

# The Differential Effects of Beverage Type on Alcohol Poisoning Mortality in Russia

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## Abstract

**Background:** Death from alcohol poisoning is a serious public health problem in Russia.

**Objective:** The aim of this study was to examine the relation between the consumption of different beverage types and alcohol poisoning mortality rates in Russia.

**Method:** Age-standardized male and female alcohol poisoning mortality data for the period 1970-2010 and data on beverage-specific alcohol sales were obtained from Russian State Statistical Committee. Time-series analytical modeling techniques were used to examine the relation between the sales of different alcoholic beverages (vodka, wine, beer) and alcohol poisoning mortality rates.

**Results:** Total alcohol sale is a statistically significant associated with both male and female alcohol poisoning mortality rates, implying that a 1-litre increase in per capita alcohol sales is associated with an increase in male mortality of 7.4% and female mortality of 9.0%. The analysis also suggests that of the three beverages (vodka, beer and wine) vodka alone was associated with alcohol poisoning mortality in Russia. The estimated effects of vodka sales on the alcohol poisoning mortality rate are clearly statistically significant for both sexes: a 1 liter increase in vodka sales would result in a 16.1% increase in the male alcohol poisoning mortality rate and in 17.9% increase in female mortality rate.

**Conclusions:** The findings from this study suggest that public health efforts should focus on both reducing overall consumption and changing beverage preference away from distilled spirits in order to reduce alcohol-related mortality rates in Russia.

**Keywords:** Alcohol poisoning; Mortality; Beverage-specific alcohol sales; ARIMA time series analysis; Russia

## Introduction

There is general agreement today that it is necessary to consider various dimensions of alcohol consumption in evaluating the risk of alcohol-related outcomes [1]. Accumulated research evidence suggests that consequences from drinking are related not only to overall level of alcohol consumption but also to the pattern of drinking. In particular, drinking pattern, characterized by episodic heavy (or binge) drinking predominantly strong spirits, may be especially detrimental to health [2,3]. Binge drinking, defined as consuming four or more drinks for women or five or more drinks for men on a single drinking occasion, is responsible for many health problems, including alcohol poisoning [4,5].

Death from alcohol poisoning is a serious public health problem in many countries [1,6-10]. Alcohol poisoning death is caused by drinking a large amount of alcohol in a short period of time. Therefore, fatal alcohol poisoning rate is assumed to be the indicator of acute consequence of drinking. This assumption is in agreement with the facts that: 1) death rates from alcohol poisoning vary widely across Europe, ranging from 0.2 to 20.0 per 100.000 of the population (in 2005 the average rate was 2.1 per 100.000 of the population, among the 25 countries of the European Union) and these differences in alcohol poisoning death rates reflect known differences in drinking patterns [5]; 2) the highest rates of death from alcohol poisoning were observed in Northern and Eastern European countries, where episodic heavy drinking of strong spirits predominates [6]; 3) the fraction of alcohol poisoning mortality showed a north-south gradient with Finland on top [3].

In relation to this [11], argue that the high Finnish alcohol poisoning

mortality compared to the other countries could be attributed to the intoxication-oriented drinking pattern [12]. Draw similar conclusions for Finland and Poland in another comparative study. In more recent analysis of quarterly time-series from Finland [13] reported that the occurrence of fatal alcohol poisonings peaked at the weekends and during holiday periods. Furthermore, alcohol poisoning has been proposed as a main indicator for alcohol-related problems for countries where episodic heavy drinking predominates [14].

The human toll from alcohol poisoning in Russia is among the highest in the world, accounting for 14381 deaths in 2010, equating to a rate of 10.1 per 100.000 of the population [15]. Russia ranks among the world's heaviest drinking countries with an annual official consumption rate about 10 litres of pure alcohol per capita, while independent estimates show a figure as high as 17 litres [16,17]. In his study [7,8] highlighted that there is no direct linear relation between consumption levels and alcohol-poisoning rates amongst former Soviet Union countries. Therefore, it seems unlikely that it is a high consumption level alone that underpins the extreme alcohol poisoning rate seen in Russia. Instead, there is growing evidence suggesting that the binge drinking pattern may be responsible for the extremely

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high level of alcohol poisoning mortality in Russia. In particular, the alcohol poisoning death rate is higher among middle-aged men, the groups that have the highest rates of excessive drinking rates [18-21]. Further, [22] studied death certificates in Moscow in 1993-95, and found that deaths from alcohol poisoning, increase on weekends, when binge drinking is most common. More recent retrospective studies have found a marked excess of heavy vodka use in working-age men whose death was attributed to alcohol poisoning [23,24]. These studies showed that the risk of premature death from alcohol poisoning among men between the ages of 35 and 54 who drank three or more half-liter bottles of vodka weekly rose dramatically.

