Seasonality and time-related aspects of suicides in Greece: an applied time-series analysis

Georgios Tsouvelas[1], Orestis Giotakos[2], Efthalia Massou[3], George Konstantakopoulos[4]

[1] Department of Psychology, School of Philosophy, National Kapodistrian University of Athens, Athens, Greece

[2] The non-profit organization "obrela", 2 Erifilis, 11634 Athens, Greece

[3] Primary Care Unit, Department of Public Health and Primary Care, School of Clinical Medicine, University of Cambridge, Cambridge, UK

[4] First Department of Psychiatry, National and Kapodistrian University of Athens, Greece & Department of Psychosis Studies, Institute of Psychiatry, Psychology and Neuroscience, King's College London, UK

Abstract

The background that underlies each committed suicide varies among people and constitutes a complex structure of psychological, behavioural and biological risk factors that may be triggered by external conditions. Recent studies have shed new light on the association of suicides with particular days and periods of year, in an attempt to resolve the inconsistencies met in literature regarding this relationship. The aim of this study is to look into any time-related patterns on suicides in Greece and to do so we analyzed the frequency of suicides over a period of 13 years (2000-2012) in terms of day of the week, month, major celebration and season. A seasonal ARIMA model revealed the association between suicide frequency and month of year, with a peak to be reached in May and July and increased numbers of suicides to be reported during spring and summer months. Monday was the most frequent day of suicide occurrence whereas Sunday was the least one. A season pattern of suicides was validated. The increase of suicide occurrences on Mondays could be explained by the "broken-promise effect" which has been described as the consequence of frustrated expectations of the weekend. Suicide peaks in spring and summer may be explained partially by biological factors (e.g. serotonergic alterations) as well as the experience of depressed people perceiving the social and emotional contrast to other people that enjoy outdoor activities at that period.

Keywords: Suicides, Greece, seasonality, weekdays, months, major celebrations, time-related patterns

Correspondence author: Dr. Georgios Tsouvelas, 7Str. Navarchou Votsi, Kato Patisia, C.P.:10445, Athens, Greece. Email: tsouvelasgiorgos@gmail.com

Introduction

Suicides constitute one of the major public health problems worldwide [1] and account for almost 1 million deaths per year [2] which might be translating into mortality rate of 16 per 100,000. Suicide rates in Greece are among the lowest in Europe [3] with 8,025 suicides being committed during the period 1992-2012 and the mean standardized suicide rate at 3.13/100,000 inhabitants [4]. For psychiatric and psychotherapeutic services, mental health clinicians and primary healthcare professionals, the understanding of the mechanism that triggers a suicide attempt is a key point in their preventative interventions; however it is not always straightforward due to the complexity and the multifactorial causation that underlies this act [5]. In the literature we meet a long list of potential risk factors, including genetic, biological, socioeconomic, and environmental [6-10],that can be categorized into two general groups, external and internal. Past studies have investigated the link between committing a suicide and the external factor of the time-point that this occurs [5], revealed interesting time patterns.

According to Panser et al. [11], the festive period of Christmas and New Year, is accompanied with a suicidal preventive effect and a subsequent increase in suicide numbers. Cavanagh et al. [12] found significantly lower Christmas suicide rates in a subgroup analysis based on data from England, as Plöderl et al. [13] and Deisenhammer et al. [14] did using Austrian data. Another known effect is that of the day of the week. Several studies have showed significantly dissimilar distribution of the number of suicides over the days of a week; for example Cavanagh et al. [11], Ceccato and Uittenbogaard [15], and Lukaschek et al. [16] observed more suicides at the beginning of the week and especially on Mondays compared to the rest of its days.

Suicidal behavior has also been examined in terms of seasonality. Most of the studies that investigate the seasonal variations in the number of suicides, recognize an accumulation of suicides and suicide attempts in spring and early summer, both for the northern and (mirror image) southern hemisphere [17,18].

