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The effect of beverage type on fatal accidents rate in Russia

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Abstract – There is a common belief that high level of alcohol consumption, in conjunction with binge drinking pattern, is a major determinant of accident mortality crisis in Russia. The aim of this study was to examine the relation between the consumption of different beverage types and fatal accident rate in Russia. Age-standardized male and female accident 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 (ARIMA) were used to examine the relation between the sales of different alcoholic beverages (vodka, wine, beer) and accident mortality rate. The analysis also suggests that of the three beverages vodka alone was associated with accident mortality in Russia. The estimated effects of vodka sales on the accident mortality rate are clearly statistically significant for both sexes: a 1 liter increase in vodka sale would result in a 9.8% increase in the male accident mortality rate and in 7.5% increase in female mortality rate. The findings from this study suggest that public health efforts should focus on both reducing the overall consumption and changing the beverage preference away from distilled spirits in order to reduce fatal accidents rate in Russia.

Key words: accidents, mortality, beverage-specific alcohol sales, ARIMA time series analysis, Russia, 1970-2010.

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Introduction

It is widely recognized that acute alcohol intoxication is associated with an increased risk for almost all categories of accidents and injuries. [1,2] In many countries alcohol plays a significant role in accidental falls, accidents caused by fire, accidental drowning. [3] A causal link between alcohol and injuries has been established from both individual and population level studies. [4,5] A systematic review of emergency department studies, published between 1995 and 2005, revealed that injured patients were more likely to be positive for BAC at the time they were admitted and to report drinking within six hours prior to the injury event compared with those who had not reported any injuries. [5,6] Of all alcohol-attributable deaths globally, WHO identified 12% as being a result of intentional injuries and 29.6% as being a result of unintentional injuries. [7] There is a dose-response relationship between alcohol and injury, with

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risk increasing with the increasing amount of alcohol consumed. [3] Alcohol-related accidents and injuries are more closely related to pattern of drinking than to the overall volume consumed. [4,7] There are several studies indicating that binge drinking is associated with high risk of trauma. [8,9] Savola and coauthors [10] reported that binge drinking is a major risk factor for head trauma among trauma patients and that the relative risk for head injury markedly increases with the increasing blood alcohol level. A study from Finland showed an excess of head traumas during weekends and this excess was associated with heavy episodic drinking. [11] Similar weekly variations of head trauma have been reported in other countries where heavy episodic drinking is also the prevailing drinking pattern. [9]

The strong support for a causal role of alcohol in accident mortality comes from the aggregate-level studies. Both longitudinal and cross-sectional aggregate-level studies have reported elsewhere a significant temporal co-variation between *per capita* alcohol consumption and accident mortality rates. [12] An analysis of time-series data for Canada covering the period 1950-1998 revealed a statistically significant association between *per capita* alcohol consumption and overall fatal accidents rate. [13] Nevertheless, the cross-country comparisons demonstrate heterogeneity with respect to strength of association between population drinking and accidental mortality. [12] In countries where high level of intoxication is an integral part of the drinking culture, the etiological significance of alcohol seems to be larger. A time series analysis, based on the data for the period from 1950-95 covering 14 European Union countries suggests that an increase in population drinking had the largest impact on accident mortality in northern Europe than in mid-Europe and southern Europe. [6] These findings provided support for the hypothesis, that the effect of alcohol on accident mortality rate is stronger in the northern European spirits countries characterized by a low *per capita* consumption with the bulk of consumption concentrated on a few occasions (binge drinking pattern), or "dry" drinking cultures, than in the southern European wine countries with a high average consumption which is more evenly distributed throughout the week, or "wet" drinking cultures. Similarly, the results of recent study suggest that changes in *per capita* consumption have a significant impact on injury mortality in 6 eastern European countries, but the strength of the association tends to be stronger in countries where intoxication-oriented drinking pattern prevails. [14]

