ANNUAL AND SEASONAL TRENDS IN MORTALITY RATES FROM EXTERNAL CAUSES IN HUNGARY

Summary of PhD Thesis

Doctoral School of Interdisciplinary Medicine

Tamás Lantos, MSc

Supervisor: Tibor Nyári, PhD, DSc

Department of Medical Physics and Informatics
University of Szeged

Szeged
2022

LIST OF PUBLICATIONS RELATED TO THE THESIS

Papers included in the thesis:

I. **Lantos T**, Nyári TA, McNally RJQ. Seasonal variation of mortality from external causes in Hungary between 1995 and 2014. *PLoS One*. 2019 Jun 6;14(6):e0217979. doi: 10.1371/journal.pone.0217979.
Journal specialty: Scopus - Multidisciplinary **SJR indicator: D1**

II. **Lantos T**, McNally RJQ, Nyári TA. Patterns of suicide deaths in Hungary between 1995 and 2017. *SSM Population Health.* 2021 Nov 7;16:100788. doi: 10.1016/j.ssmph.2021.100788
Journal specialty: Scopus - Health (social science) **SJR indicator: D1**

Other related publications:

III. **Lantos Tamás**, Nyári Tibor. Seasonal variation from suicides in Hungary between 1995 and 2014. [Öngyilkosság általi halálozások szezonális változása 1995 és 2014 között Magyarországon] *XXXI. Neumann Kollokvium*, Szeged, pp. 108-113. (In Hungarian)

1. INTRODUCTION

External causes of death include accidents and acts of violence. In the mid-1990s, they used to be the third most common cause of death (after circulatory diseases and neoplasms) in Hungary; at that time, our country had recorded one of the highest mortality rates from external causes throughout Europe. Over the next 20 years, external causes have slipped back to fourth place among the main causes of death – behind digestive diseases –, still causing an average of nearly 8000 deaths a year. These causes mainly affect younger age groups; on the other hand, among elderly, Hungary is one of the countries with highest external-cause mortality in Europe.

Although external causes form a very heterogeneous group of deaths causes, three causes of death clearly stand out from the others in Hungary: suicides, accidental falls, and traffic accidents; they are also the leading external causes of death in many European countries. Consequently, it is worth dealing with them separately, as they largely determine the pattern and trends of the total external-cause mortality. Nonetheless, external causes of death deserve special attention not only because of their relatively high frequency, but also because they are highly dependent on the social order and its change. However, they are still not the focus of investigations.

From 1960, the Hungarian suicide mortality rate had been consistently among the highest ones for decades. Accordingly, suicide, as the leading external cause of death, has been investigated numerous times and in many ways. Higher suicide rates were reported in south-eastern Hungary than in the north-western parts of the country. Furthermore, a greater level of urbanicity is associated with a lower level of suicide rates. Moreover, completed suicides were decreasing from 1986 to 2006 but this was followed by a stagnant phase.

Investigating seasonality of suicide deaths is essential as its findings could be key elements in the prevention. Previous Hungarian studies have reported a seasonal peak in early summer (May–June). This can partly be explained by the “relative unhappiness” phenomenon (due to increased intensity of social life) and the “broken-promise effect” (with the beginning of summer, unfulfilled expectations lead to extreme forms of disappointment).

Several risk factors for suicide are already known, including sociodemographic factors, such as gender, age, and marital status (i.e., males, older people and non-married people are more likely to take their own lives). Moreover, educational attainment shows one of the most consistent and strongest relationships with various indicators of health status, including those that might lead to suicidal ideation. Furthermore, apart from these factors, the role of suicide method might also be important in a seasonal investigation of suicide mortality.

Although seasonal variation in mortality from suicide was studied in many countries in Europe and, specifically in Hungary, the general cyclic pattern, and annual trends of mortality rates from external causes have not been investigated yet. These trends are important as they could lead to preventive measures and greater understanding of the underlying causes.