In this paper, we focused on the case of Greece, a country of great interest due to the economic crisis that hit it in 2008. Since then, the Greek people have experienced a decade of dramatic social rearrangements with adverse effects on various aspects of their daily life [4]. Periods of economic crises are usually associated with a significant increase of suicides [19-21], and that it is also reported in a recent study over the course of the economic crisis in Greece [3]. Papaslanis et al. [4] compared the number of suicides taking place few years before and after the onset of the crisis, 2001-2007 vs 2008-2011, and reported an increase of suicides by 27.2%

The purpose of our study is to investigate the hypothesis of time-related suicidal behaviour. For the analysis, the number of suicides per day over a 13-year period in Greece has been used. To the best of our knowledge this is the first study in Greece that aims to investigate seasonality of suicides via a seasonal autoregressive integrated moving average (SARIMA) model on monthly level. Moreover, we examined whether the suicide frequencies in terms of days of a week and in terms of season, confirm the distributions met in the majority of the published studies, according to which it is expected an augmentation of suicides through the period of financial crisis 2008-2012.

Methods

For our analysis we used the number of suicides per day occurred in Greece in the period January 2000 – December 2012 from the records of the Hellenic Statistical Authority (ELSTAT). Apart from the descriptive statistics on the aggregated data, we applied SARIMA models that incorporate a seasonal and a non-seasonal part onto the disaggregated by month data. For this analysis, we created two indicators, one for the day of the week with values 1(=Monday) to 7(=Sunday) and a second one for the meteorological calendar of the Northern Hemisphere, where winter includes the months December, January and February; spring March, April and May; summer June, July and August; and autumn includes September, October and November. In order to investigate whether there are significant differences in the number of suicides in major Greek public

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holidays, we compared the monthly mean number of suicides with the number of suicides of the corresponding day as well as the 3-day period before and after, as suggested by Deisenhammer, Stiglbauer and Kemmler [14]. Therefore, a new database was constructed where for each variable of major Greek celebrations, the daily data on each celebration day and the ±3day period were allocated to celebration day whereas daily data on all other days of that month were allocated to the non-celebration variable. This approach minimizes the bias due to seasonal variation since the rest of the year is used as a control period [13,22].

Additionally to the seasonal differences, we investigated the effect of the economic crisis upon the trends of suicides in the country. The first signs of the crisis appeared in the Greek economic indicators in 2008. The problem reached a peak during 2009-2010 and it was after the first memorandum in May 2010, when the circumstances of the crisis changed dramatically Greek people's lives. The period that our data cover, allowed us to subdivide the 13-year examined period into two sub-periods: "before" crisis, comprising the years 2000 up to 2007 and "during" crisis, from 2008 up to 2012. All statistical tests were performed at a significance level of 5%. IBM SPSS version 23 was used for all analyses.

Results

Descriptives

The day of the week with the largest number of suicides was Monday and that with the smallest was Sunday. May was the month with the largest number of suicides and February with the smallest. As for seasons, most of the suicides occurred during summer while the less during winter. (see Table 1).

	Nº suicides 2000-2012	Annual Mean No of suicides
Day of the week		
Monday	485	37.3
Wednesday	448	34.5
Tuesday	428	32.9
Thursday	426	32.8
Friday	417	32.1
Saturday	412	31.7
Sunday	401	30.8
Month		
May	284	21.8
Jully	279	21.5
June	275	21.2
August	262	20.2
April	253	19.5
March	249	19.2
September	249	19.2
January	242	18.6
November	242	18.6
October	239	18.4
December	224	17.2
February	220	16.9
Season		
Summer	813	62.5
Spring	786	60.5
Autumn	733	56.4
Winter	686	52.8

Table 1: Number of suicides and annual mean number of suicides per day, month and season of the year for the period 2000-2012

Suicides and seasonality

A time-series model for monthly number of suicides was developed to examine the effect of time for the years 2000 - 2012. The 12-month series was used to identify a seasonal ARIMA (1, 0, 2) (1, 0, 1)12 model. The goodness of fit test for that model is presented in the residual ACF and PACF graphs (see Figure 1).