There is common belief that high level of alcohol consumption in conjunction with binge drinking pattern is a major determinant of accident mortality crisis in Russia. [15] The findings suggest that population drinking and accidental deaths rate are positively related at the population level in Russia. [14,16] Additional development of the idea that alcohol can have a detrimental effect on accident mortality in Russia came from individual level studies. Analysis of daily variations of deaths based on data from Moscow City death certificates revealed a significant increase in deaths from alcohol poisoning and accidents on Saturdays, Sundays and Mondays. [17] This pattern of daily variations in fatal accidents is consistent with the pattern of drinking in Russia. A case-control study in Izhevsk based on proxy information from families of 1750 men aged 25-54 who died in 2003-2005 reported that periods of heavy drinking were associated with increased risk of deaths from external causes. [18] A more recent study of 22658 forensic autopsies, performed in the

Siberian city of Barnaul during 1990–2004 has shown that among the autopsied men aged 35-69 years who were reported to have died from external causes 76% of men and 65% of women were BAC-positive and 25% of men and 24% of women had blood concentration of alcohol 4 g/l or more. [19]

In line with these pieces of evidence, we assume that occasional heavy drinking of vodka in Russia should result in a positive association between vodka sales and accident mortality at the aggregate level. In this study we will test the hypothesis of beverage-specific effect on accident mortality by analyzing the Russian time series data between 1970 and 2010.

Material and methods

Data

The data on sex-specific accident mortality rates (Table 1) per 1000.000 of residents were taken from the Russian vital statistics registration system. The data on beverage specific alcohol sales per capita (in liters of pure alcohol) were obtained from the Rosstat's (Statistic Committee RF) reports. Concerning the issues of data quality, an earlier study has confirmed the reliability of the statistics on violent death for the Soviet period. [20] In the post-Soviet period virtually all deaths from external causes were subjected to forensic autopsies, which include blood al-

Table 1. ICD 10 codes of causes of accidental injury.

Causes of death	ICD 10 code
Falls	W00-W19
Exposure to inanimate mechanical forces	W20-W49
Exposure to animate mechanical forces	W50-W64
Accidental drowning and submersion	W65-W74
Other accidental threats to breathing	W75-W84
Exposure to electric current, radiation and extreme ambient air temperature and pressure	W85-W99
Exposure to smoke, fire and flames	X00-X09
Contact with heat and hot substances	X10-X19
Contact with venomous animals and plants	X20-X29
Exposure to forces of nature	X30-X39
Accidental poisoning by and exposure to noxious substances	X40-X49
Overexertion, travel and privation	X50-X57
Accidental exposure to other and unspecific factors	X58-X59

cohol level inspection and histological examination of organs. [21]

Statistical analysis

To examine the relation between the changes of consumption of different types of alcoholic beverages and accident mortality across the study period, a time-series analysis was performed using the statistical package "Statistica". The dependent variables were the annual accident 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. [22] 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:

$$\tilde{N}x_t = x_t - x_{t-1}$$

This means that the annual changes 'Ñ' 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 'pre-whitening'. This is subsequently followed by an inspection of the cross-correlation function in order to estimate the association between the two prewhitened time series. It was Box and Jenkins [23] who first proposed this particular method for undertaking a time series analysis and it is commonly referred to as ARIMA modeling. We used this model specification to estimate the relationship between the time series of fatal accidents and beverage-specific sales in this paper. In line with previous aggregate studies [22,24] we estimated the semi-logarithmic models with logged output. The following model was estimated:

$$\nabla LnM_t = a + \beta \nabla A_t + \nabla N_t$$

where Ñ means that the series is differenced, M is accident mortality rates, a indicates the possible trend in accident 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 fatal accidents rate associated with a 1-liter increase in alcohol consumption is given by the expression: $(\exp(\beta_1)-1)*100$. 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

The trends in the sex-specific accident mortality rates are displayed in Figures 1-2. It is visible that the patterns of accident mortality for men and women were uniform. For both sexes, the time series accident mortality rates fluctuated greatly over the period: increased from 1970 to 1981, decreased markedly in 1982, dropped sharply between 1984-1987 (by 39.7% for men and 26.6% for women), than jumped dramatically between 1987 and 1995 (2.2 times for men and 1.8 times for women). From 1995-1998 there was a fall in the rates before they again rising between 1998 and 2002 and then started to decrease in the most recent years.