We hypothesise that cyclic trends could be also detected in other categories of deaths from external causes and that annual trends in mortality rates of external causes of deaths are decreasing. Previous studies showed that the pattern of mortality from external causes is different among males and females and by age-groups. Therefore, we applied a divided age-group structure and calculated mortality trends by gender.

2. AIMS OF THE THESIS

The aims of the thesis were:

- to investigate the annual and (monthly) seasonal trends in mortality rates from external causes in Hungary during the 20-year interval between 1 January 1995 and 31 December 2014 (Study I). That is,
    - to characterise mortality rates from external causes,
    - to calculate age-standardised mortality rates,
    - to fit annual and seasonal trends in mortality rates from external causes,
    - to carry out these analyses by gender.

- to describe detailed patterns of suicide deaths in Hungary between 1 January 1995 and 31 December 2017 (Study II). That is,
    - to confirm the findings of Study I for pattern of suicide,
    - to fit general annual and seasonal trends of suicide deaths,
    - to carry out risk estimation for detecting of socioeconomic factors of suicide (gender, age, region, marital status, and educational attainment, respectively),
    - to analyse the seasonal patterns for suicide rates (adjusted to one of the potential risk factors and by suicide method, respectively).

3. MATERIALS AND METHODS

3.1. Study population

Data on the (yearly) population were obtained from the published nationwide population register operated by of the *Hungarian Central Statistical Office* (HCSO; Study I: 1995-2014, Study II: 1995-2017). There were no monthly population data available, therefore we have used annual population data and the monthly birth and death data to estimate the numbers of population by months. The HCSO provided data on the number of births for each month over the study period but by gender only for each year. The number of births in each month for each gender was estimated assuming no monthly variation in the gender ratio within any year.

3.1.1. Monthly data for mortality from external causes in Hungary

The monthly data concerning the external cause of deaths have been published online by the HCSO. These data were classified according to the International Classification of Diseases (ICD-10) codes.

Due to similar characteristics, some of the causes of death were grouped together: *traffic accidents* include railway, motor vehicle and other transport accidents; *cold/heating-related accidents* include accidents caused by smoke, fire, and flames and exposure to excessive cold; *other causes* include other accidents and other external causes of morbidity and mortality. Since the numbers of deaths from water transport accidents, air transport accidents and lightning were too small (<50), these death causes were added to the category *other causes*.

Data on both the population and numbers of deaths from external causes were classified by age groups as follows: 0-19 years ('youth'), 20-34 years ('young adult'), 35-59 years ('middle-aged adult') and over 60 years ('older adults').

Thus, age-specific death rates were calculated. Furthermore, the mortality rates of external causes were directly standardised using the *European Standard Population* (ESP) published in 1976 to make comparisons easier (age-standardised mortality rates, ASMRs).

3.1.2. Patterns of suicide deaths in Hungary

More detailed data on suicide deaths were available on the online HCSO database. The following factors were concerned in our analyses (as a single factor only): gender, age, (statistical) region, marital status, educational attainment, and suicide method.

Data on both the population and number of deaths due to suicide were classified by *age group* as follows: 0–19 years ("youth"), 20–34 years ("young adults"), 35–49 years ("middle-aged adults"), 50-64 years ("older adults") and over 65 years ("elderly"/pensioners).

Territorial units were based on the second level of NUTS 2013 (Nomenclature of Territorial Units for Statistics, 2013 revision) classification.

Marital status was used as a binary variable (married vs. non-married) in the analyses. *Educational attainment* was classified according to the ISCED-97 (International Standard Classification of Education, 1997 version) system.

The following suicide methods were distinguished: "Violent" (*Hanging, Jumping from a height, Drowning, Firearm*), "Non-violent" (*Self-poisoning by drugs, Self-poisoning by chemicals and other substances, Self-poisoning by gases*) and "Other/unspecified".

For the general population, age-specific death rates were calculated. The suicide mortality rates were directly standardised by age using the *Revised European Standard Population* (RESP) published in 2013 to make comparisons possible (age-standardised suicide rates, ASSRs).

