Acta Clin Croat 2023; 62:397-405

doi: 10.20471/acc.2023.62.03.1

Original Scientific Paper

ANALYSIS OF TIME, PLACE AND METHOD OF SUICIDE IN THE AREA OF BJELOVAR-BILOGORA COUNTY IN THE 1988-2017 PERIOD

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SUMMARY – The aim of the study was to analyze changes in the number of suicides associated with seasonal variables, calendar month, time of day *versus* variable location and method of suicide. Data were obtained from the Analytical Police Department of Bjelovar-Bilogora County for the 1988-2017 period. The process of Croatian application process into the European Union, accompanied by economic and social changes, was a significant socioeconomic event, which divided the analyzed period into two parts. Significant changes in the impact of the analyzed variables on the suicides committed in the two observed periods were tested with the χ^2-test and Fisher exact test. Consistency of the results, as well as absence of the impact of significant changes would show less susceptibility of the covariate variable to the effect of socioeconomic factors. In the case of time of day and location of the suicides, there was no significant difference when comparing results between the 1988-2004 and 2005-2017 periods; however, a statistically significant difference was confirmed when considering the month of suicide (February) and season (winter, borderline result for autumn). Statistically, the most significant changes were found in the methods of suicide. The two observed periods differed in the mean suicide rate.

Key words: *Time of day; Location; Method; Suicide*

Introduction

Suicide is a public health problem; it is estimated that millions of people *per* year commit suicide, and about 25 million people manifest nonviolent suicidal behavior. Dynamically speaking, a high degree of aggressive potential, ocnophilic character and pronounced narcissistic vulnerabilities are in the center of the suicidal behavior[1]. Lack of compliance and sensitive mirroring between mother and child in early childhood and traumatic experiences (if parent figures are abusing, depriving or absent) cause internalizing pathological connections and poor ability to present and regulate feelings[2]. According to the Three-Step Theory (3ST), the ideology of suicidal behavior stems from pain and hopelessness. In further dynamics of events, there is weakening of connection as a key protective factor against the escalation of suicidal ideation. The last step is change from the idea to attempt suicide, facilitated by dispositional, acquired and immediate factors[3]. By disposition we mean a set of neural, transmitter, hormonal, immune and other characteristics of a person that make them riskier for suicidal behavior, caused by exogenous and endogenous unfavorable factors; by motive we mean internal subjective impulse leading to suicidal action; and the reasons are direct exogenous triggers of suicidal behavior[4]. Based on different theoretical approaches, we can talk about

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Received October 15, 2019, accepted April 5, 2020

planned or affective, impulsive or slow, direct or indirect, active or passive, public or secret, single, double or multiple, altruistic, tendentious, demonstrative, simulated, anomic, balanced, egoistic suicide; however, suicide is always a multi-causal act that is accomplished under the interaction of biological, psychological, social, spiritual and other factors[5]. In this paper, the authors pay attention to factors related to daily, monthly and seasonal variations (influence of the season, calendar month, time of day).

At the beginning of the 19th century, it was noticed that most suicides occurred in late spring and early summer[6]. The scientists interpret seasonal changes in suicide dynamics by the radiation, sunlight and temperature influence on anxiety levels[7,8]. Circadian rhythms are physiological, mental, and behavioral changes, such as sleep or hormone production, that align our body with the 24-hour rhythm of the Earth's rotation, annual seasonal cycles, and other natural cycles. The circadian system in suprachiasmatic nuclei regulates monoaminergic activity in the brain and the expression of circadian genes affects mood, so significant shifts and mismatches of circadian rhythms may represent the pathophysiological mechanism of episodes of mood disorders and suicidality in susceptible persons[9]. However, some researchers associate the dynamics of suicide in relation to time of day, month and season with socioeconomic impacts[10]. Differences within a group of people who had committed suicide have led sociologists to conclude that chronobiological factors have sociological consequences to which certain social groups are more vulnerable, which increases suicidal risk. In some groups, vulnerability is related to the age and gender influence, marital and family factors, ethnocultural and economic factors, trauma at early and later ages, social support, various crisis situations, etc. The lower number of suicides in the winter is interpreted by slowing down the dynamics of social activities in winter months. Some authors associate seasonal changes with feelings of anticipation of positive events during the vacation/holidays[11], or with change in available methods of committing suicide[12]. Others consider that the impact of seasonal fluctuations is so small that it may be irrelevant when adjusting for other risk factors, such as gender and mental illness[13], and that the credibility of papers analyzing seasonal effects of suicide in a narrow geographical area (for example, at country level)[14] is questionable. Thus, two conflicting opinions have evolved with respect to interpretation of the effects of biological and socioeconomic factors on variables such as time of day, month, and season of committing suicide. The authors have already processed and published the results based on data on the impact of age, gender, war events, economic changes, physical and mental illness, and earlier suicide attempts on suicide dynamics in the Bjelovar-Bilogora County area[15-18]. Given that these data relate to about the same time period and the same test sample, it would not be justified to take them in this paper. The subject of the interest in this paper was the sensitivity of variables (impact of the season, calendar month, time of day) to the socioeconomic impacts. The relationship dynamics between these variables and suicides was compared between the two analyzed periods characterized by completely opposite socioeconomic conditions (war and post-war period *vs.* period of positive economic development triggered by Croatian application process into the European Union /EU/)[19] in relation to the factors that are thought to be predominantly influenced by socioeconomic factors (place and method of committing suicide).

