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Reduction in Suicide Mortality Following a New National Alcohol Policy in Slovenia: An Interrupted lime-Series Analysis

William Alex Pridemore

Indiana University

Aleksandra J. Snowden

Indiana University, Marquette University

# ABSTRACT

## Objectives.

We assessed the impact on suicide mortality of a new national policy in Slovenia that limits the availability of alcohol.

## Methods.

We obtained monthly total, male, and female suicide counts in Slovenia between January 1997 and December 2005 and then employed autoregressive integrated moving average (ARIMA) techniques to model the effect of the alcohol policy (implemented in March 2003).

## Results.

There was a significant decrease in the total number of monthly suicides following the policy's implementation. Subsequent analyses revealed this association to be caused solely by the impact on male suicides. Specifically, there was an immediate and permanent reduction of 3.6 male suicides per month (95% confidence interval =-0.4,-6.9), or approximately 10% of the preintervention average. The policy had no statistically significant effect on female suicides.

## Conclusions.

Our results show the effectiveness of this specific policy in reducing male suicides in Slovenia and also hint at the potential of public policy in reducing the public health burden of alcohol-related harm more generally.

In the late 1990s, Slovenia's level of alcohol consumption was among the highest in Europe, at over 14 L of ethanol per adult per annum.[1] During the same period, the standardized death rate from suicide — approximately 30 per 100000 residents — was higher than in any western European nation.[2] Recognizing the high levels of alcohol consumption and related harm, Slovenian public health experts and others lobbied for a new national policy.[3] After considerable effort in the face of opposition, the Slovenian National Assembly passed new legislation[4] in January 2003 that aimed to reduce alcohol-related harm by restricting alcohol's availability. Although implementation of such policies provides scholars with unique scientific opportunities, the empirical literature contains few studies of the effects of these natural experiments on violence.

Research on alcohol and suicide at the population level often finds an association between the two, although the strength of this relationship varies by nation depending on the drinking culture. In general, the association is weak or absent in central and southern European nations but significant in northern Europe.[5][6] Ramstedt, for example, examined gender- and age-specific associations between alcohol and suicide in several western European nations.[6] Grouping countries into low-consumption (Finland, Norway, Sweden), medium-consumption (Austria, Belgium, Denmark, Ireland, Netherlands, United Kingdom, former West Germany), and high-consumption (France, Italy, Portugal, Spain) nations, he found that yearly changes in per capita alcohol consumption were related to yearly changes in gender- and age-specific suicide rates. Further, results showed that suicide rates were more responsive to changes in alcohol consumption in "dry" (low-consumption) than in "wet" (medium- and high-consumption) drinking cultures.

Although still few in number, population-level studies of alcohol and suicide in eastern Europe are growing, probably because of the strong association between alcohol and violence in the region, especially in Slavic nations.[7-12] Pridemore and Chamlin found a positive association between heavy drinking and suicide in Russia between 1956 and 2002 for both total and gender-specific rates.[9] In Belarus, Razvodovsky found an association between alcohol and suicide, which was stronger for spirits than for beer and wine.[10][11] Landberg, in a study similar to Ramstedt's in aim and method, examined the association between drinking and suicide in 7 eastern European nations.[7] The results showed a significant association between alcohol and suicide in each nation, but they also revealed that the sizes of the effects were stronger in countries in which spirits were the preferred form of alcohol (Belarus, Poland, Russia) than in nations in which nonspirits (wine or beer) were preferred (Bulgaria, former Czechoslovakia, former German Democratic Republic, Hungary).

These studies have reached similar conclusions about the population-level association between alcohol and suicide: it is stronger (1) for spirits than for beer and wine and (2) in countries in which the drinking pattern is characterized by binge drinking. Research in western Europe, which has focused less on beverage preference than on "wet" and "dry" drinking cultures, has shown that the association is usually stronger in dry cultures.[5][6] However, the dry drinking cultures in Europe are usually in countries in which spirits are the beverage of choice and binge drinking is more common. In eastern European studies, more attention is given to the consumption of spirits than of wine and beer,[7][8][10][11] and binge drinking is common in the region, especially in Slavic countries.