The graphical evidence suggests that the temporal pattern of Russian accident mortality for males and females fits closely with changes in vodka sales per capita (Figures

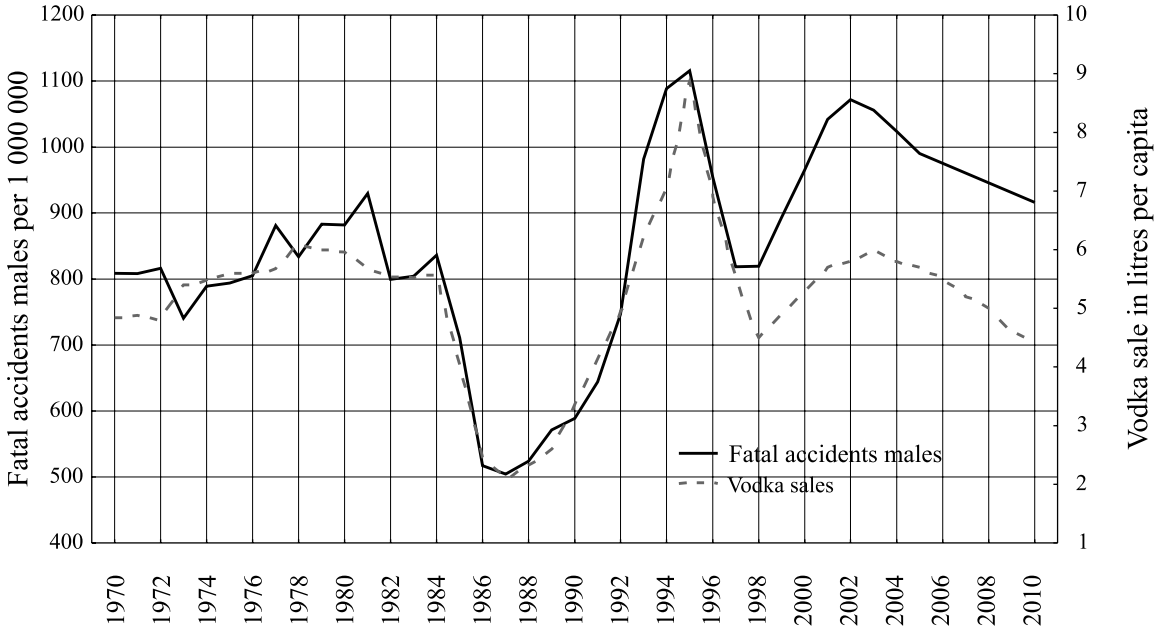

Figure 1. Trends in male fatal mortality rate and vodka sales per capita in Russia between 1970 and 2010.

