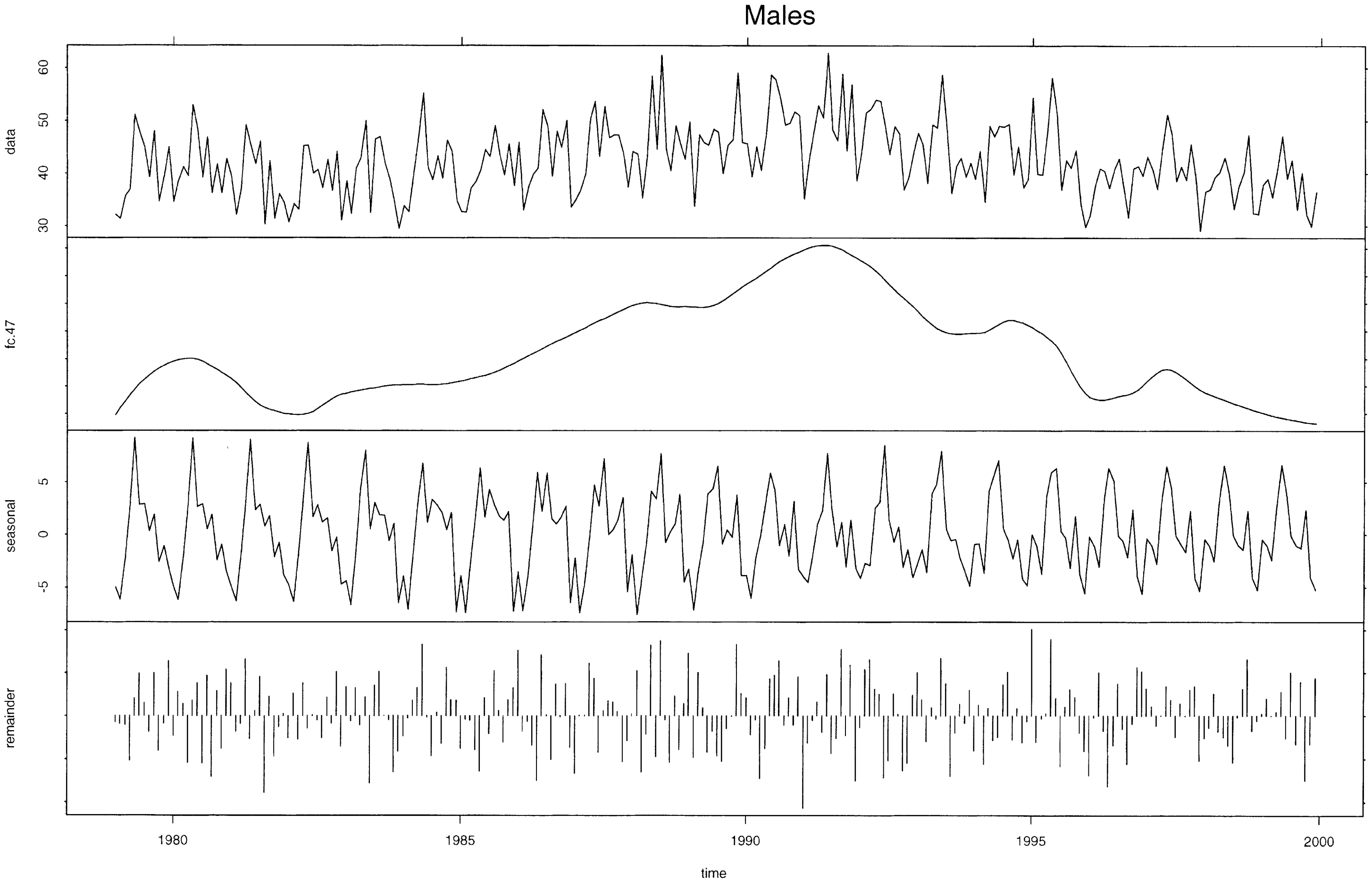

Fig. 1. A seasonal-trend decomposition of suicide occurrence among women and men over the study period, respectively. Panels from the top: the monthly data on suicides per 100,000 person-years; the smoothed data for trend using a span of ∼ 4 years (47 months); the data for the seasonal component of non-reduced oscillations; and the remainder from the model. The scale bars to the right represent the corresponding unit in each panel.