The aim of the study was to confirm the constant impact of factors related to daily and seasonal variations (season, month, time of day) on committed suicides in relation to the variables predominantly influenced by socioeconomic factors (place and method of suicide).

Material and Methods

The aim of the study was to analyze the impact of the factors of season, calendar month and time of day on the dynamics of suicides from 1988 to 2017. The analyzed outcome was the permanent nature or change in the individual variable impact on the dynamics of suicide. The significance of change in each variable impact on suicides was confirmed by dividing the analyzed period into two parts and comparing the impact of the analyzed variable on the dynamics of suicides in both periods.

The first part covered the period from the beginning of 1988 to the end of 2004, and the second part covered the period from the beginning of 2005 to the end of 2017. The first data group (1988 to 2004) covered the period before the start of the EU application process, and the second data group (2005 to 2017) related to suicides committed after the start of the EU application process. Why might the Croatian application process into the EU be a reason in-

fluencing suicide rates in Croatia? Access to the EU has caused positive economic changes, changes in the field of education and training, has influenced culture and art development, security issues, monetary issues, migration, etc.[19], and it is therefore justified to expect significant fluctuations in the variables that are under the influence of socioeconomic factors. The analyzed variables were age, day, month, season, method and location of suicide. The authors considered the variables such as the season, calendar month and time of day to be under predominant influence of biological factors while the variables under the main influence of sociological factors were the location and method of committing suicide.

Data for analysis were obtained from the Analytical Service of the Police Department of Bjelovar-Bilogora County in April 2018. The database covers suicides committed between January 1, 1988 and December 31, 2017. The data obtained are different from those of the Croatian Institute of Public Health due to differences in the manner and content of the collected data.

Authorization for access to the data was given by the competent body of the Ministry of the Interior Affairs of the Republic of Croatia. Before downloading the data, the authors made a written statement that they would treat the data respecting ethical and medical principles. Access was provided to fully anonymous data. This implied limitations to further statistical processing because the data could not be compared with the data of the local health service. Data were processed by the SPSS statistical program. Produced were descriptive and analytical statistics, but descriptive results were not presented because they did not bring any novelty to the works mentioned before. Nonparametric statistics were used due to the nature of data (asymmetric distribution). The significance of differences in the proportions of each variable in the two analyzed periods was tested by the χ^2-test. In the two-way test, a significance level of 5% was used. When it was not possible to use the χ^2-test, Fisher exact test was used. For the purposes of calculating the suicide rate when comparing the two periods and due to the large changes in the country's population over the observed period, the average population for the analyzed periods was used.

Null hypothesis

When comparing the variables such as the season, calendar month and time of day between the two periods analyzed, there were no significant or minor differences in committed suicides, suggesting that the analyzed variables were more influenced by biological rhythms than by socioeconomic factors. Comparison of the variables of location and method of committing suicide would confirm significant difference between the two periods analyzed, which would indicate greater sensitivity to the effects of socioeconomic factors.

Results

When observing the entire study period, most suicides occurred in May. A statistically significant difference in the number of committed suicides *per* month between the two observed periods is shown in Table 1.