In line with these pieces of evidence, we assume that the devastating combination of high overall level of alcohol consumption and frequent consumption of large quantities of alcohol (mainly vodka) on a single occasion should result in a positive association between vodka sales and alcohol poisoning mortality at the aggregate level. In this study we will test the hypothesis of beverage-specific effect on alcohol poisoning mortality by analyzing Russian's time series data between 1970 and 2010.

## Methods

### Data

The data on age-adjusted sex-specific alcohol poisoning mortality rates per 1000.000 of the population are taken from the Russian State Statistical Committee (*Rosstat*). During the period 1969-91 the Soviet death classification was changed three times. The Soviet list from 1965 was based on ICD8 and the lists of 1981 and 1988 based on ICD9. From 1989-1998 Rosstat used a coding scheme that was based on ICD-9. From 1999 a new coding system based on ICD-10 was introduced. The Russian coding system is claimed to be compatible with ICD-9 and ICD-10. For example Rosstat's code 165 (until 1988) and 163 (1989-1998) 'Accidental poisoning by alcohol' corresponds with ICD-9 code E 860.0-E 860.9, and code 249 (since 1999) corresponds with ICD-10 code X 45.0-X45.9. The data on per capita beverage-specific alcohol sales (vodka, wine, beer in liters of pure alcohol) were taken from Rosstat's annual reports.

### Statistical analysis

To examine the relation between changes in the consumption of different types of alcoholic beverage and alcohol poisoning mortality across the study period a time-series analysis was performed using the statistical package "Statistica". The dependent variables were the annual alcohol poisoning mortality and the independent variables were aggregate beverage-specific alcohol sales. Bivariate correlations between the raw data from two time-series can often be spurious due to common sources in the trends and due to autocorrelation [25, 26]. One way to reduce the risk of obtaining a spurious relation between two variables that have common trends is to remove these trends by means of a 'differencing' procedure, as expressed in formula:

$$\nabla x_t = x_t - x_{t-1}$$

This means that the annual changes '∇' in variable 'X' are analyzed rather than raw data. The process whereby systematic variation within a time series is eliminated before the examination of potential causal relationships is referred to as 'prewhitening'. This is subsequently followed an inspection of the cross-correlation function in order to estimate the association between the two prewhitened time series. It was Box [27] who first proposed this particular method for undertaking a time series analysis and it is commonly referred to as autoregressive

integrated moving average (ARIMA) modeling. We used this model specification to estimate the relationship between the time series alcohol poisoning mortality and beverage-specific alcohol sales in this paper. In line with previous aggregate studies [17,26,28-30] we estimated semi-logarithmic models with logged output. The following model was estimated:

$$\nabla \ln M_t = a + \beta \nabla A_t + \nabla N_t$$

where ∇ means that the series is differenced, M is alcohol poisoning mortality rates, a indicates the possible trend in mortality due to other factors than those included in the model, A is the beverage-specific alcohol sales, β is the estimated regression parameter, and N is the noise term. The percentage increase in alcohol poisoning mortality rate associated with a 1-litre increase in alcohol consumption is given by the expression:  $(\exp(\beta_1) - 1) \cdot 100$ . The temporal structure of the error term was estimated by using autoregressive (AR) or moving average (MA) parameters in the model. A diagnostic test for residual correlation is given by the Box-Ljung Q-test, which indicates whether the model has been adequately fitted.

## Results

According to official statistics, the male alcohol poisoning mortality rate increased by 13.8% (from 290.7 to 330.7 per 1000.000 of population) and female mortality rate increased by 43.2% (from 48.2 to 69.0 per 1.000.000 of population) in Russia from 1970 to 2010. Across the whole period the male alcohol poisoning mortality rate was 4.3 times higher than the female rate (346.2 vs. 81.2 per 1 000.000) with a rate ratio of 6.0 in 1970 decreasing to 4.8 by the 2010. The trends in the sex-specific alcohol poisoning mortality rates are displayed in Figures 1 and 2. As can be seen, the pattern of alcohol poisoning mortality for men and women was uniform. For both sexes the time series alcohol poisoning mortality rates fluctuated greatly over the period: increased from 1972 to 1981, decreased markedly from 1981 to 1983 (by 18.6% and 12.2% for men and women respectively), dropped sharply between 1984-1988 (2.5 times for men and 2.8 times for women), than started on an upward trend from 1988-1990, before jumping dramatically during 1991 to 1994 (3.2 times for men and 3.9 times for women). From 1994-1998 there was a fall in the rates before they again rising between 1998 and 2003 and then started to decrease in the most recent years.

