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Influence of meteorological conditions on suicide rate in the province of Córdoba☆

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Abstract
Introduction: Suicide mortality has increased in recent decades. There are multiple factors influencing the risk of suicidal behaviour (biological, cognitive and personality-related factors) that could interact with seasonal changes. The aim was to determine how certain meteorological factors (temperature, wind and rainfall) influenced suicides in the province of Córdoba committed over a specific time period.
Material and methods: A total of 100 suicides registered in the Institute of Legal Medicine of Forensic Sciences of the province of Córdoba were collected through an observational, analytical and retrospective study. We recorded sociodemographic variables, pathological background, factors related to suicide and meteorological variables according to the website of the State Meteorological Agency.
Results: Statistical significance was obtained regarding sex and its relationship with wind; showing an association of women's suicides with higher wind speed in comparison to men (P = .043). An association was also observed between sex and the seasons of the year (P = .042) concluding that women commit suicide more frequently during the spring (45.8%), while men commit suicide more often the autumn (28.9%).
Conclusions: Our study suggests that suicides are influenced by meteorological variables; in particular it offers some new insights in relation to the influence of wind speed and seasonality according to sex.

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PALABRAS CLAVE
Suicidio;
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Precipitaciones;
Variables meteorológicas

La influencia de las condiciones meteorológicas ambientales en la mortalidad por suicidio en la provincia de Córdoba

Resumen
Introducción: La mortalidad por suicidio se ha incrementado en las últimas décadas. Existen múltiples factores que influyen en el riesgo de la conducta suicida (biológicos, cognitivos y relacionados con la personalidad) que pueden interactuar con los cambios meteorológicos ambientales. El objetivo del estudio fue conocer cómo influyen ciertas variables meteorológicas (temperatura, racha de viento y precipitaciones) en las muertes por suicidio en la provincia de Córdoba durante un período temporal concreto.
Material y métodos: Mediante un estudio observacional, analítico y retrospectivo se recogieron un total de 100 suicidios registrados en el Instituto de Medicina Legal y Ciencias Forenses de Córdoba, recopilando variables sociodemográficas, antecedentes patológicos, factores relacionados con el suicidio y variables meteorológicas obtenidas de la web de la Agencia Estatal de Meteorología.
Resultados: Se obtuvo significación estadística en cuanto al sexo y su relación con la racha de viento; demostrando asociación con rachas mayores de viento en suicidios de mujeres con respecto al de hombres (p = 0,043). Se observó también una asociación entre el sexo y las estaciones del año (p = 0,042) concluyendo que las mujeres cometen suicidios con más frecuencia durante la primavera (45,8%), mientras que los hombres llevan a cabo el acto suicida preferentemente durante el otoño (28,9%).
Conclusiones: Nuestro estudio indica que los suicidios se ven influenciados por las variables meteorológicas; en concreto aporta ciertas novedades en cuanto a la influencia de la velocidad de la racha de viento y el patrón estacional con el sexo.

Introduction

The WHO records that every year approximately 800,000 people worldwide commit suicide. Of these, 123,853 deaths occur in Europe, of which almost 80% are men. At a European level the figures offered by Eurostat (for 2016)[1] indicate that suicide is strong indicator of problems which society should address. Eurostat[1] suicide mortality statistics give a figure of 7.41/100,000 inhabitants for Spain. This is slightly below the European average (10.33/100,000) and far lower than the figures for Eastern countries (18.09/100,000 for Slovenia; 18.56/100,000 for Latvia and 28.27/100,000 for Lithuania). In Spain in the year 2017 3,679 people died due to this cause, of whom 74% were men and 26% women. The problem is similar in size in Andalusia (692 people with an identical distribution according to sex) reported by the *Instituto Nacional de Estadística*.[2]

The geographical differences in suicide mortality in Andalusia have displayed stable patterns over time at different geographical levels and according to age group and sex. The highest mortality due to suicide is associated with higher altitude above sea level, greater material privation (different indexes that reflect a worse socioeconomic situation), lower population of the local basic health area and more frequent consumption of antidepressants. The centre of Spain and higher areas concentrate the highest rates of suicide, in association with higher antidepressant consumption and more material privation. Suicide rates in these areas are far higher than the Spanish average, and have constantly remained so over recent decades.[3]

It should be pointed out that death by suicide is the first cause of non-natural death in the province of Córdoba. Alcalá la Real, Priego de Córdoba and Iznájar form the zone with the highest suicide rate in Spain, and it is known as the ''Suicide Triangle''. This area was analysed by Sáez Rodríguez et al.,[4] who concluded that the number of suicides in Priego de Córdoba was three time higher than the national average at the time of their study (3,18:1).