Table 1. Significance of difference in the number of suicides according to month of committing suicide between two observation periods (1988-2004 and 2005-2017)

	Month of committing suicide											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
χ^2-test	1.90	6.72	0.07	0.02	0.12	0.80	0.89	0.06	0.00	1.55	0.00	2.50
p	0.17	0.01	0.80	0.89	0.73	0.37	0.34	0.81	0.95	0.21	1.00	0.11

Table 2. Significance of difference in the number of suicides according to seasonality of committing suicide between two observation periods (1988-2004 and 2005-2017)

	Season of committing suicide			
Season	Winter	Spring	Summer	Autumn
χ^2-test	5.11	0.47	0.89	3.74
p	0.02	0.49	0.35	0.05

A statistically significant difference between the two periods was only recorded in one month (February). In February, significantly more suicides were committed between 2005 and 2017. Analysis of these results revealed that the mentioned difference was conditioned by the number of suicides in one year only. In February 2011, more suicides were committed than in February of any other year.

Looking at the entire period analyzed, most suicides were committed in spring. A statistically significant difference in the suicide number seasonality between the two periods observed is shown in Table 2. The observed periods were statistically significantly different only in winter, and significantly more suicides were committed in the 2005-2017 period. Autumn values were at the limit of statistical significance.

The two periods did not differ in the number of suicides by time of day (Table 3).

Throughout the study period, most suicides were committed by hanging. A statistically significant difference in the number of suicides by the method of execution between the two periods observed is shown in Table 4. There was a statistically significant difference between the two periods in the method of committing suicide such as poisoning, hanging, drowning, jumping from height, jumping in front of the vehicle, and the

Table 3. Significance of difference in the number of suicides according to hour of day of committing suicide between two observation periods (1988-2004 and 2005-2017)

	Hour of committing suicide					
Hour	0-4 AM	4-8 AM	8-12 AM	12 AM-4 PM	4-8 PM	8-12 PM
χ^2-test	0.00	0.00	0.72	0.04	0.03	0.09
p	0.99	0.94	0.40	0.84	0.87	0.77

Table 4. Significance of difference in the number of suicides according to method of committing suicide between two observation periods (1988-2004 and 2005-2017)

	Method of committing suicide									
	Poisoning	Hanging	Drowning	Firearm	Explosive devices	Self-burning	Cold weapons	Jump from building	Throwing under the vehicle	Other
χ^2	7.88	8.09	10.05	0.40	3.41	*FET	0.66	1.20	*FET	68.32
p	0.00	0.00	0.00	0.53	0.06	1.00	0.42	0.27	0.00	0.00

*FET = Fisher exact test

Table 5. Significance of difference in the number of suicides according to location of committing suicide between two observation periods (1988-2004 and 2005-2017)

	Place of committing suicide			
	House	Outbuildings	House environment	Other
χ^2-test	0.34	0.00	0.02	0.33
p	0.56	1.00	0.89	0.56

Table 6. Difference in the number of suicides between two observation periods (1988-2004 and 2005-2017)

Time interval	Number of suicides	Number of inhabitants in the County
1988-2004	745	142,153
2005-2017	428	126,380

category "other". Changes were primarily caused by a decrease in the number of suicides in the categories "explosive devices" and "other" in the 2005-2017 period.

The two periods did not differ in the number of suicides by location of execution (Table 5). More than 10% of data referred to the "other" group, i.e., 13.08% in the 1988-2004 period and 11.70% in the 2005-2017 period.

In Croatia, census is performed every 10 years (1981, 1991, 2001 and 2011), so the population in the periods observed was expressed as arithmetic mean. Further calculation for the 1988-2004 period yielded a mean annual suicide rate of 30.83/100,000, and for the 2005-2017 period, the suicide rate was 26.05/100,000.

Discussion

The authors of this study tried to prove permanent nature of the impact of daily and seasonal variation (season, month, time of day) on committed suicides in relation to the effect of socioeconomic factors (location and method of suicide) during two different time periods (1988-2004 *vs*. 2005-2017) divided by the Croatia accession to the EU.

Considering months, significant difference in the compared periods was found only in February. In the overall results, February was the month with the lowest suicide number, so even small changes in the number of suicides were statistically significant (the difference was based only on change in the number of suicides in February in one year). April was a month with the highest suicide rate (10.57%). Most papers report similar results, emphasizing age differences and violent/nonviolent method; violent suicide chronograms of young adults and elderly were quite distinct in the occurrence of peaks in March-April and August, respectively, with low rates in December-January[20].