3.2. Statistical methods

Annual trends were investigated using negative binomial (NB) regression models in analyses by gender and type of death from external causes. Incidence rate ratios (IRRs) and 95% confidence intervals (CIs) were calculated.

Additionally, NB regression model was used for overdispersed count data to investigate the effect of possible risk factors (gender, age group, region, marital status, and educational attainment) in relation to dying by suicide in Study II. *p*-values less than 0.05 were considered statistically significant.

3.2.1. Seasonal trends

We have used geometrical models for analysing cyclic variation which was introduced by Edwards. However, Edwards' method used only the number of observations. Walter and Elwood generalised Edwards' idea by including the population at risk. They described that seasonal fluctuation of an event which occurs on a fixed date every year might be described using cyclic patterns over time. The Walter-Elwood seasonality test has greater power for detecting seasonal trends, thus this test is robust for detecting seasonal effects.

Stolwijk et al. described the application of generalised linear models (GLMs) for investigating seasonality which is an extension of the Walter-Elwood method and based on similar geometrical approaches. We have applied NB regression from GLMs' family to investigate (also) the seasonal trends.

In Study II, seasonal variation in suicide deaths was investigated using NB regression in analyses overall, by gender and suicide method first: month of death was the only

independent factor included in the model. Moreover, sine and cosine terms were included in the model to control for annual seasonality. Thereafter, one of the significant risk factors (obtained from the "initial" NB regression noted before) was added to the (fundamental) model as an explanatory variable.

Consequently, data on the month of the death were aggregated over the study period and cyclic trends in these monthly data were investigated using the methods mentioned above.

All these models mentioned above included the corresponding stratum-specific population (broken down by levels of a single given risk factor) as an exposure variable (Study II). In addition, quarters were also used to investigate cyclic trends of suicides, which were defined as Q1 (January, February, and March), Q2 (April, May, and June), Q3 (July, August, and September) and Q4 (October, November, and December).

4. RESULTS

4.1. Seasonal variation of mortality from external causes in Hungary

Overall, 154,211 deaths from external causes (66% males and 34% females) were registered in Hungary during 1995-2014. Suicide/self-harm, accidental falls and traffic accidents were the most common causes (35%, 33% and 16%, respectively).

As was the case with the crude numbers and age-specific mortality rates, the highest age-standardised rate (AMSR) was also detected in the case of *suicide and self-harm* with a rate of 24.1 per 100,000 persons per year (95% CI: 23.9–24.3). The largest number of suicides (52% of all cases) was found in the age group 35-59 years; however, the highest age-specific mortality rate with 45.1 per 100,000 persons per year was observed in the above-60 age group.

Both in view of crude numbers and age-standardised mortality rates, the second most frequent death cause was *accidental falls* with an ASMR of 19.8 per 100,000 persons per year (95% CI: 19.6-20). In the age group below 20 years, there was no death from this cause at all. This was the only death cause to have had more (even in crude numbers) female victims than male ones (54% and 46%, respectively). There were many more men among the victims of this external cause in the group aged 35-59 years (the age-specific mortality rates were 18.2 and 2.6 per 100,000 persons per year, respectively). In the age group 20-34 years, there were no female victims of this death cause at all. However, the excess of deaths from this cause in the above-60 age group was enough for women to 'surpass' men even proportionately – even if this difference was not significant (25.1 versus 24.6 per 100,000 persons per year).

The third most prevailing death cause was *traffic accidents* with an ASMR of 11.2 per 100,000 persons per year (95% CI: 11.1-11.4). Although most cases of death due to traffic accidents were registered in the age group 35-59 years, the highest age-specific mortality rate was found in the group aged over 60 years. 79% of the traffic accident victims were men and there were (both in crude numbers and proportionately) more male victims in each of the age groups. The difference between males and females was most noticeable in the group aged 20-34 years (22.1 versus 2.7 per 100,000 persons per year).

The other external causes were one order of magnitude smaller (in terms of mortality rates) than the leading ones. Therefore, they will not be discussed here.