Multiple factors influence the risk of suicidal behaviour. In any case, according to White et al.[5] suicide is a complex phenomenon in which biological, cognitive, and personality factors contribute to susceptibility, and these in turn interact with environmental factors. This study observed that suicides peak in spring and summer, which may be due to greater exposure to sunlight altering biological mechanisms, possibly by deregulating serotonin or the production or metabolism of melatonin.

In a review of the literature published in 2010,[6] the authors argue that human beings have a physiological limit on the amount of exhausting work they can do in hot conditions; thus workers should reduce the amount of work they do and avoid working during the hottest time of day. All of this would lead them to reduce their income and interrupt their everyday social activities, creating psychological anxiety associated with severe mental health problems, possibly including higher mortality due to suicide. In line with

these arguments, a study in Sao Paulo found an association between a higher incidence of suicides by hanging and the hottest, brightest days.[7]

Numerous studies confirm a high peak in suicides during the spring.[5,8–11] Christodoulou et al. observed that the said peak was mainly associated with the male sex, older people and violent means of suicide (hanging, firearms, falls and drowning...). They also found a secondary increase in autumn.[12]

Ajdacic-Gross et al. found a positive preliminary association between temperature and mortality due to suicide, in men as well as in women.[13] Interestingly, the positive association between temperature and suicide arises chiefly in the winter months, complemented by an intermediate peak in the summer. These authors interpret this to mean that the said association is not due to high temperatures, but rather to the lack of low temperatures. The same researchers found that the amplitude of the spring peak was declining, while new smaller peaks were emerging at other times of year, especially in industrialised western countries.[14] Additionally, Lin et al. also examined the association between monthly suicide rates and climatic influences, including air pressure, temperature, sunshine, humidity and precipitation in Taiwán.[15] Nevertheless, they only found evidence of an association of temperature with seasonality and suicide, most particularly violent suicide, although they found no significant association between precipitation and the seasonal peaks in suicide in spring and autumn.

Some researchers have found a positive association between sunlight, temperature, humidity and suicide,[16] while others state that this relationship does not exist.[17]

A study carried out in Spain[8] agrees with others that are mentioned above[5,9–11] on the existence of a maximum peak in suicides during the spring. This fact was justified by the fact that this time of year is characterised by a change in everyday life that involves the need for personal and social readjustment, making it potentially stressful and the cause of the increase in suicides. Nevertheless, they also remark that it is not the weather which leads individuals to commit suicide, but rather than this occurs under special meteorological conditions. Vulnerability to stress is considered to be the core phenomenon, while a range of meteorological factors act as additional stress-causing agents which give aggravate somatic diseases or psychiatric disorders.[18]

Although suicide is an act that is influenced by internal factors, external factors such as environmental meteorological ones may become relevant: it is the potential influence of the latter on suicides in our province that forms the subject of our work. For this we analyse the possible relationship between the different environmental meteorological variables (temperature, speed of wind and precipitation) and suicides committed during a specific time of year.

Material and methods

An observational, analytical and retrospective study was performed of a total of 100 cases of death by suicide registered in the Legal and Forensic Science Institute of the province of Córdoba, consecutively taking all of the cases that occurred prior to the start of this study until the calculated sample size was reached. In this way all of the suicides which occurred from 19 October 2016 to 22 June 2018 were selected, obtaining the following data from each one of the previously anonymised files of the Pathology Department. These files included the protocols and reports on removal of the body, including the doctor's report: sex, age, dates of suicide, season of the year, day of the week, suicide mechanism, drug consumption, suicide note, previous attempts and known psychiatric pathology categorised as no pathology, depressive disorder, bipolar disorder, psychotic disorder or others. In turn, for each case we gathered data on all of the environmental meteorological parameters from the closest weather station to the place of suicide, using the website of the State Meteorological Agency (AEMET): maximum temperature (°C), minimum temperature (°C), average temperature (°C), wind speed (m/sec) and precipitations (mm). 15 meteorological stations were used, distributed throughout the province of Córdoba: they were Aguilar, Aeropuerto, Benamejí, Cardeña, Córdoba, Doña Mencía, Espiel, Fuente Palmera, Hinojosa, La Rambla, Montoro, Pragdena, Priego, Valsequillo and Villanueva.

The study protocol was approved by the Research Ethics Committee of the *Hospital Universitario Reina Sofía*, Córdoba, Spain.

Once the data had been tabulated statistical analysis was undertaken using version 25 of the SPSS® program. Descriptive statistics were obtained for each variable analysed, and then sociodemographic variables (sex and age) were studied in association with the meteorological parameters (average temperature, wind speed and precipitation). To this end, and after applying the normalcy tests to the variables and checking for the absence of the same, comparisons between the said variables were undertaken using the Mann Whitney U-test in the case of the sex variable, and the Kruskal-Wallis test for the age variable.