The expected suicide-season ratio is consistent with that of months and seasons, which was partially confirmed. A statistically significant difference was recorded for winter and marginal significance of difference for autumn. These differences were reciprocally linked; the percentage of suicides committed in winter was 24.33% in the 2005-2017 period *versus* 18.79% in the 1988-2004 period; the ratio was reversed for the autumn when it was 19.79% in the 2005-2017 period *versus* 24.70% in the 1988-2004 period. It is possible, and even probable, that the change in the suicide number in the winter resulted in a shift in the number of suicides in other periods. Mathematically, in the calendar months, given that there are 12 in total, the change 'spread' over the remaining 11 months, but did not spread evenly over the remaining 3 seasons. In each period separately and in total in the 1988-2017 period, the highest number of suicides occurred in spring, then in summer, which corresponds to literature data[21]. During winter, the human circadian rhythm tends to delay, but in early spring the circadian rhythm progresses in line with the earlier sunrise time. In depressed patients with a slow endogenous circadian rhythm, exposure to bright light early in the morning during spring further slows down their circadian rhythm, as bright light appears during the phase response curve 'delay zone' for light, which can cause mixed manic episode or emotional instability and increase the risk of suicide in susceptible individuals[22].

The effect of the time of day on committing suicide is related to the circadian rhythms already mentioned, but also to the phases of the Moon[23,24], sleep disorders[25], etc. However, other factors, such as the effect of age and gender[26], manner of committing suicide[27], ethnic or geographical origin[26], cannot be ruled out. According to the results obtained, in the total sample (1998-2017), most suicides occurred between 8:00 and 12:00 AM (23.24%) and between 12:00 AM and 4:00 PM (23.16%). In the 1988-2004 period, most suicides occurred between 8:00 and 12:00 AM (24.22%) and in 2005-2017, between 12:00 AM and 4:00 PM (23.55%). Differences in the suicide rate by the time of day did not show statistical significance. Similar results are reported by Preti and Miotto in neighboring Italy, with the highest incidence of suicide between 8:00 and 11:00 AM; however, in young people, the peak suicide rate was shifted to 4:00 to 7:00 PM, which is explained by differences in the rhythm and circumstances of the activities of young and old people[29]. The late morning and early afternoon hours were the time of the highest incidence of suicide in the study by Gallerani *et al*.[30], and the period between 6:00 and 4:00 PM in the study by Williams and Tansell[31]. It is interesting to link suicidal behavior with stages of the menstrual cycle[32,33]. We can confirm by the experience the impact of social factors on daily rhythm of life, e.g., twice a year shifting hours, working shifts, reducing the time to go to sleep during holidays, etc. However, even in such reflections, it seems more likely that behavioral and social changes affect biological factors and thus possibly alter the dynamics of suicide, rather than having a direct effect of these factors on suicidal behavior.

The two periods observed were statistically significantly different according to the method of committing suicide. Suicide by hanging was prevalent in both periods; however, in the period up to 2004, there were significantly more suicides committed by explosive devices, which is explained by their availability during the war and post-war period. Consequently, in the period after 2005, the number of suicides committed in other ways increased, primarily drug poisoning, drowning, jumping in front of the vehicle or from a height. In the literature, the choice of suicide method is associated with racial characteristics[35], impulsive and aggressive behavior during life[36], political protest[37] geographical and cultural characteristics[38], rural/urban environment[39], imprisonment[40], gender and type of mental illness[41], perception of speed and safety of method[42], availability and cultural 'popularity' of a particular method[43,44], etc.

In the total sample and analyzed periods separately, the frequency of suicide location ranged from home as most common, through suicide in commercial premises, then around the home, to 'other areas' as the least frequent choice of suicide location. There were no statistically significant differences in the choice of suicide location between the two analyzed periods, which is contrary to what was expected. The method of committing suicide is linked to the choice of the place of execution[44], so it is logical to expect that significant differences in the method of committing suicide will be accompanied by differences in the choice of the place of committing suicide. However, the fact that reduction in suicides by explosive devices was not accompanied by change in the choice of the place of committing suicide is explained by two possible reasons. First, the group of persons who committed suicide with explosive devices accounted for a relatively small percentage of suicides (5.28%). Changes in such a small group of cases could have been correctly allocated to multiple groups of choosing suicide sites, which is why there was no statistically significant change in the results. Another possible reason is the large number of suicides in the "other places of execution" group, within which it is difficult to monitor changes in suicides due to different places of execution that are classified in this category by the periods observed. Using firearms and explosive devices as a means of suicide is linked to war by other local authors[45,46]. Gender differences not only influence the choice of suicide method, but also the choice of the location of suicide[47]. The choice of location is also linked to the planning, intent and complexity of suicide[48], the intensity of suicidal intent[49], public message[50] (media attention and adverse effects on people who witness suicide). The location of suicide may also have a specific cultural significance[51].