The impact of alcohol policies on violence — and on suicide specifically — has received less empirical attention. A few recent studies, however, have examined the Soviet anti-alcohol campaign in the mid- to late 1980s.[13] Although assessments of the campaign's long-term public health effects are mixed,[14] studies provide evidence of short-term success in reducing alcohol consumption and alcohol-related harm, including suicide. Research by Värnik et al.,[15] for example, found that the alcohol policy in Estonia led to a 40% reduction in suicides in which alcohol was present in the blood of the victim (i.e., blood alcohol content [BAC]-positive suicides), with men and women equally affected. Once the campaign ended, the number of BAC-positive suicides began to increase. A similar analysis by Nemtsov examined alcohol consumption and suicide in Russia between 1965 and 1999.[16] Nemstov found that the antialcohol campaign was accompanied by a substantial decline in suicides. In related studies, Nemtsov found that violent deaths (including suicide) decreased 33% during the campaign.[17][18]

Slovenia is a small central European country with a historically high rate of alcohol consumption. Its history, geography, and culture have resulted in an eclectic mix of alcohol beverage preferences. Slovenia's geographic location provides an ideal climate for viticulture, and the country produces wines from 3 growing regions.[19][20] In addition, the region's historical connections with the Austro-Hungarian Empire contribute to a tradition of beer brewing and heavy beer drinking. Spirits are also commonly consumed in Slovenia The most common is made of fermented fruit juices and is often offered as a sign of hospitality and consumed with meals. In short, Slovenia possesses a wet drinking culture, and alcohol has historically been — and continues to be — an important part of the culture.[21]

Alcohol consumption increased in Slovenia in the 1980s, and in 1997 the country had the highest level of consumption in its reference group of European nations (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Poland, Romania, and Slovakia). In 1997, the annual rate of alcohol consumption was more than 14 L per adult.[1][22] Unregistered consumption is also high, likely exceeding 5 L per person per annum.[23] By recent estimates, 13% of Slovenian adults are heavy drinkers and 21% of the population consumes more than a relatively safe amount of alcohol per day (10 g for adult women, 20 g for adult men)[24][25]

Slovenia's annual suicide rate of more than 30 per 100000 residents is also among the highest in the world.[26] This high rate is not new. When Slovenia was part of Yugoslavia, its suicide rate surpassed that of other Yugoslav republics. The annual suicide rate in all of Yugoslavia in 1982, for example, was 16 per 100000, but the Slovenian rate was 33 per 100000.[27] The annual mean suicide rate in Slovenia between 1985 and 1996 was 31.5 per 100000.[25] The rate among men during this period fluctuated around 50 per 100000 and was several times that among women, which was more stable and in the low teens.[28]

On January 28, 2003, the Slovenian National Assembly passed legislation limiting the availability of alcohol products in an attempt to reduce consumption and alcohol-related harm.[3] The law established a minimum age of 18 years for drinking and purchasing alcoholic beverages and limited where and when alcohol products can be purchased. For example, stores and gas stations are prohibited from selling any alcohol between 9 PM and 7 AM, the sale of distilled spirits is prohibited from a store's opening time until 10 AM, workplaces must be alcohol free, and alcohol is no longer allowed to be sold from vending machines.[4]

Preliminary data suggest that this new alcohol policy may have had an impact on alcohol-related harm. Between 2003 and 2005, there was a 12% reduction in registered alcohol consumption in Slovenia, from 11.7 L to 10.3 L per adult per annum.[29] This was accompanied by a 12% decrease in alcohol-related traffic accidents[29] and an 11% reduction in absences from work because of illness.[30] There was also a steep drop in the standardized death rate for liver diseases and cirrhosis between 2002 and 2005, from 29.5 per 100000 to 21.9 per 100000[30] Because alcoholic liver disease and cirrhosis are chronic conditions, immediate decreases in their rates in response to policy or other interventions may seem counterintuitive. There is substantial evidence of such effects, however, from Slovenia's Eastern European neighbors during the Soviet antialcohol campaign in the 1980s as well as German-occupied Paris in 1942.[31] Given Slovenia's high rates of alcohol consumption and suicide, as well as the intriguing decreases in alcohol-related harm following implementation of the new law, scholars are provided with a rare natural experiment for examining the impact of a national alcohol policy on suicide mortality. We assessed the impact of a national alcohol policy on suicide mortality in Slovenia using interrupted time-series techniques.

# METHODS

The dependent variables in this study were overall and gender-specific monthly suicide counts. Counts are appropriate because the country's population increased by only about 18000 during this period.[32] In Slovenia, cause of death is determined by the doctor who treated the decedent and is then confirmed by a coroner or pathologist Deaths are classified according to the International Classification of Diseases, 10th Revision (ICD-10),[33] with suicides coded as X60 to X84. The time series we used began in January 1997 and ended in December 2005. There were 108 monthly observations, with 74 months of preintervention data (the policy was enacted in March 2003) and a post-intervention series of 34 months. Data were obtained from the Statistical Unit of the Institute of Public Health of the Republic of Slovenia.