The graphical evidence suggests that the temporal pattern of Russian alcohol poisoning mortality for males and females fits closely with changes in vodka sale per capita (Figures 1 and 2). There were sharp trends in the time series data across the study period. These trends were removed by means of a first-order differencing procedure. The specification of the bivariate ARIMA model and outcome of the analyses are presented in Table 1. According to the results, total alcohol sales is a statistically significant associated with both male and female alcohol poisoning mortality rates, implying that a 1-litre increase in per capita alcohol sale is associated with an increase in male mortality of 7.4% and female mortality of 9.0%. The analysis also suggests that of the three beverages vodka alone was associated with alcohol poisoning mortality in Russia. The estimated effects of vodka sales on the alcohol poisoning mortality rate are clearly statistically significant for both sexes: a 1 liter increase in vodka sale would result in a 16.1% increase in the male alcohol poisoning mortality rate and in 17.9% increase in female mortality rate. The association between beer sale per capita and alcohol poisoning rate was also positive for both sexes, but statistically not significant

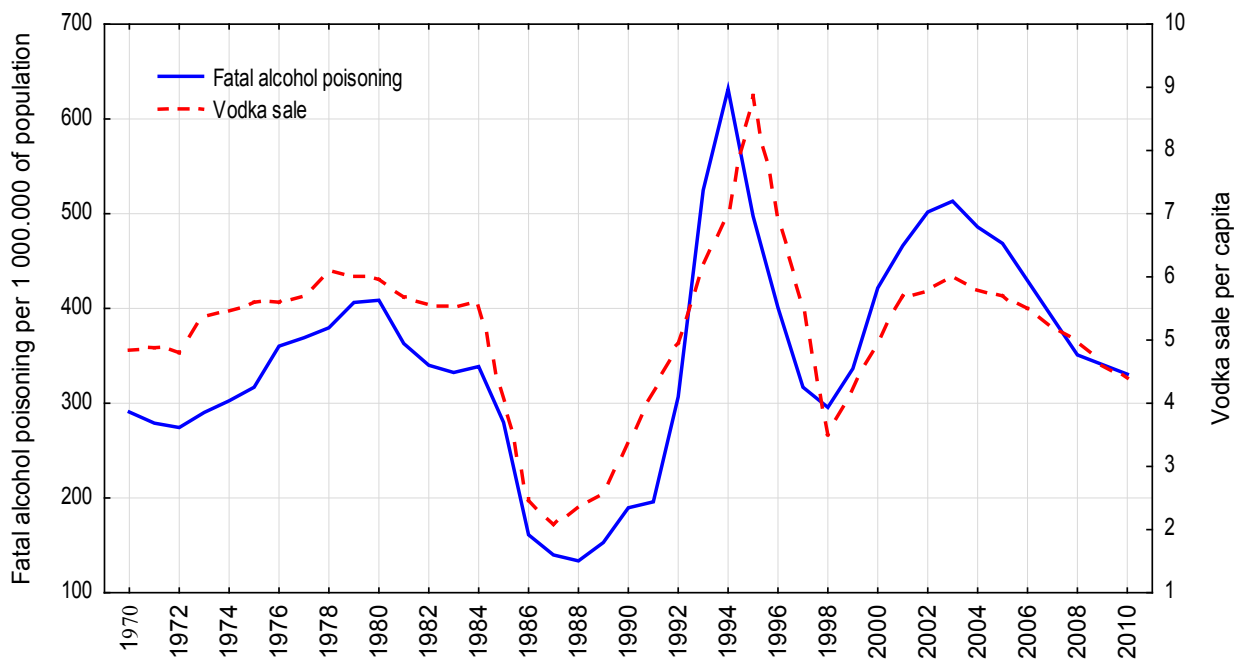


Figure 1: Trends in male alcohol poisoning mortality rate and vodka sales per capita in Russia between 1970 and 2010.