Since 1999, there has been a trend of suicide in Croatia; in 2016, the suicide rate was 13.2/100,000 for all age groups. Despite reduction in the rate of suicides in the Bjelovar-Bilogora County, the suicide rate in the county is still higher than the Croatian average[17], and the interpretations are different[52]. The calculated mean annual suicide rate differed in the two observation periods, and it is difficult to say what should be considered a 'significant' difference. Every human life is important. The figure of 4.78 in relation to 100,000 is small, but if we rephrase and express it as 5 lives saved each year from suicide in the county, then it is not a small figure.

The study suffered from some limitations. We were faced with several restrictions in our work. Data from the Registry of Missing Persons, Suicides and Injuries of the Ministry of the Interior Affairs differ from those of the Croatian Bureau of Statistics in terms of the manner and content of data collection[53]. Another limiting factor is multiple protection of data, which makes it impossible to connect or include and compare data from other databases (e.g., psychiatry department archives). The format in which data were submitted narrowed the possibilities of further classification and creation of new combinations of data. Another limitation was the narrow geographical area to which the data related, which significantly reduced their significance. Then, a limiting factor was a small amount of data despite a long period of time (this was especially evident when data were divided into two periods and then each group had more than 10 subgroups, e.g., calendar months, thus yielding so small numbers that made statistical processing questionable). No data were collected (because data were not available for such a long period of time) to ensure monitoring of chronobiological and sociological factors (daily temperature fluctuations, barometric pressure, intensity of solar radiation and light, data on income, working and residential status, education, number of family members, earlier traumatic experiences, etc.). As part of such thinking, the authors argue that it will not be possible to produce high-quality and significant study on this topic without establishment of a National Suicide Prevention Center, which would provide a network of

people motivated to work on suicide prevention from all over Croatia and centralize the collection of suicide data and data relevant to monitoring the dynamics of suicide. Therefore, we hope that our research will be one of the incentives to create a quality National Suicide Prevention Strategy.

Conclusion

Analysis of differences in the number of suicides *per* month between the 1988-2004 and 2005-2017 periods confirmed statistical significance of differences for February and winter (with marginal significance for autumn). There were no statistically significant differences in the time of day of committing suicide. Among the variables that were expected to be more correlated with socioeconomic factors, the choice of suicide method showed significant changes over the compared periods, but unexpectedly, this difference was not accompanied by significant differences in the choice of suicide location. The expectation that changes would be less pronounced in the results related to the time (month, season, time of day) compared to the location and method of committing suicide was not confirmed. In conclusion, we must agree with the opinion of other authors that some seasonal patterns of suicidal behavior are highly replicated, but the underlying mechanisms are poorly understood and efforts to isolate seasonal variables such as bioclimatic and socioeconomic variables to assist in identifying factors mediating seasonality have often resulted in inconclusive findings[13]. Between the two periods observed, the mean suicide rate decreased from 30.83 to 26.05.

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Sažetak

ANALIZA VREMENA, MJESTA I METODE SAMOUBOJSTVA NA PODRUČJU BJELOVARSKO-BILOGORSKE ŽUPANIJE U RAZDOBLJU 1988.-2017.

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Cilj istraživanja je bio analizirati promjene u broju samoubojstava povezanih sa sezonskim varijacijama, kalendarskim mjesecom i dobi dana u odnosu na varijable lokacije i metode izvršenja samoubojstva. Podaci su dobiveni od Analitičkog odjela Policijske uprave Bjelovarsko-bilogorske za razdoblje 1988.-2017. Proces pridruživanja Hrvatske Europskoj uniji praćen gospodarskim i društvenim promjenama bio je značajan društveno-ekonomski događaj prema kojem je analizirano razdoblje podijeljeno na dva dijela. Značajnost razlika utjecaja analiziranih varijabla na samoubojstva počinjena u dva promatrana razdoblja testirane su χ^2-testom i Fisherovim egzaktnim testom. Konzistentnost rezultata, odnosno odsutnost značajnih promjena ispitivanih varijabla upućivala bi na slab utjecaj socioekonomskih čimbenika na broj samoubojstava. U slučaju dobi dana i mjesta samoubojstava nisu utvrđene značajne razlike u usporedbi rezultata promatranih razdoblja. Potvrđena je statistički značajna razlika u odnosu na mjesec samoubojstva (veljača) i godišnje doba (zima, granični rezultat za jesen). Statistički gledano, najznačajnije promjene zabilježene su u metodama samoubojstva. Dva promatrana razdoblja razlikovala su se i u srednjoj stopi samoubojstava.

Ključne riječi: *Doba dana; Mjesto; Metoda; Samoubojstvo*