Lastly, the possibility was considered that there is a relationship between the seasons of the year, the months and days of the week with the sociodemographic variables (sex and age). The chi-squared test was used for this comparison, in which the absolute values of the corrected residues were also considered (> 1.96; CI 95) in connection with statistical significance ($P < .05$); in the case of age they were grouped in quartiles.

The limit of statistical significance was taken in all cases to be $\alpha = 0.05$.

Results

24% of the cases analysed corresponded to women and 76% corresponded to men, with an average age of 58.51 years (standard deviation [SD] ± 17.13). Respecting the meteorological variables, the average temperature was 17.17 °C (SD ± 8), with 0.4 mm (SD ± 1.62) precipitation and a wind speed of 31.88 m/s (SD ± 11.77).

Table 1 shows the descriptive values of some of the qualitative variables.

The day of the week was studied, and Wednesday was found to stand out (21%) as the day with the highest suicide rate. Nevertheless, no statistically significant differences were found in comparison with the other days.

Table 1 Descriptive analysis of some qualitative variables of the sample.

Qualitative variables	N = 100 (%)
Psychiatric pathology	
No psychiatric pathology	19
Depressive disorder	38
Bipolar disorder	1
Psychotic disorder	1
Other	1
Not shown in the judicial file	40
Season of the year	
Spring	26
Summer	25
Autumn	24
Winter	25
Previous attempted suicide	
None	6
1 attempt	11
$\geq$ 2 attempts	6
Not shown	77
Suicide note	
No	5
Yes	10
Not shown	85

The suicide mechanism used by the vast majority was hanging (62%), followed by falling from a height (19%), poisoning (7%), firearm discharge (4%), drowning (3%) and throat cutting (2%), while other mechanisms were used in the remaining 3% of cases.

When the age variable was analysed the seasons were found to have an influence, more specifically for autumn ($P < .05$). The highest number of suicides during this season corresponded to subjects $\geq$ 74 years old, followed by those aged 47-57 years. After these come the subjects aged from 58-73 years, while those aged $\leq$ 46 years were the least likely to commit suicide during this time of year. We cannot draw conclusions for the other seasons of the year because their values were not significant.

No statistically significant differences were found respecting age and the meteorological conditions recorded (average temperature, wind speed and precipitations) (Table 2).

Respecting sex we found statistical significance in association with wind speed. It was clear that women commit suicide when wind speed is higher (average speed =35.75 m/sec $\pm$ SD 12.85); while men commit suicide at lower wind speeds (average speed =30.64 m/sec $\pm$ SD 11.21) (Table 2).

The fact of being a man or woman was not found to be statistically significant in association with the temperature or precipitations (Table 2). However, it should be underlined that sex was significantly associated ($P = .042$) with the seasons of the year (Fig. 1). 45.8% of the women committed suicide in spring, while 8.3% did so in autumn. The opposite phenomenon was observed in the men, with the highest percentage of suicides in autumn (28.9%), and the lowest percentage in spring (19.7%).

Discussion

Suicides in men were found to be more common than they are in women (76% vs. 24%); this fact has repeatedly been found.[2,4,8,17,19] Although few authors dare to offer explanations for the factors that would justify these differences in favour of a higher rate of mortality due to suicide among men, Möller-Leimkühler[19] indicate that this increased vulnerability occurs above all in the youngest men. They state that in gender terms the traditional role of men is the key to explaining this risk, as among other things it is favoured by unsuitable coping strategies due to men's lower expressivity, their reluctance to ask for help and other factors such as alcohol abuse. We believe that another factor that may influence the predominance of men who commit suicide is that they are more prone to short circuited reactions and impulsiveness and aggression, including self-harm. However, all of these theories require deeper study if they are to be proven.

The results of this study suggest that climatic variables had a certain degree of influence on the suicides committed during the period analysed in the province of Córdoba. Many authors[6,9,13,20] have found a positive association between temperature and suicide, although there is no agreement on the mechanism which underlies this finding, so that more detailed works are required in this field. Extreme temperatures have been associated with a fall in everyday social activities, with the resulting psychological anxiety.[6] Nevertheless, such temperatures also influence the serotoninergic system and increased impulsiness.[21] Our study does not make it possible to draw conclusions in association with this phenomenon.

The sex of suicides and its association with the weather has often been studied. According to the results of this study, different seasonal patterns may be observed according to sex. Thus there are more suicides by women in spring (45.8%) and fewer in autumn (8.3%); the opposite occurs for suicides by men, which peaks during the autumn (28.9%) and falls during spring (19.7%). The age variable was also found to be associated with the autumn. This time of year is selected most especially by the oldest suicides in our study ($\geq$ 74 years); the youngest suicides ($\leq$ 46 years) are the least likely to act during this season. These data do not concord with those of the study by Lathi et al., who found a significant peak in autumn for minors.[22] These authors hypothesised that this fact may be associated with psychosocial factors such as the start of the school year. For the seasonal distribution of suicides, the majority of works confirm that there is a peak of suicides in spring,[8–11] while others states that they fall in spring and increase significantly in autumn.[12,14,23] In any case, apart from this seasonal pattern in association with age, once the data in our study had been broken down we found no different in deaths due to suicide according to the season of the year, as they were distributed almost equally among all 4 seasons.