4.1.1. Annual trends in mortality

The NB regression model for annual age-standardised data revealed a declining trend in the yearly ASMRs for all types of death from external causes except for *other causes* (IRR: 1.014, 95% CI: 1.006–1.021; $p<0.001$) during the study period. However, in the case of *drowning-related death causes*, the annual trend was significant ($p<0.001$) only for males. Furthermore, the annual trend for *accidental poisoning and exposure to alcohol* was also significant ($p=0.038$); however, in the case of males – they accounted for the 95% of the victims – it was no longer significant ($p=0.057$).

Referring to the leading external death causes, the annual trend was significant ($p<0.001$) for each one of them. The annual suicide rate declined from the maximum of 31 per 100,000 persons in 1995 to the minimum of 16 per 100,000 persons in 2014. There was an IRR trend per annum of 0.974 (95% CI: 0.971–0.977). A similar decreasing trend was detected for the annual rate of deaths due to accidental falls (from 31 to 12) and traffic accidents (from 17 to 5) with an annual IRR of 0.957 (95% CI: 0.950–0.964) and 0.951 (95% CI: 0.939–0.963), respectively. Similar annual trends were also observed by gender.

4.1.2. Seasonal trends

The overall number of the deaths from *suicide and self-harm* was the highest among all deaths from external causes. Regarding the overall number of external-cause deaths December was the most frequent month of the year. Using the Walter-Elwood method, a significant cyclic trend was found in the monthly deaths from each kind of external cause except for *accidental poisoning / exposure to alcohol*.

There was significant seasonality in the mortality rates from *accidental falls* with a winter peak (peak in December). A winter peak was also detected in the mortality rates from *other accidents caused by submersion/obstruction* (January) and cold/heat-related accidents

(January/February). There was also a significant peak for *other causes* (in December); however, it is a heterogeneous group of external death causes and so needs to be treated with caution.

The Water-Elwood method revealed significant seasonality in the mortality rates from *suicide/self-harm* with a summer peak (June). A summer peak was also observed in the mortality rates from *accidental drowning/submersion* (June/July) and *accidents caused by electric current* (July). The mortality rates from traffic accidents peaked significantly in September. However, no more cyclical variation was discovered in the mortality rates either from any other kind of external-cause deaths or from all external causes combined.

It is worth noting that, in the case of accidental falls, the seasonality was significant only for females; for the other types of external death causes, there was no such difference between men and women. Generally, no more than a month difference was detected in peaks.

NB regression models confirmed the findings obtained by the Walter-Elwood method. There was no significant double peak model of seasonality.

4.2. Patterns of suicide deaths in Hungary

In total, 60,210 suicide deaths (76% males and 24% females) were registered in Hungary during 1995–2017. The group aged over 35 years accounted for more than 86% of all victims.

Hanging, self-poisoning by drugs and jumping from a height were the most common (specified) methods of suicide (62%, 12%, and 6%, respectively).

4.2.1. The pattern of suicide by sociodemographic factor

4.2.1.1. Gender and age group

The suicide rate (SR) is about 3.5 times higher among men than among women (42 versus 12 per 100,000 persons per year). The male-to-female (M/F) ratio was the highest in the group aged 20–34 years (5.3), then this ratio declined progressively towards the older age groups.

4.2.1.2. Age-specific rates

The age group with the largest number of suicides was different: the group aged between 50 and 64 years (29% of all cases) overall, the 35-49-year-old age group (31%) for males and the group aged over 65 years (40%) for females, respectively. However, the highest age-specific suicide rates were observed in the latter age group both overall and by gender. Both in the whole population and by gender, growing rates were detected across age groups.

During 1995–2017, all these age-specific rates fell (by 47–67%). Similar drops can be observed gender-wise, with one exception: the rate for women aged under 20 years rose (from

0.7 to 1.1 per 100,000 persons, by 57%). In this age group there were eight times as many male victims as female ones in 1995. In contrast, there were barely more than twice as many in 2017.