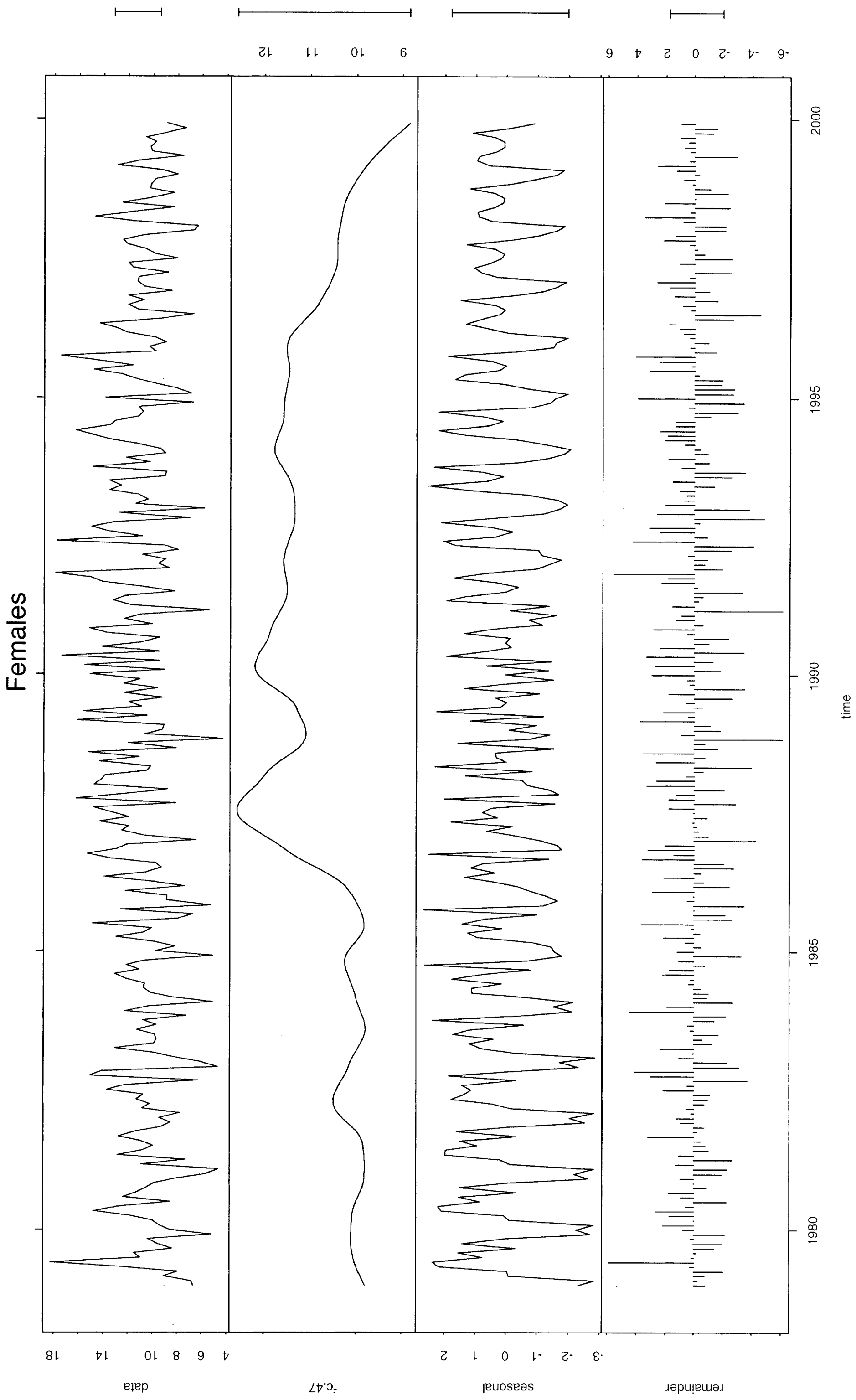

Fig. 1 (*continued*).