Figure 1. Graph of ACF and PACF residuals for the (1, 0, 2), (1, 0, 1) ARIMA model.
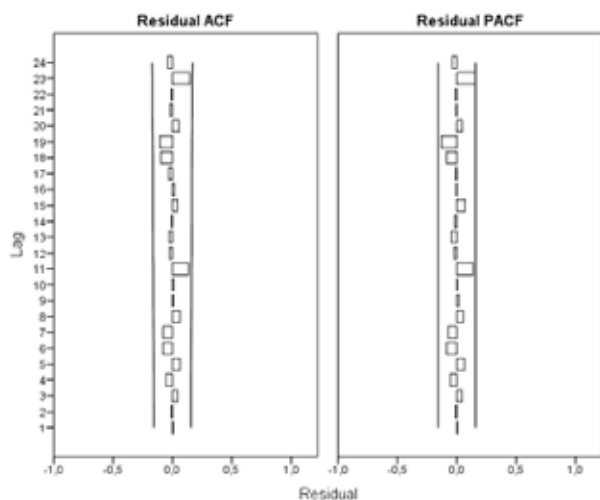
There was significant seasonality effect for all the months (seasonal autoregressive, lag 24 (SAR12) = 0.98, t = 15.35, p < .001. R^2 value of the final model was 0.35 (See Table 2 and Figure 2).

Table 2: ARIMA/SARIMA regression models for monthly number of suicides for the period 2000-2012

Independent variables	β	SE	T	p
AR1	0.58	0.19	2.97	.003
MA1	0.44	0.20	2.24	.026
MA2	-0.22	0.09	-2.30	.023
SAR12	0.98	0.06	15.35	<.001
SMA12	0.88	0.17	5.19	<.001
R2	0.35			

Note: AR1 = autoregressive, lag 1; MA1 = moving average, lag 1; MA2 = moving average, lag 2; SAR12 = seasonal autoregressive; SMA12 = seasonal moving average, lag12.

Figure 2. Monthly suicide time series for the period 2000 – 2012 in Greece
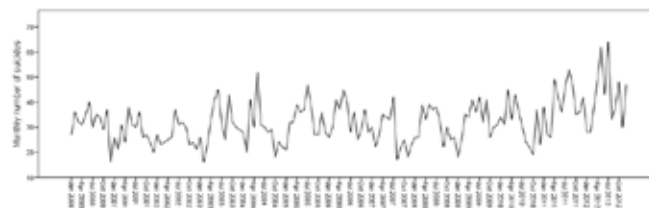
Suicides, seasons and days of the week

A two way analysis of variance was conducted to test whether there were differences on the number of suicides per day by seasons (4: winter, spring, summer, autumn) and by day of the week (7: Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday). The main effect was statistically significant, $F_{(27,4721)} = 4.14$, p < .001, $\eta2 = .023$. Both main effects at the season group $F_{(3,4721)} = 19.41$, p < .001, $\eta2 = .012$, and the day group $F_{(6,4721)} = 7.33$, p < .001, $\eta2 = .009$ were significant.

The Bonferonni post hoc criterion was used on the differences among days and revealed systematic differences on number of suicides on Mondays (when we met the largest number of suicides) and Fridays, Saturdays and Sundays (when we met the smallest number of suicides). Regarding the season post hoc analysis, the Bonferonni criterion indicated that there were systematic differences on number of suicides between springs and summers (when the largest number of suicides are met) and autumns and winters (when we had the smallest number of suicides). There were not differences at the interaction of season and day of the week on the number of suicides per day $F_{(18,4721)} = 0.53$, p < .948, $\eta2 = .002$ (see Table 2 and Figure 3).

Table 3. Daily mean number of suicides per season and day of the week for the period 2000 - 2012

	Winter	Spring	Summer	Autumn						
	M	M	M	M	Df	F	η2			
Suicides	0.89a	1.16b	1.16b	0.98a	3,4721	19.41***	.012			
	Monday	Tuesday	Wednes-day	Thurst-day	Friday	Saturday	Sunday			
	M	M	M	M	M	M	M	df	F	η2
Suicides	1.25a	1.07ab	1.10ab	1.05ab	0.99b	0.95b	0.93b	6,4721	7.33***	.009

Note: *** $p < .001$. Means that share a common letter do not differ significantly according to the Bonferroni post hoc test at $a = .05$.