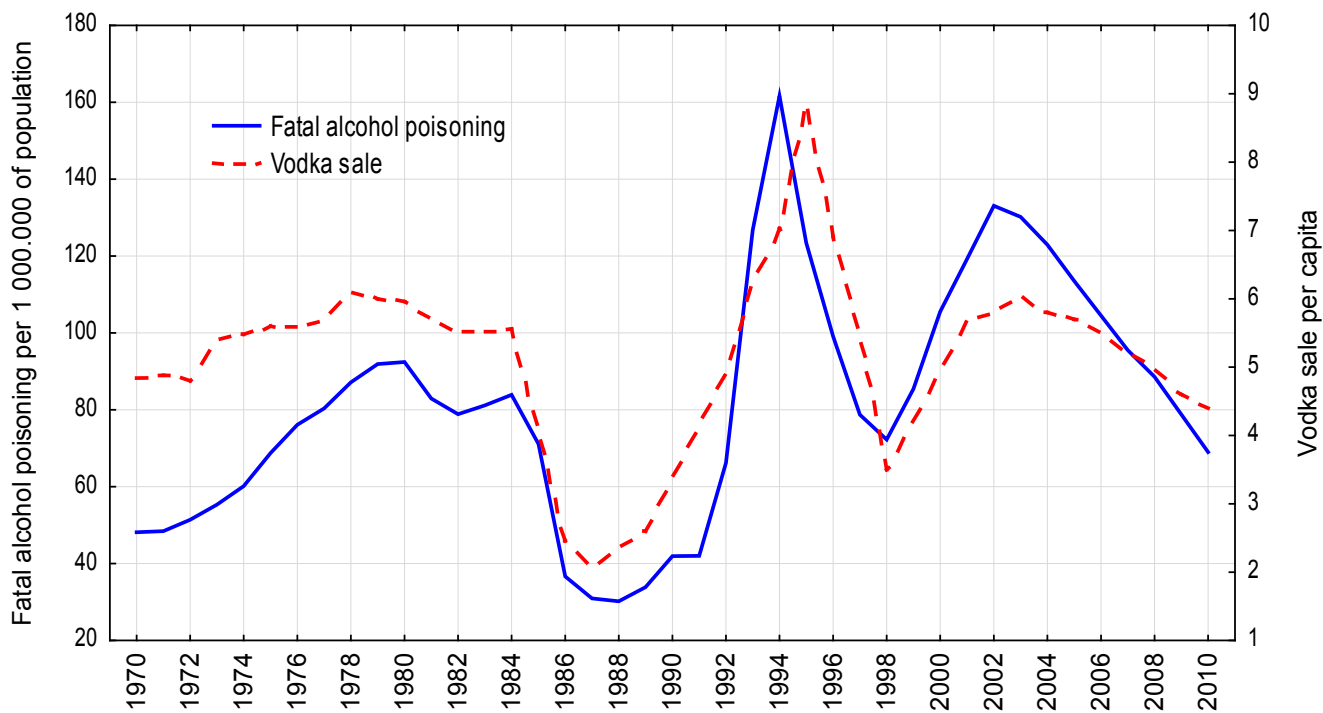


Figure 2: Trends in female alcohol poisoning mortality rate and vodka sales per capita in Russia between 1970 and 2010.

Parameter	Total alcohol sale		Vodka sale		Wine sale		Beer sale	
	model	estim.	model	estim.	model	estim.	model	estim.
mortality males	0.1.0	0.074*	0.1.0	0.161*	0.1.0	0.013	0.1.0	0.005
mortality females	0.1.0	0.09*	0.1.0	0.179*	0.1.0	0.016	0.1.0	0.008

\* -  $p < 0.001$

The general form of non-seasonal ARIMA model is (p,d,q), where p - the order of the autoregressive parameter, d - the order of differencing, and q - the order of the moving average parameter. Q test for residuals are satisfactory in all models.

**Table 1:** Estimated effects of beverage specific alcohol sales on alcohol poisoning mortality rates.

## Discussion

The results of present study are important because despite the growing literature on alcohol and mortality in Russia there has been no prior time-series analysis of beverage-specific effect of alcohol sales on alcohol poisoning mortality in the country. According to the results of time-series analysis there was a positive and statistically significant effect of per capita alcohol sales and vodka sales on alcohol poisoning mortality in Russia. These findings clearly indicate that population drinking and alcohol poisoning mortality are positively related phenomena in Russia.