We used autoregressive integrated moving average (ARIMA) techniques,[34] which are ideally suited for assessing the impact of an intervention, such as a new law, on a time series. The first stage; of ARIMA analysis involves estimating a univariate model that accounts for the systematic variation in the time series that is independent of the intervention. This is commonly referred to as a noise model. In the second stage, the effect of the intervention on the time series is estimated through selection of a transfer function. This is called the intervention model. The fit of these models are then tested with several diagnostics. If these checks show the model to be inadequate, new models are estimated until a statistically appropriate model is found.

The effect, if any, of the alcohol policy on suicide mortality can be determined empirically by testing for 3 common functional forms (i.e., transfer functions).[35] One is an abrupt permanent change in the level of the outcome series. "Permanent" is meant only to include the length of the postintervention time series being analyzed. This lis estimated by a zero-order transfer function by the equation

(1)

where ω0 is the parameter to be estimated and It is the intervention. A second functional form is a gradual permanent shift in the level of the outcome series. This is estimated by a first-order transfer function represented by the equation

(2)

where the δ1 parameter provides the rate of the shift and B is the time series backshift operator. The final functional form is an abrupt but temporary shift in the level of the outcome series, referred to as a pulse function, and is estimated by applying a first-order transfer function to a differenced intervention series. It is represented by the equation

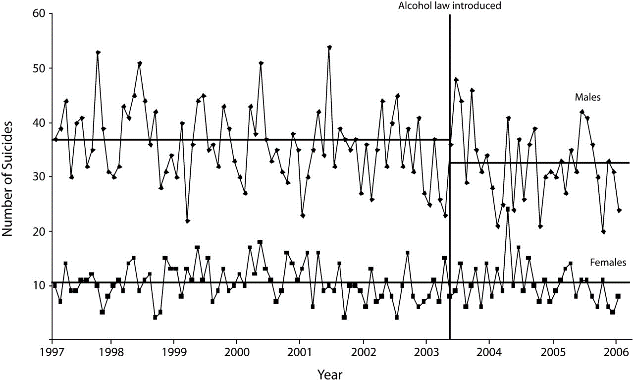
(3)

The model that best represents the effect of the intervention can be determined by estimating each of these transfer functions and evaluating their fit to the data through several diagnostics. In our analyses, all computations were performed with RATS Version 6.35 (Estima, Evanston, IL).

# RESULTS

Monthly male and female suicide counts are shown in Figure 1. Mean monthly suicide counts for the entire period were 45.5, 35.0, and 10.5 for total population, men, and women, respectively. Preintervention means were 46.7, 36.2, and 10.5; postintervention means were 42.8, 32.3, and 10.5. There was no statistically significant change in suicides among women, but there was a 10% decrease in suicides among men. However, neither Figure 1 nor these means tell us if any changes were part of an ongoing pattern in the time series or if they resulted from the intervention. To answer this question, we turn to the ARIMA models.

Figure 1. Number of monthly male and female suicides: Slovenia, 1997-2005.



Note. “Alcohol law” refers to national legislation limiting the availability of alcohol products, enacted March 2003. Pre- and postintervention mean figures are represented by the horizontal straight lines.

The first step of interrupted time series analysis is to estimate a noise model that takes into account any systematic variation from unmeasured stochastic processes that could confound the influence of the alcohol policy on the dependent series. The left column of Table 1 provides information about the form and statistical adequacy of the final univariate models. The form of the seasonal ARIMA model is

(4)

where p is the order of the autoregressive parameter, d is the order of differencing, q is the order of the moving average parameter, P is the order of the seasonal autoregressive parameter, D is the order of seasonal differencing, Q is the order of the seasonal moving average parameter, and s is the seasonal period.