Figure 3. Estimated marginal means of the daily number of suicides by season and day of the week for the period 2000-2012 in Greece

Suicides and major celebrations in Greece

Multiple paired-samples t-tests were conducted to compare the number of suicides during major Greek public celebrations. For the comparison we used the mean number of suicides per day for each month comparing the mean number suicides for the day or for the ±3 day period with the mean number of suicides per day for each month of the 13 years period. These tests
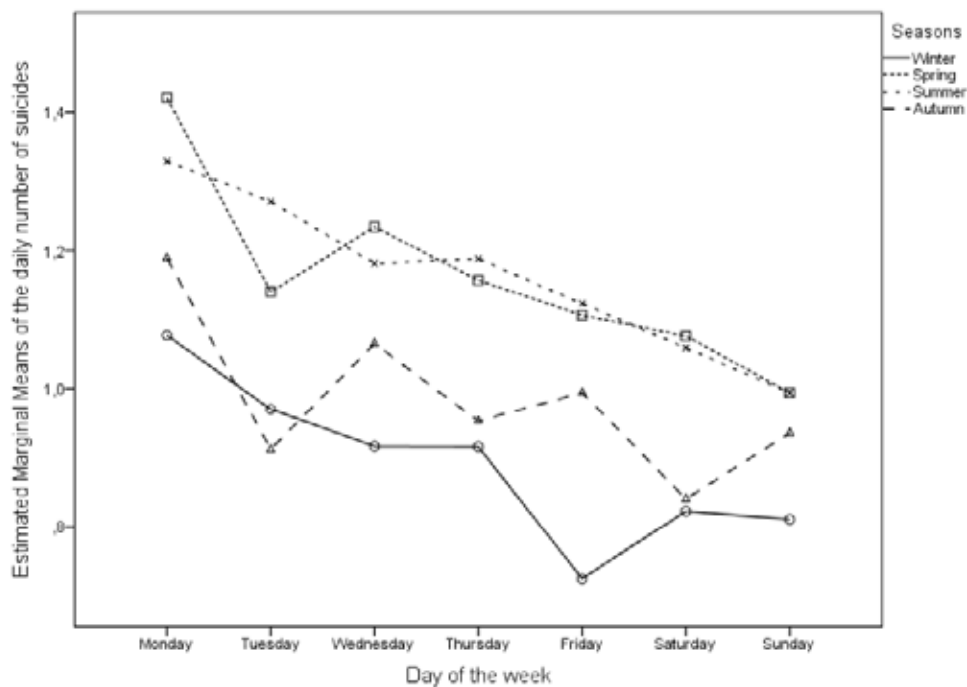
revealed that there was significant difference in the number of suicides during the 17th November celebration (Athens Polytechnic uprising) period (±3 days) (M = 1.29. SD = 0.47) and the mean number of suicides in November (M = 0.91. SD = 0.26); t(12) = -2.45. p = .031. Moreover, there was significant difference between the number of suicides in Christmas period (±3 days) (M = 0.75. SD = 0.24) and the mean number of December (M = 0.75. SD = 0.24); t(12) = 2.51. p = .027 (see Table 3).

Table 4: Suicide means. Standard deviations and paired t test for major celebrations in Greece during 2000-2012

Mean of suicides	M	SD	t	df	p
January	0.88	0.16	-0.15	12	.881
Year's Day	0.92	1.04			
January	0.88	0.16	0.80	12	.442
New Year's Day ±3 days	0.82	0.29			
January	0.88	0.16	-0.37	12	.721
Epiphany	1.00	1.22			
January	0.91	0.19	1.34	12	.204
Epiphany ±3 days	0.78	0.30			
February	0.88	0.18	-1.06	12	.310
Valentine's day	1.23	1.24			
February	0.89	0.19	-0.12	12	.910
Valentine's ±3 days	0.90	0.32			
March	1.02	0.36	1.22	12	.247
National Independence Day (25th March)	0.69	0.95			
March	0.98	0.38	-0.66	12	.521
National Independence Day (25th March) ±3 days	1.09	0.57			
May	1.33	0.26	-0.33	12	.744
Labor Day	1.46	1.51			
May	1.31	0.25	-0.33	12	.750
Labor Day ±3 days	1.37	0.74			
April/May	1.24	0.24	0.97	12	.352
Easter	1.00	0.91			
April/May	1.24	0.25	0.15	12	.879
Easter ±3 days	1.22	0.51			
August	1.05	0.28	0.14	12	.889
Holy Mary's Day (15th August)	1.00	1.15			
August	1.06	0.29	0.75	12	.468
Holy Mary's Day (15th August) ±3 days	0.98	0.42			
October	0.93	0.25	1.45	12	.171
National OHI day (28th October)	0.54	0.97			
October	0.87	0.28	-1.37	12	.195
National OHI day (28th October) ±3 days	1.05	0.42			
November	0.99	0.22	-0.54	12	.601
17h November Celebration (Athens Polytechnic uprising)	1.15	1.07			
November	0.91	0.26	-2.45	12	.031
17th November Celebration (Athens Polytechnic uprising) ±3 days	1.29	0.47			
December	0.89	0.30	0.67	12	.513
Christmas	0.69	0.95			
December	0.92	0.31	2.51	12	.027
Christmas ±3 days	0.75	0.24			