Furthermore, the results of beverage-specific modeling indicated that vodka was the key beverage driving the association between per capita alcohol consumption and alcohol poisoning rate. These results are consistent with the previous findings from other settings that spirits is the most significant beverage-specific predictor of alcohol poisoning rate. For instance, the regression analysis of quarterly time-series for fatal alcohol poisonings and alcohol retail sales in Finland showed that it was the sales of spirits rather than total alcohol sales that increased fatal alcohol poisoning rate: 1% increase in the sales of spirits increases the number of fatal alcohol poisoning by 0.4% [13]. Similarly, it was shown that in Belarus, the level of per capita vodka consumption is a better predictor of the alcohol poisoning rate than the total level of alcohol consumption or wine/beer consumption: 1% increase in the sales of vodka increases the fatal alcohol poisoning rate by 1.2% [31,32].

The stronger association between alcohol poisoning rate and vodka sales may be attributable to sociobehavioral mechanisms. A more likely explanation for this finding is that the about 80% of those who died from alcohol poisoning were alcohol dependent [15] and they tend to prefer spirits as the least expensive form of alcohol [33]. A second possible explanation for these findings is that drinking pattern of spirits users was substantially different from wine or beer users. There is suggestive evidence that consumption of spirits is more closely associated with larger quantities of alcohol consumed per occasion [34].

Surprisingly, the size of the bivariate association between vodka sales and alcohol poisoning mortality rates for women is higher than for men. It seems plausible that women are more sensitive to an increased risk of alcohol-related mortality. Furthermore, the narrowing male-female rate ratios since 1970s suggests that the adverse effects of alcohol abuse among women may be becoming a pervasive feature of post-Soviet Russia. In his recent study, based on the results of RLMS [35] highlighted that frequent heavy drinking almost doubled among women between 1994 and 2004.

It is likely that a combination of factors such as what is consumed and how it is consumed, as well as the consumption of alcohol surrogates, underlies the extremely high alcohol poisoning rate recorded in Russia. Elucidating the phenomenon of extremely high fatal alcohol poisoning rate in Russia, however, does little to understand the reasons for its dramatic fluctuations across time. Most commentators agree that the affordability and availability of vodka is one of the

most important predictor of the dramatic fluctuations in Russian mortality from alcohol poisoning during the last decades [9,36-38]. One of the intriguing phenomenon in this context is the substantial decline in alcohol poisoning mortality rate between 1980 and 1984. [15] that this decline was most likely due to the creation of three new services: medical-labor dispensaries (Decree of March 1, 1974) and the narcological and resuscitation services (resolution of December 1976). The impact of these measures, according to the author, showed up only after the passage of several years because of organizational difficulties [15]. There is, however, alternative explanation of this phenomenon. In the early 1980s the Soviet leaders, Andropov first and then Chernenko, took a number of measures aimed at alcohol availability restriction [30]. It was done within a campaign to strengthen public order and discipline in the workplace. There is evidence that this policy resulted in a decline of both alcohol consumption per capita and alcohol-related mortality level. Similarly, the sharp decline in the fatal alcohol poisoning rate in the mid-1980s corresponds with the Gorbachev's anti-alcohol campaigns, which significantly reduced vodka consumption by limiting its availability [15,37].

The dramatic increase in the alcohol poisoning mortality rate in the early 1990s corresponds to the dissolution of the Soviet Union and the profound socioeconomic changes occurring during the transitional period to post-communism. Treisman argue that the increase in heavy drinking of vodka in the early 1990s, which explains much of the rise in mortality from alcohol poisoning, resulted largely from an increase in the affordability of vodka [39]. With price liberalization in 1992, vodka became much more affordable because of a dramatic drop in its relative price. The increase of vodka consumption in this period was also due to increase of its availability following the abolishment of the state alcohol monopoly in January 1992 [15]. In the period from 1995 the real vodka price recovered somewhat until 1998, after which point the trend turned down again [15]. After 1998, alcohol poisoning deaths increased as well.