Table 1. Final Noise and Intervention Models for Effect of the Slovenian Alcohol Policy on Monthly Total, Male, and Female Suicide Counts: 1997-2004

|  |  |
| --- | --- |
| Noise Model | Intervention Model |
| Total Suicides |  |
|  |  |
|  | for observations 1-74 |
|  | for observations 75-108 |
| Q=27.5, df=35, *P*=.81 | , *P*=.092 |
|  | Q=26.69, df=34, *P*=.81 |
| Male Suicides |  |
|  |  |
|  | for observations 1-74 |
|  | for observations 75-108 |
| Q=36.7, df=35, *P*=.39 | , *P*=.033 |
|  | Q=36.91, df=34, *P*=.34 |
| Female Suicides |  |
|  |  |
|  | for observations 1-74 |
|  | for observations 75-108 |
| Q=59.5, df=35, *P*=.006 | , *P*=.982 |
|  | Q=59.66, df=35, *P*=.006 |

Note. ARIMA=autoregressive integrated moving average; θ=moving average parameter; B=backward shift operator; ω0=zero-order input parameter of a transfer function; It=intervention series; at=random shock at t observation; Yt=the t observation of the times series; Yt\*=estimate of Yt;It = a dummy variable representing the impact of the event; Q = Ljung-Box test statistic for the null hypothesis that the model residuals are distributed as white noise.

Table 1 shows that the total and male suicide time series both required the specification of first-order seasonal differencing to remove drift, as well as a first-order seasonal moving average parameter to remove autocorrelation. The Q statistic is the Ljung — Box test statistic for the null hypothesis that the model residuals are distributed as white noise (i.e., they are uncorrelated). The Q statistic for the final noise models for total and male suicides meets the diagnostic criterion that none of the autocorrelations is significant at the .05 level. The raw time series for female suicides presents an interesting case. As shown in Table 1, an initial model containing only the constant suggests there is a significant amount of systematic variation remaining (Q=59.5; P=.006). The addition of both nonseasonal and seasonal autoregressive and moving-average components, however, did not result in improvements in the diagnostics relative to the initial trend model, and thus the latter was retained as the noise component.

The right column in Table 1 shows the final transfer function models assessing the impact of the Slovenian alcohol policy on monthly suicide counts. After estimating zero-order, first-order, and pulse models for each of the 3 series, the diagnostics revealed that a zero-order response best fit the data from each of the 3 series. The pre- and postintervention series means shown in Figure 1 provide a graphical display of the results presented in the right column of Table 1. The findings suggest that the alcohol policy had no effect on suicides among women (ω0=-0.01; P=.982). Note that there was a potential outlier in the female postintervention series in March 2004. After we controlled for this with a dummy variable and reestimation of the models, the inference remained the same. This means that the impact of the policy on the total number of suicides (ω0=-3.30; P=.092) is a function of the result for men. Specifically, the intervention model for men shows that the alcohol policy led to an immediate and permanent decrease of more than 3.6 suicides among men per month (ω0=-3.62; P=.033), or a 10% reduction compared with preintervention levels.

# DISCUSSION

Our findings are clear. After we controlled for other factors, we found that the implementation of the 2003 alcohol policy was followed by an immediate and permanent reduction in male suicide mortality in Slovenia. Alcohol abuse plays an important role in the public health burden in Slovenia and in many other nations.[29][36-39] Alcohol has a direct effect as a risk factor for many types of morbidity and mortality. It also has an indirect effect because it is partially responsible for other problems that in turn influence health and the risk of suicide. Population-level studies have confirmed the association between alcohol and suicide in many nations, including eastern European countries.[5-12]

Many view alcohol abuse and suicide as individual behaviors beyond the reach of public policy. The evidence shows, however, that policy can influence patterns of alcohol consumption.[40] Research also finds that nations' suicide rates, individually and relative to those of other nations, vary on the basis of sociocultural factors and social change. Thus, our finding that alcohol policy can reduce suicide mortality provides a significant contribution to the public health and public policy literature. Given the seriousness of suicide, a logical conclusion is that less-serious alcohol-related harms can also be reduced through alcohol policy.

## The Association Between Alcohol and Suicide

The empirical literature provides evidence of an association between alcohol and suicide at the population level in many nations,[5-12] and recent research in Slovenia shows that 74% of suicide victims were under the influence of alcohol.[41] Although extensive discussions of the theoretical links between alcohol and suicide can be found elsewhere, we briefly mention 2 issues here.