Note: In the mean number of the month it was excluded the day or the period ±3 days. The mean number of Easter depends on the year (April or May).

Suicides and financial crisis

An independent samples t-test was conducted to compare the number of suicides per day before the Greek economic crisis (period 2000-2007) with that of the first period of the crisis (period 2008-2012). According to this, there was significant difference in the mean number of suicides of the period 2000-2007 (M = 0.98. SD = 1.03) and the mean number of suicides of the period 2008-2012 (M = 1.16. SD = 1.12); t(3643,97) = -5.67, p < .001.

Discussion

We examined 5,023 cases of suicide recorded in the study period in Greece for significant differences in their frequency in terms of temporal aspects. In particular, fluctuations observed concerning the day of the week, the seasonal distribution and the period of economic crisis in Greece. Suicidal behavior is a complex phenomenon and the result of the interplay of various factors; thus it can never be fully explained by a single factor According to Deisenhammer Stiglbauer and Kemmler [14] these factors may be chronic / distal or acute / proximal, neurobiological or psychological, societal or individual, genenetic, biographical, or environmental. As suggested by Woo, Okusaga and Postolache [23] geographic location, allergens, allergy related asthma, rhinitis, and atopic dermatitis, suicide method and occupation are factors that were found to be related to seasonality in suicide. However, more research is needed to elucidate the association between mental disorders, bioclimatic factors, viruses, pollutants and the underlying mechanisms of this phenomenon [22].

Our first objective was to examine seasonal trends in suicide incidence. The results showed seasonal trends in suicide incidence in Greece that reaches their peak in spring and summer season. While conducting a systematic literature on seasonal variations in suicides in Greece, we didn't meet any conclusions based on the methodological approach that was used in this paper, the seasonal ARIMA models. According to Tsai and Cho [24] SARIMA is more appropriate than multiple regression for the time-series analysis of seasonality. When considering the suicides according to the seasonal distribution, there was a peak in number of suicides in May and summer months (as an aggregated set of months), when significantly more suicides occurred than those in the "darker" seasons. Our results validate the pattern of seasonality that is also observed in relevant references on Europe [25,26] and Asian countries [27-29].

There were two socio-psychological theories that try interpret the seasonal patterns in suicide. According to Durkheim [30] suicide incidence is higher in spring and summer because social and occupational activities—that mostly take place at daytime—increase in spring and summer as the days become longer. Indeed, suicide incidence is higher at daytime [31-33], and peaks in suicide incidence shift throughout the year in the same way as the change in timing of sunrise and sunset does [31]. The second one is suggested by Gabennesch [34] who introduce a psychological interpretation for the spring-peak. During this period of the year people have expectations for feeling better at times that might promise a new beginning, such as spring, weekends, or holidays. In cases where these expectations are greater than what they deliver, a negative effect on subjective well-being may be triggered and often this effect might be worse than before their expectations being developed. Therefore, the peak of number of suicides in the bright, warm months could be linked to the experience of depressive people, who perceive a contrast between their social and emotional deficits and the perceived reality of other people that enjoy their outdoor activities [14].

Furthermore, biological interpretations have been given regarding the seasonality in suicides. In this context, there is seasonal variation in the binding potential of the serotonin transmitter [35], or association with the number of hours of sunshine as Lambert et al. [36] suggested. Makris et al. [37] shed light on the serotonergic antidepressants while the role of melatonin has been additionally investigated. [38].