designed to describe variation in the geomagnetic field caused by these irregular current systems (Menvielle and Berthelier, 1991).

We analysed the effect of solar activity using Wolf numbers for the annual number of sunspots coded in categories of <50, 50 to 100, and >100. The data were retrieved from the Internet web site http://sidc.oma.be/html/sunspot.html. We also analysed the effect of geomagnetic activity using the following geomagnetic activity indices: K for the 3-h periods coded on a logarithmic scale of 0 to 9, and Ak for the 24-h periods coded on a linear scale of 0 to 400 (for details, see Nevanlinna and Kataja, 1993). The data were retrieved from the geomagnetic recordings of the Nurmijärvi observatory for the southern part of Finland (see http://sumppu.fmi.fi/MAGN/K-index/NURMIJARVI), and those of the Sodankylä observatory for the northern part of Finland (see http://sumppu.fmi.fi/MAGN/K-index/).

2.2. Statistics

Time series analysis of suicide incidence was carried out using locally weighted regression, a seasonal-trend decomposition procedure based on loess (Cleveland and Devlin, 1988; Cleveland et al., 1990). This method decomposes time series in three (trend, seasonal, and the remainder) components using a sequence of smoothing operations, and it is robust in detecting both trends and seasonal variation. Separate analyses were applied for men and women.

The analysis of incidence rates of suicide was modelled with Poisson regression (Breslow and Day, 1994), using population register data to compute residence area and sex-specific denominators for these calculations. In these models, explanatory variables were as follows: sex, district of residence (22 districts) as a categorical variable, the linear and quadratic terms of time (1979 to 1999), and the first and second harmonics of seasonal variation (month). The seasonal variation was modelled on the basis of monthly frequency of suicides, with the means of harmonic series (Jones et al., 1988). We used likelihood ratio statistics to test the significance of explanatory variables, and their interactions. The effect of geomagnetic activity was analysed using generalised additive models (Hastie and Tibshirani, 1990), with the explanatory variables as above, and, in addition, a smoothed monthly mean of the geomagnetic activity index Ak as an explanatory variable.

3. Results

The number of suicides, incidence per 1000 person-years, and risk ratios with 95% confidence intervals from the Poisson regression model are given in Table 1. The combination of linear and quadratic terms of year confirmed that the peak of suicide incidence was in 1990 when there were 1512 suicides and the suicide mortality was 30.3 per 100,000 inhabitants.

The seasonal oscillation was most pronounced when the number of suicides was relatively low, first in the beginning and again in the end of the study period ($\chi^2=21$, df$=8$, $P=0.007$; see Figs. 1 and 2). One annual peak of incidence was observed in the first years of the study period, after which two or multiple peaks per year became common. There was a seasonal effect on suicide occurrence among the study population ($\chi^2=156$, df$=4$, $P<0.00001$), and the risk of suicide was highest in May and lowest in February over the study period.