4.2.1.3. Age-standardised rates

In the total population, the ASSR between 1995 and 2017 was 27.3 per 100,000 persons per year (95% CI: 27.1–27.5). In the male and female subpopulations, the ASSRs during the same period were 46.2 (45.8–46.6) and 12 (11.8–12.2), respectively. In 1995, the annual suicide rate was 36.7 per 100,000 persons (95% CI: 35.5–37.9); in 2017, the same rate was less than half of that: 16.5 (15.7–17.3). During the 23 years of the study, these rates were similarly halved for both genders: there was a decrease for males from 59.7 (57.3–62) to 28.2 (26.6–29.8) and for females from 18.1 (16.9–19.2) to 7.2 (6.5–7.9).

4.2.1.4. Region

Western Transdanubia had the lowest suicide rates, both in 1995 and 2017, as well as in the whole period (also by gender); similarly, the Southern Great Plain had the highest rates in every respect. The M/F ratio was the lowest in Central Hungary (2.6) and the highest in Western Transdanubia (4.3).

4.2.1.5. Marital status

In the whole population, the suicide rate was nearly the same for married persons and non-married ones. This apparent contradiction is resolved by the fact that there are few married persons in the age group below 20 years (and very few of them die of suicide).

If only the subpopulation over the age of 20 was considered, the mortality rate for unmarried persons was more than 1.5 times higher (40.2 versus 26.2 per 100,000 persons per year). These rates decreased to a similar extent (by 56–60%) between 1995 and 2017 in the two groups. The M/F ratio was about 25% higher in the married subpopulation (4.3 versus 3.4).

4.2.1.6. Educational attainment

During 1998–2017, suicide rates gradually decreased with higher levels of education. This was also the case for 2017; however, in 1998, primary school non-completers were not far behind vocational school graduates in this respect. In 19 years, the suicide rate for the latter group dropped to nearly one-third. The largest M/F ratio was also observed in this group (4.8); after that, this ratio fell progressively towards those with higher educational attainment.

4.2.2. Risk factors

Incidence rates for groups within categories (compared to the group with the lowest risk of suicide in the category i.e. the *reference group*) were obtained from the NB regression. The risk of suicide was significantly (p<0.001) higher in men than in women (IRR=3.5).

An increasing suicide risk was observed across age groups: the incidence rate (compared to under-20 age group) for groups aged 20–34, 35–49, 50–64 and over 65 years was 7.6 (95% CI: 6.9–8.2), 18.3 (16.7–19.9), 20.7 (19.1–22.5) and 23.7 (21.8–25.8), respectively.

Western Transdanubia had the lowest risk of suicide among the regions. The suicide risks (compared to that region) for the worst regions (Northern and Southern Great Plain) were about twice as high (IRR=1.8 and IRR=2, respectively).

In the whole population, there was no significant difference (p=0.714) between incidence rates for married persons and non-married ones; however, for the subpopulation aged over 20 years only, the suicide risk was significantly (p<0.001) higher for married persons than for non-married ones (IRR=1.5). We also examined the suicide risk for unmarried persons in the subpopulation aged over 15 years, which showed a slight decrease (IRR: 1.3, p<0.001).

A significant growing trend in suicide risk was detected among those with lower educational attainment: the incidence rate (compared to the most educated group i.e. people with a college/university degree) for people completing secondary, vocational and primary school, and primary school drop-outs was 1.55 (95% CI: 1.47–1.64), 2.97 (2.81–3.13), 3.67 (3.47–3.88) and 4.29 (3.96–4.65), respectively.

4.2.3. General trends

The NB regression model for annual data revealed a declining trend in the yearly suicide rates (IRR: 0.972, 95% CI: 0.969–0.975; p<0.001). A similar significant (p<0.001) decreasing trend was detected both for males (IRR: 0.972, 95% CI: 0.969–0.976) and females (IRR: 0.969, 95% CI: 0.966–0.972).

Using the Edwards test, a significant (p<0.001) cyclical trend was found in monthly suicide deaths with a peak at the end of June. There was a similar significant (p<0.001) seasonal pattern in suicide rates with a peak in June for both sexes, and there was essentially no gender difference in the peak. Seasonal investigations on a quarterly basis led to similar results.