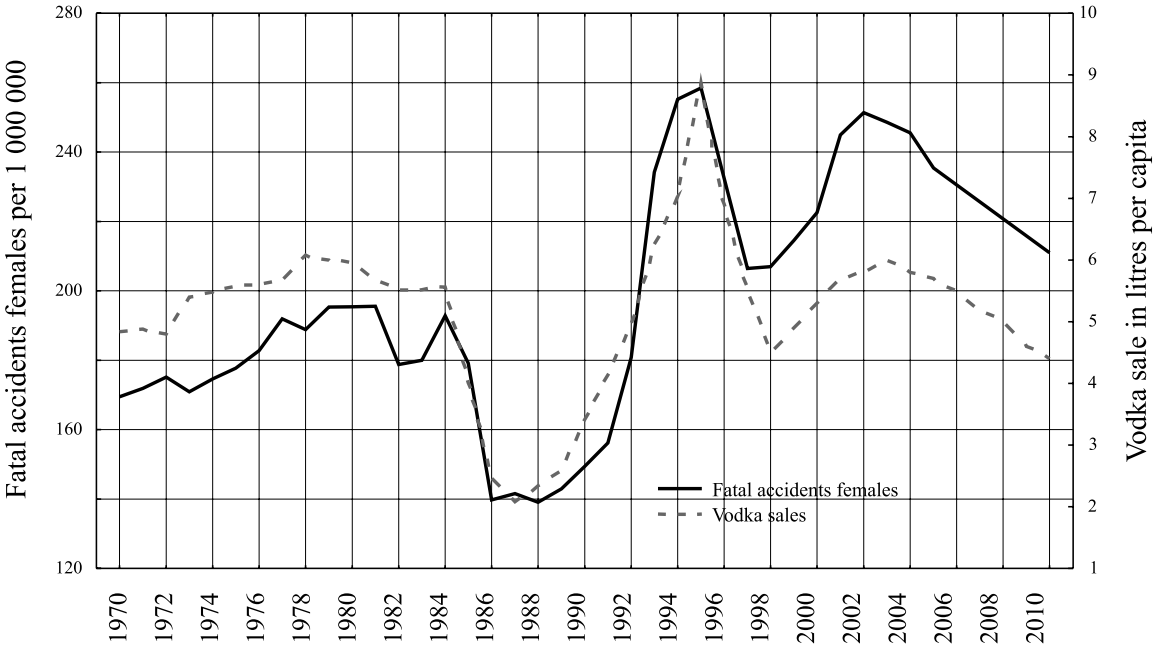

Figure 2. Trends in female fatal mortality rate and vodka sales per capita in Russia between 1970 and 2010.

Table 2. Estimated effects of beverage specific alcohol sale on accident mortality rates.

Parameter	Total alcohol sale		Vodka sale		Wine sale		Beer sale	
	model	estim.	model	estim.	model	estim.	model	estim.
mortality males	0.1.1	0.059*	0.1.1	0. 098*	0.1.1	0.083	0.1.1	0.056
mortality females	0.1.1	0.044*	0.1.1	0. 075*	0.1.1	0.062	0.1.1	0.039

*$p < 0.001$

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.

1-2). There were sharp trends in the time series data across the study period. These systematic variation was well accounted for by the application of first-order differencing and the specification of a first order moving average parameter. All of the final univariate models meet the diagnostic criterion (i.e., none of the autocorrelation functions are significant at the 0.05 level). After pre-whitening the cross-correlations between the beverage-specific alcohol sales and accident mortality time series were inspected. There was a statistically significant cross-correlation between total per capita alcohol sale, vodka sales and accident mortality for males and females at lag zero. The size of the instantaneous bivariate association between total alcohol sales and accident mortality and between vodka sales and accident mortality were substantially greater than their respective standard error. At the same time, there was no cross-correlation between the level of wine or beer sales and accident mortality rate.

The specification of the bivariate ARIMA model and the outcome of analyses are presented in Table 2. According to these results, total alcohol sale is a significantly associated with both male and female accident mortality rates, implying that a 1-liter increase in per capita alcohol sales is associated with an increase in male mortality of 5.9% and female mortality of 4.4%. The analysis also suggests that, of the three beverages, vodka alone was associated with accident mortality in Russia. The estimated effects of vodka sales on the accident mortality rate were clearly statistically significant for both sexes: a 1 liter increase in vodka sales would result in a 9.8% increase in the male accident mortality rate and in 7.5% increase in female mortality rate. The association between beer sales per capita and fatal accident rate were also positive for both sexes, but not significantly.