Wind speed is a parameter that has not been analysed very much in the literature. Koszewska et al. found no association between the appearance of the ''foehn'' wind (which is dry and warm from the south, and occurs in a specific geographical area of Poland) and suicides in the same area.[24] Nevertheless, our study found a higher wind speed

Table 2 Influence of meteorological variables on suicides according to the age and sex of the individual.

	Average temp (°C) χ (± SD)	*P*	Wind speed (m/sec) χ (± SD)	*P*	Precipitations (mm) χ (± SD)	*P*
Age (years)[a]						
≤ 46	16.98 (± 7.18)	0.275	30.85 (± 11.11)	0.89	0.31 (± 1.39)	0.335
47–57	14.76 (± 7.47)		33.38 (± 16.58)		0.81 (± 2.18)	
58–73	18.41 (± 8.43)		30.61 (± 7.55)		0.08 (± 0.18)	
≥ 74	18.95 (± 8.69)		32.92 (± 10.81)		0.43 (± 1.98)	
Sex[b]						
Woman	18.59 (± 8.29)	0.289	35.75 (± 12.85)	0.043	0.44 (± 1.52)	0.832
Man	16.72 (± 7.91)		30.64 (± 11.21)		0.39 (± 1.66)	

[a] Level of statistical significance obtained after comparison using the Kruskal–Wallis statistic.
[b] Level of statistical significance obtained after comparison using the Mann–Whitney-U statistic.

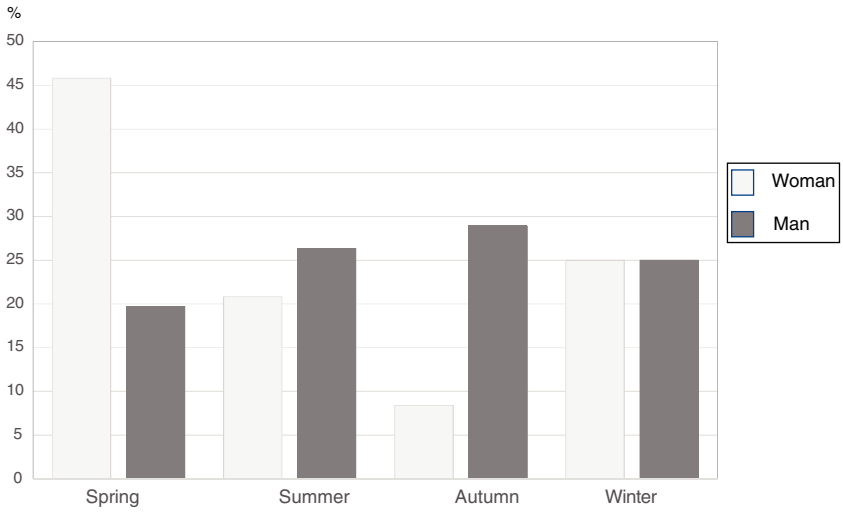

Figure 1 Seasonal distribution of suicides according to sex.

during suicide by women (average speed =35.75 m/sec) than was the case for men (average speed =30.64 m/sec). These results do not agree with those supplied by Gómez González et al.,[8] who recorded the majority of suicides occur with mild winds (< 2.79 m/sec).

Precipitations are another climatic factor that varies with the season, and it has therefore been postulated to be a parameter which influences suicide. Ajdacic-Gross et al.[13] and Lin et al.[15] examined precipitations in their studies in Switzerland and Taiwan, respectively, without finding any notable influence on suicide frequency. In the same way, a recent study undertaken in Colombia[25] found no evidence to link precipitations with suicide tendencies. These data fit with the observations in our work, as we found no statistically significant differences that associated the sex or age of suicides with the presence of rainfall.

Lastly, the sample size of our study should be taken into account as its chief limitation, as although we analysed a higher number of suicides than the minimum sample required for statistical calculations, 100 cases do not form a very large sample that would be able to supply robust conclusions.

Conclusions

This study shows that there are certain significant new associations between the influence of wind speed and the seasons and the sex of the individual. Our results show that a higher percentage of women commit suicide in spring, while more men do so in autumn. A higher wind speed too was significantly associated with a higher rate of suicide among women.

Conflict of interest

This work received no specific funding from public, commercial or not-for-profit sector bodies.

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