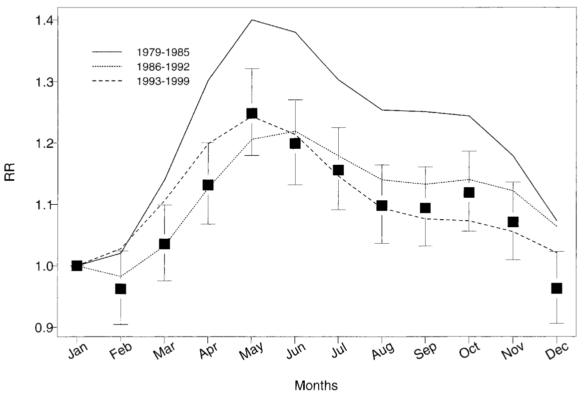

Fig. 2. Annual variation in the relative risk of suicide in the study population. The squares represent the monthly data for risk ratios, using January as the reference, and the bars represent the 95% confidence limits. The lines represent the adjusted risk ratios based on a model with the sex, geographical area, month of the second order harmonics, year of study in categories (1979 to 1985, 1986 to 1992, 1993 to 1999), and the interaction term of the latter two as background explanatory variables.

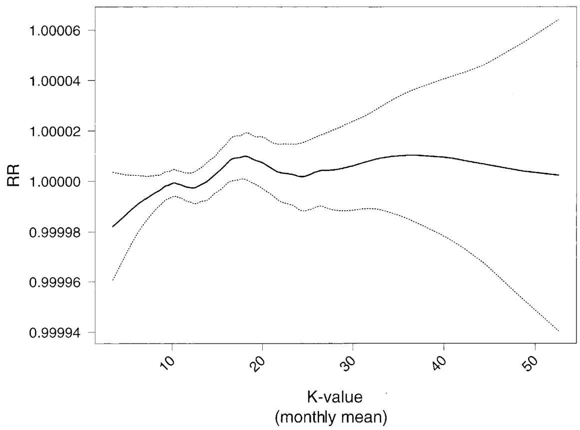

Fig. 3. Relative risk (RR) of suicide in the study population with respect to the smoothed monthly mean index of geomagnetic activity (*Ak* value). The estimation of RR (solid line) with 95% confidence limits (dashed lines) was calculated using a generalised additive model with the sex, geographical area and year of study as background explanatory variables.

The solar radiation also had an effect on suicide occurrence ($\chi^2 = 23$, df = 2, $P = 0.00001$), the risk being greatest during the periods of strongest solar activity (Table 1). However, the risk did not increase linearly with intensifying solar activity. The effect of geomagnetic activity on the risk of suicide was weak (Fig. 3). There were no interactions between the sex and the remaining variables, or between the seasonal components and geomagnetic activity.

4. Discussion

Our main finding was that there was marked fluctuation in suicide occurrence by season in a nationwide analysis of a northern population. The seasonal effect on suicide rates concerns the population. Thus, this finding extends our previous analysis (Partonen et al., 2003) and disagrees with those recent reports claiming the disappearance of the seasonal effect on suicide (Yip et al., 2000; Parker et al., 2001).

We also found that the seasonal effect was most pronounced when the number of suicides was relatively low. Although the solar and geomagnetic activity was associated with the risk of suicide, its effect was weak, if compared with the effect of sex for example, and non-linear. Therefore, it is likely that the fluctuation in this activity that routinely takes place by season has no meaningful influence on the seasonal pattern observed in death from suicide.

A weakness of the present study was that we did not have individual data on alcohol consumption or mental disorders. Mental disorders are frequent among individuals completing suicide and are known to carry a high-risk for death from suicide (Henriksson et al., 1993; Harris and Barraclough, 1997). From the epidemiological perspective, the conditions most relevant for prevention are affective disorders and alcohol dependence (Mortensen et al., 2000). Seasonal changes in the course of depressive disorder, its treatment indices, and suicide seem to coincide, pointing at the importance of depressive episodes as a cause of death from suicide (Eastwood and Peacocke, 1976; Maes et al., 1993; Rihmer et al., 1998).

In conclusion, there is robust oscillation in suicide occurrence by season. The fluctuation is most pronounced when the number of suicides is relatively low. The intense changes in the solar radiation and geomagnetic activities that occur by season, however, are unlikely to have a substantial contribution to the seasonal pattern in suicide.

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