4.2.4. Seasonality by risk factor

Adding one of the significant risk factors to sine and cosine terms in the NB model, both the seasonal pattern and the factor remained significant. At each level of each factor, the number

of suicide deaths reached its peak between early June and early July. Generally, no more than a half-month difference was detected in peaks in suicides within the levels of a given factor.

4.2.5. Seasonality by suicide method

There were differences in peaks by suicide method. The peak of non-violent suicides was in early June; suicides committed by violent methods peaked in late June. However, within violent and non-violent methods, there were differences of more than one month (firearm and jumping from a height) and almost two months (drug overdose and chemical poisoning), respectively. Overall, even a difference of more than two months was detected. Quarterly peaks were nearly the same as those observed in a monthly breakdown.

5. DISCUSSION

5.1. Main findings

The leading external causes of death were suicide, unintentional falls and traffic accidents, accounting for 84% of the mortality from all external causes combined. The number of deaths due to external causes was higher for males in all age groups. Declining annual trends in the ASMRs for almost all kinds of death from external causes were found during the study period. Consequently, an improving tendency can be observed in Hungary relating to the mortality due to external causes. This decrease (by 55%, from 94 to 42 per 100,000 persons) is particularly important since the mortality from external causes is traditionally high in the Central and Eastern European Countries.

However, Hungary is still far from the EU-15 average in respect to mortality rates due to external causes (nearly twice higher than the ones in EU-15). Furthermore, the decrease in deaths due to external causes is primarily attributable to the spectacular fall observed in accidental mortality. This is linked to the EU accession in 2004 and the directive that was introduced at this time, which makes it compulsory to install safety belt systems in all types of vehicles that are placed on the market. Nevertheless, we cannot fail to mention that Hungary had switched from manual coding of death causes to machine coding in the same year.

There was a declining trend in the mortality from traffic accidents during 1995-2014 (especially since 2007) in Hungary. This is likely to be the result of a restriction of the traffic law. One of the main elements of this regulation is that drunk driving is strictly punishable (“zero tolerance”), and a high fine on the spot can be imposed even in the case of low alcohol consumption. It is important to note that the 2007 amendment to the law had earned impressive

media coverage; thereby, citizens were properly informed about the changes, which could also have contributed to a large decrease in accidents. We speculate that further limitations on speed in the Highway Code would have similar (positive) consequences.

There was also a significant decrease in the number of fatal falls and a sharp drop was observed in 2005. We might assume that some regulations had a role in this decrease: a new decree on the professional rules for managing local public roads was adopted in 2004, which obliges municipalities to develop winter road management plans. Hungary used to be the leading one among the countries with highest fall-induced mortality rates in the EU; in 2012, its place was taken by Slovakia in this respect. Consequently, the creation of appropriate regulatory background and its enforcement are important in the prevention of accidental falls.

Significantly decreasing annual trends in suicide rates were found during 1995-2017: the yearly suicide mortality rates halved. Similar trends were observed in both genders. Despite the higher rate of decline, age-standardised suicide rate is still about 1.5 times higher than in the EU overall. Both death rates from suicide and falls were higher among the elderly; therefore, the development of a social and health care system that supports older people can be an important element of prevention.

Risk estimates of suicide rates were calculated by gender, age group, region, marital status, and educational attainment, highlighting a nearly 3.5 times greater risk in males than in females overall. The risk of suicide in males was more than threefold in all age groups. A significantly increased risk of suicide mortality was observed for non-married persons; greater age and lower education also raised the risk of suicide.

Either significant seasonal variation peaking in winter or significant summer-peak seasonality was observed in most of the external-cause mortality rates (except for traffic accidents which peaked in September). Significant seasonality was detected in monthly suicide mortality rates, with a peak in late June. The pattern of seasonal effect remained almost unchanged after adjusting the (sociodemographic) factors mentioned above for seasonality in NB regression models. Seasonal trends with a peak from late June to mid-July were observed in mortality rates for all suicide methods except for firearm and drug overdose (mid- and late May, respectively). However, there was no significant seasonal variation in monthly suicide rates from gas poisoning, mostly due to the low number of cases.