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                                                                                     time-series analysis

The second objective of the study was to examine the relationship between the day of the week and the suicide events. Regarding the distribution of suicides, we found a peak at the beginning of the week where significantly more suicide cases occur on Monday while the least suicides take place on Friday, Saturday and Sunday. This is consistent with most of the previous study results [11,13,14,26]. The peak number of suicides just at the beginning of the week, in turn, could also have a "broken-promise effect" [14,34]. For a depressive person the expectations of the recovery effect of a weekend, is not the same as it has been experienced in the past before the appearance of depression, or if the weekend does not bring the hoped-for positive social experiences, then that person may suffer during the work week that seems much harder.

Our third objective was to examine seasonal trends in suicide incidence in reference to Greek holidays and celebrations. Regarding to the time around Greek holidays and celebrations, our investigation showed no statistical deviations except for the period Christmas (lower) and the celebration of 17th November (higher). The incidence of suicide at Christmas differed from other days in December. According to Deisenhammer Stiglbauer and Kemmler [14] there was a lower tendency for suicides during the period of 17 December to 8 January. Our finding about Christmas period is in line with international research [39-42]. Despite the suggestion that people experience lower emotional well-being and life satisfaction before Christmas, and that alcohol use and psychopathology severity are increased at Christmas time [39,43], which are all risk factors for suicide r, this is not confirmed by our study. Moreover, as suggested by relevant international studies, the overall utilization of psychiatric emergency services and admissions, the number of self-harm presentations, non-fatal suicide attempts, and completed suicides are all decreased [39,44]. A reduced risk of suicides on - especially family significant - holidays could also be related to the actually increased social contacts that take place then, which can be emotionally positive and act as a border to suicidal attempts [14]. International studies found that only men showed significant fewer suicides on Christmas day [45], while others reported a greater reduction in women [12,40]. In our study we did not explore the impact of sex dif-

ferences due to the available sample size. Future studies could address the impact of gender in suicides' seasonality in Greece.

We also found higher mean of number of suicides the days around the celebration of 17th November in comparison with the mean number of suicides of the month. The reasons for this result are not yet entirely understood. The interpretation of this trend is complicated and there are not any findings in the relevant bibliography to interpret it. Overall, there was not observed significant impact of the Greek celebrations/holidays on suicides' seasonality.

Our fourth aim was to examine whether there are differences in the number of suicides between a pre-crisis period (years 2000-2007) and a during crisis period (years 2008-2012) that hit Greece and led to tough social changes. This is the first study that investigates differences at the daily number of suicides during this crucial period and our analysis revealed statistically significant increase in the number of suicides during the Greek economic crisis. Our findings were in accordance with relevant studies [4,46,47] and should be considered in caution since using daily number of suicides maybe be a very sensitive measure in detecting differences between the two periods. Chew and McCleary [48] proposed dual hypotheses for suicidal seasonality: bioclimatic and sociodemographic hypotheses. Although they emphasized that these two dimensions may not be mutually exclusive, and physical climate and social activity do interact, as well as both socio-demographic and bioclimatic factors affect suicide seasonality, they recognized that socio-demographic factors explained more cross-sectional variation. However in a study the results indicate that climatic factors have more effect on suicidal seasonality than the economic factors [24]. Future studies could address the relationship between socio-demographic and bioclimatic factors on suicides' seasonality.

Our work clearly has some limitations. In order to prevent loss of anonymity, Hellenic Statistical Authority (ELSTAT) does not publish daily data in age groups and geographical areas breakdowns. The period we studied was relatively small (13 years) and the present findings are based on population of a single country. Although the descriptive results do not allow

any identification of causal variables, they offer a context within which hypotheses for future work on this direction may be formulated.

The results of the present study validate the association of the frequency of suicide with certain days and seasons. Our findings can benefit the understanding of temporal aspects of suicide in Greece. This study contributes also to knowledge and awareness about high-risk time frames. The high-risk time frames identified and that take place in May, in the summer season and on Mondays may be used for planning mental health interventions and prevention strategies. Obtaining better understanding of suicide mechanisms that trigger the seasonal peaks of suicide attempts, may lead to the identification of factors that are amenable to preventative interventions [27].

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