Discussion

The outcome of the time-series analysis suggests a positive and statistically significant relationship between the accident mortality rate and population drinking in Russia. In an international comparison, Russia stood out with an alcohol effect that was larger than what had previously been estimated for the Western Europe. [13] Furthermore, the results of beverage-specific modelling indicat-

ed that vodka was the key beverage driving the association between per capita alcohol consumption and accident mortality rate. These results are consistent with the previous findings from other settings that spirits is the most significant beverage-specific predictor of accident mortality. In particular, the results from recent time series analysis based on Belarusian data from 1970 to 2005 suggest that 1 liter increase in overall alcohol sales would result in a 6.2% increase in the accident mortality rate, while a 1 liter increase in vodka sales is expected to increase the number of deaths from accidents and injuries by 10.7%. [25]

In agreement with previous studies [25], we have found the gender differences in the association between per capita vodka sales and accident mortality rate, which mean that the impact of changes in per capita vodka sales appear to be larger on male accident mortality. Beverage preference and harmful drinking pattern might be responsible for the gender difference in the association between the accident mortality rate and vodka sale as vodka continues to be the drink of choice for the majority of men in Russia, while women not only drink less often than men, but those who do, consume vodka less frequently than men. Indeed, according to a population survey, 44% of men and only 6% women reported that they drink an equivalent of 25 cl of vodka or more at one occasion. [26] According to a more recent study, 28% of men and 4% of women consume at least 200g (86+ g of pure alcohol) on one occasion at least once every 2-3 weeks. [27]

Natural experiments, such as sudden and large changes in alcohol consumption level, provide an opportunity to test the efficacy of policy attempts to reduce the rate of alcohol-related problems in the population. These types of experiments are being used in the social epidemiology and allow a rigorous evaluation of the efficacy of public health interventions. Russia, due to its high overall level of consumption, hazardous drinking pattern and its high fatal accidents rate, provides an important contextual setting for this type of analysis. There is evidence that the accident mortality trends in Russia are influenced by the four major factors: the long-standing mortality crisis that began in the USSR in the 1960s, the brief Andropov's anti-alcohol campaign in the early 1980s, Gorbachev's anti-alcohol campaign 1985-88 and severe socio-economic crisis imposed by rapid society transformation in the early 1990s. A fairly close aggregate-level match between vodka sales and accident mortality during the Andropov's and Gorbachev's anti-alcohol campaigns may be used as evidence for the hypothesis suggesting that alcohol is responsible for a substantial number of accident deaths in Russia.

The increase in vodka consumption has contributed to the dramatic rise of accident deaths between 1992 and 1995. The increase of alcohol consumption in this period was to a great extent due to an increase of alcohol availability following the repeal of the state alcohol monopoly in January 1992.[16] It is obvious, therefore, that the increase in heavy drinking in Russia during transition, which triggered the dramatic rise in accident mortality, resulted also from an increase of the affordability of vodka. With price liberalization in 1992, vodka became much more affordable, because of a sharp drop in the price of vodka relative to those of other goods and alcoholic beverages including beer. [28] By 1995, the real price of vodka fell to its lowest point, after which point the real vodka price recovered until 1999, and then the affordabil-

ity trend turned down again. [16] The relative fall of prices for vodka explains an apparent paradox – an increase of alcohol consumption against a background of economic crisis.

Since 2002, Russia has experienced a steep decline of the accident mortality rate. There was also a parallel downward trend concerning the population drinking, driven mainly by a decrease of vodka consumption. A coincidence in the accident mortality and vodka sales trends allows us to hypothesize that the reduction of the accident mortality rate during the last years might be attributed to the implementation of the alcohol policy reforms in 2001-2006, which increased the government's control over the alcohol market. [29] The policies included strict regulatory requirements for alcohol products, which resulted in a decline of distributors and increased consumer prices. Making vodka less affordable through differential taxation was the essential element of the Russian alcohol policy.