First alcohol may act directly as a disinhibitor for those contemplating suicide. One might argue that because of the high levels of suicide in Slovenia and many eastern European nations, attitudes toward suicide are more permissive; however, a recent study found no evidence for permissive attitudes toward suicide among Slovenians.[42] This finding suggests that alcohol is a disinhibitor, especially because alcohol is found in the systems of three quarters of Slovenia's suicide victims.[43]

Second, heavy drinking is indirectly associated with other risk factors for depression and social isolation, including family disintegration and the loss of employment and positive social friendship networks. As has been found elsewhere, these networks seem especially important in Slovenia, where prior research has shown that divorced or widowed people are at higher risk for suicide than are single or married people.[28]

## Differential Effects by Gender

A population-level association between alcohol and suicide among men but not among women is not an uncommon finding. There may sometimes be methodological reasons for this. For example, the substantially lower female suicide rates usually exhibit little variation from the mean rate, thus making it difficult to find a statistical association. Substantively, however, men likely view the violent alternative of suicide with more permissiveness than do women, as suggested by the fact that male suicide rates are normally higher than female rates. Similarly, levels of heavy drinking are higher among men. Women, less than men, abuse alcohol; as a response to their problems. Women certainly find other mechanisms of self-defeating behavior, but their lower levels of alcohol abuse may be reflected in the weaker association between alcohol and suicide sometimes found for women. Whatever the cause, this weaker association is certainly the case in Slovenia, where recent research shows that about 45% of male suicide victims were intoxicated, compared with 18% of female suicide victims.[43] This finding, together with variation by gender in levels of drinking and in gender-specific suicide rates, would theoretically make it easier to detect any effect of the law in the male relative to female suicide time series.

## Alcohol and Suicide in Slovenia

Slovenia represents an important case study. First, the nation has high levels of both alcohol consumption and suicide. Second, although studies of other southern European nations show weak or no evidence of an association between alcohol and suicide at the population level, research on other eastern European countries, including Slovenia's neighbor Hungary, reveals a significant association. Although small, Slovenia is an amalgam of these different influences in important ways, as revealed in the aspects of its drinking culture already mentioned. This suggests that other nations may learn from Slovenia's experience in crafting policy to reduce alcohol-related harm, including violence. That the apparent association between alcohol and suicide holds in this wet drinking culture in which spirits are not the beverage of choice also has implications for the theoretical and empirical literature.[5][8]

## Limitations

There are a few limitations to consider when interpreting our results. First, we have data only for all suicides, not for suicide victims who were drinking at the time of death. Future research may be able to obtain forensic data — and thus BAC — and specifically analyze BAC-positive suicides over time in Slovenia. If the alcohol law was in fact effective in decreasing alcohol-related suicides, we would expect to see a decrease in BAC-positive suicides following its implementation. Alternatively, one could analyze suicides in which alcohol was absent, for which no reduction would be expected. Providing such a control would strengthen the conclusions we have drawn.

A second limitation is the possibility that the sudden decrease in male suicides in Slovenia simply reflects a larger pattern occurring in this region of Europe. Although time-series analyses were not carried out for Slovenia's neighbors, a cursory look at their suicide patterns suggests this was not the case. Further, a decrease in suicides is only one of many forms of alcohol-related morbidity and mortality in Slovenia that appears to have dropped following the implementation of the policy.[29][30]

Third, the Slovenian legislation contained a suite of policies that attempted to influence alcohol availability in multiple ways. It is likely that not all were equally effective, especially regarding severe alcohol-related harm such as suicide. This leaves us unable to determine the precise mechanisms through which the 2003 legislation resulted in the decrease in male suicides shown here.

Finally, Slovenia is a small nation that possesses high levels of both alcohol consumption and suicide. It is possible that similar policies enacted in other nations, which may exhibit different levels of consumption and suicide, may not experience a similar decline in suicide mortality.

## Conclusions

For those interested in the effects of public policy on public health at the population level, interrupted time-series methods are well suited for the purpose and provide rigorous tests of association. Unfortunately, there have been relatively few studies that take advantage of these techniques to examine the impact of such policies. In the case of Slovenia, our results provide strong evidence that national alcohol policy can be created and implemented in a way that reduces even the most serious of harms.

Alcohol is no ordinary commodity. Alcohol-related harm comes in many forms, including violence directed at the self and others, and epidemiological studies provide substantial evidence of the public health burden of alcohol. Research also reveals that alcohol policy can reduce this harm.[40] Unfortunately, counter-efforts by industry and others often succeed in minimizing the effectiveness of legislation aimed at reducing the public health threat of alcohol through making it more expensive and limiting its promotion and availability. When taken together with results from other studies of public health and public policy, however, our findings should inform health officials and others of the widespread benefits of alcohol policy and encourage them to consider this option more carefully.

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