Since 2003, Russia has experienced steep decline in alcohol poisoning mortality rate and vodka sales per capita. A coincidence in the vodka consumption and mortality trends allows several experts to hypothesize that the reduction in the number of alcohol poisoning deaths during the last decade might be attributed to the implementation of the alcohol policy reforms, which increased government control over the alcohol market by raising taxes and restricting sales [2,40,41]. In his recent study [42] concluded that the implementation of alcohol policies was responsible for a decline in deaths due to alcohol poisoning. It also appears likely that the shift in the structure of consumption from vodka towards beer as a result of alcohol control measures resulted in considerable improvement in alcohol poisoning mortality trend during the last decade.

The findings in this analysis are subject to several limitations as a number of factors may have affected the results. This principally applies to the quality of the data used. An earlier study of violent mortality data from the Soviet period concluded that they were not deliberately falsified [43]. Nevertheless, a rising rate of "injury death

of undetermined intent” in the post-Soviet period may indicate declining quality in alcohol poisoning mortality statistics [44]. Several recent studies also have suggested that there may be a substantial underreporting of alcohol poisoning mortality in Russia [45]. Nemtsov has even argues that in Russia the real fatal alcohol poisoning figure may be up to 65% higher than that recorded in the official statistics [15].

Further, when trying to assess the impact of per capita alcohol consumption on alcohol-related outcomes it is important to have accurate consumption figures. In present study we relied on official alcohol sales data as a proxy measure for trends in alcohol consumption across the period. However, the unrecorded consumption of alcohol was commonplace in Russia throughout the study period, especially in the mid-1990s, when a considerable proportion of vodka came from illicit sources [15,46]. The consumption of homemade spirits (samogon) and surrogates might also have a particularly negative impact on alcohol poisoning mortality [47]. The findings from Izhevsk (Russia) study indicated that among working-age males who reported surrogate use, the relative risk of dying from causes directly related to problem drinking (e.g. alcoholic psychosis, alcoholic cardiomyopathy, alcoholic liver cirrhosis and acute alcohol poisoning) was 25.5 in relation to those who consumed only legal alcoholic beverages [48].

The most important in this context was the appearance on the market of large quantities of surrogates made with technical spirits in the early 1990s [46]. The estimates showed that technical alcohol accounted for approximately 20 percent of all alcohol consumed [16]. A large increase in the drinking of poor quality homemade alcohols and very dangerous surrogates, underlies the extremely high alcohol poisoning rates recorded in the early 1990s. Several cases of mass poisoning by surrogate alcohols were recorded during the last decade. The first case was registered in Yekaterinburg (Siberia) in 2004, and further reports spread among the 21 regions throughout Russia during the following years [15]. Surrogate alcohols have been a common source of ethanol among the low-income Russian population due to their availability and low cost [49]. Consumption of industrial alcohols which contains high concentrations of diethyl phthalate (DEP) and polyhexamethyleneguanidine hydrochloride (PHMG) is particularly dangerous and remains a widespread problem in contemporary Russia [50].

Finally, it is likely that increase in alcohol poisoning mortality in Russia in the mid-1990s, at list partly, is a consequence of deterioration in the quality of health care system, following the collapse of Soviet Union in late 1991. Emergency medicine might have been especially hard hit during this period. However, some doubt that deteriorating healthcare explains much of the alcohol poisoning mortality crisis. For instance, Brainerd and Cutler 2005 argue that the fatality rate after an adverse health event seems to have changed little during the 1990s.

In conclusion, this is the first time-series analysis of beverage-specific alcohol sales and alcohol poisoning mortality rate in Russia, which has shown that alcohol poisoning mortality tend to be more responsive to changes in vodka sales per capita than to the wine or beer sales. The outcomes of this study provide indirect support for the hypothesis that unfavorable mixture of higher level of vodka consumption and binge drinking pattern is a major risk factor for alcohol poisoning mortality in Russia [51-53]. The results from present study also suggest a close aggregate-level link between alcohol availability and alcohol poisoning mortality and support the idea that high availability of alcohol is associated with increasing in binge drinking. The outcomes of this

study also provide indirect support for the hypothesis that the profound fluctuations in alcohol poisoning mortality seen in Russia during the last decades could be related to vodka availability/affordability as indicated by close temporal association between the number of deaths from alcohol poisoning mortality and vodka sales per capita. The findings from the present study have important implications as regards alcohol poisoning mortality prevention. A comprehensive approach to the prevention of excessive drinking is needed to decrease alcohol poisoning deaths. There are several evidence-based strategies to reduce excessive drinking such as raising alcohol prices and reduction its availability which had the greatest impact on binge drinking among adults.

#### Conflict of interest

None declared.

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