It would be important for general practitioners to know when suicide peaks: although the summer climax is no longer surprising for researchers in this area, it is much less known among GPs. Of course, not only health professionals are responsible for prevention; raising public awareness on suicide is also essential: since it is still a general misconception that winter

holidays are the most depressive period of the year, depressed people get less attention in the summer when they would really need it.

5.2. Strengths and limitations

The data were obtained from vital registers; although Hungary's vital statistics performance index is one of the best in the world, there may be cause-of-death biases. Additionally, the official Hungarian population estimates did not account for international migration in the period 1995-2001, which caused a sudden increase in population between 1999 and 2000. Despite the limitations of the published data, we are confident that our results do reflect real trends (at a population-level).

Instead of only reporting mortality rates (or ASMRs), we used regression models to estimate trends in deaths from external causes (including suicide) in Hungary. The description of incidence rates in terms of seasonal variation or cyclic trends is important in many epidemiological studies since the population-level investigation can be utilised in the prevention. Overdispersion did not influence our results as the NB regression method was employed in both risk estimation and investigation of mortality trends. The longest study period available was used in these analyses. One of the additional advantages is the analysis by gender.

As far as we are aware, our research has been the first epidemiological study reporting the effect of seasonality for deaths from external causes in Hungary (Study I).

Our epidemiological investigation on nationwide data (Study II) relates to the risk of suicide by sociodemographic characteristic, such as gender, age group, region, marital status, and educational attainment. We also used the Edwards test in the monthly cyclical trend analyses, which confirmed the findings of the NB regression model, as both yielded similar results. As far as we are aware, this has been the first epidemiological study to investigate the seasonal variation of suicide deaths by NUTS2 region in such a detailed way in Hungary.

Environmental effects are involved in the aetiology of mortality. The available Hungarian monthly mean temperature and precipitation data generally supported these hypotheses for external-cause mortality. Unfortunately, there were no monthly (detailed) environmental data available to investigate causality more precisely. Despite daily temperature data being unavailable, heat-related seasonal effects were found in mortality from suicide, accidental drowning/submersion, and traffic accidents.

6. CONCLUSIONS

The creation of appropriate regulatory background (decree on managing local public roads, directive on safety belt systems, restriction of the traffic law) and its enforcement were important in the prevention of deaths due to external causes (especially accidental falls and traffic accidents). However, Hungary is still far from the front line of EU in respect to both external-cause and suicide mortality rates.

To reduce the overall mortality rate from external causes (especially those that are associated with seasonal differences such as traffic accidents and suicides) and to prolong life expectancy, preventive measures must be taken (e.g. increased police presence on the roads at the opening of the academic year, cultural education programs on suicide and its seasonal pattern conducted with the involvement of the media – targeting both the civilian population and health professionals – to pay more attention to men, the elderly and patients with depressive disorder, especially in summer); however, further cohort studies should be carried out to investigate this hypothesis using detailed individual data.

7. KEY NOTES

- Annual and seasonal trends in mortality rates from external causes and suicides (in detailed) were investigated in Hungary during 1995-2014 and 1995-2017, respectively.
- Suicide, unintentional falls and traffic accidents mortality declined significantly. The declining annual trend was significant both for males and females.
- Suicide risk was significantly higher in men than in women, and it increased with age and decreased with education level. Marriage was a protective factor against suicide.
- Significant declining trends in annual mortality were also found for assault, cold/heating-related accidents and accidents caused by electric current.
- Significant winter-peak seasonality was found in the mortality rates from accidental falls, cold/heat-related accidents and other accidents caused by submersion/obstruction.
- Significant seasonal trends with a peak from June to July were observed in death rates from suicide, accidental drowning/submersion and accidents caused by electric current.
- Seasonal pattern of suicide mortality (peak in late-June) remained almost unchanged after adjusting sociodemographic factors.
- There were differences in seasonal peaks by suicide method.
- Environmental effects are involved in the aetiology of suicide and accidents.