It appears likely that the shift in the structure of consumption from vodka towards beer as a result of alcohol control measures have had a positive impact on bringing down the accident mortality rate in Russia during the recent decade. Recently, Pridemore and coauthors [31], had reported findings that support to this hypothesis. Using sophisticated analytical techniques (autoregressive integrated moving average interrupted time series analysis) they concluded that the implementation of alcohol policies was responsible for a decline in male traffic fatalities. This empirical and research evidence suggest that recent Russian government's attempts to curb the high alcohol-related mortality have been successful and provide additional evidence that pricing policy may be an effective strategy to reduce the alcohol-related burden.

Before concluding, it is necessary to address some potential limitations of the study that may have affected the outcome. In particular, it must be recognized that unregistered alcohol comprises a considerable portion of overall alcohol consumption in Russia. Substantial cuts in production and sales, combined with an increase of prices of alcoholic beverages during the anti-alcohol campaign, resulted in a growth of samogon consumption. [28] The same is true for the transitional period after the collapse of the Soviet Union. Following the repeal of the state alcohol monopoly in 1992, the alcohol market became highly fragmented, and the country was flooded by a wave of homemade, counterfeit and imported alcohol of low quality. [28]

Furthermore, there was the risk of omitted variable bias in this work. While some experts have underlined the importance of binge drinking as the main reason for the violent mortality crisis in Russia in the 1990s, others had called attention to the effect of psychosocial distress of economic and political reforms. [31] However, the close aggregate level association between alcohol consumption and accident mortality rate strongly supports an alcohol related hypothesis and suggests that, rather that playing major causal role, psychosocial distress may represent a confounding factor.

Finally, it should be emphasized that vodka sales per capita in the early-1990s exceeded the level recorded in the 2000-2005, while accident mortality rate in the early-1990s exceeded the level in the 2000-2005, though not significantly. Therefore, further research is clearly needed to understand the true nature of this apparent paradox.

In conclusion, the present study replicates the previous findings from other settings that suggest that accident mortality rate tends to be more responsive to changes in distilled

spirits sales per capita than to the total level of alcohol sales. The outcome of this study also provides the indirect support for the hypothesis that the profound fluctuations in accident mortality seen in Russia during the last decades could be related to vodka availability/affordability as indicated by the close temporal association between the number of deaths from accidents and vodka sales per capita. Assuming that drinking spirits is usually associated with intoxication episodes, these findings support the hypothesis that binge drinking pattern may potentiate the negative role of alcohol in Russian violent mortality crisis.

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Conflict of interest

None to declare

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Utjecaj vrste pića na učestalost fatalnih nesretnih udesa u Rusiji

Sažetak – Dosadašnje spoznaje: Postoji opće vjerovanje da su visoke razine konzumacije alkohola, zajedno s opijanjem po tipu 'binge-drinking' glavna odrednica mortaliteta u nesretnim slučajevima u Rusiji. Cilj: Ispitati odnos između konzumacije različitih tipova alkoholnih pića i incidencije fatalnih nesretnih slučajeva u Rusiji. Metoda: Podaci o prema dobi standardiziranom mortalitetu u muškaraca i žena iz perioda 1970-2010 i podaci o prodaji određenih tipova alkoholnih pića izvađeni su iz arhive Statističkog komiteta ruske države. Korištena je tehnika analize vremenskih serija (ARIMA) da se ispita odnos između prodaje pojedinih tipova alkoholnih pića (votka, vino, pivo) i razine mortaliteta. Rezultati: Analiza podataka sugerira da je od tri navedena pića, samo votka povezana s povećanim mortalitetom kod nesretnih udesa u Rusiji. Procjenjuje se da je učinak votke na mortalitet kod nesretnih udesa jasno statistički značajan kod oba spola: porast konzumacije votke od 1 litre rezultira s 9.8% povećanjem mortaliteta u nesretnim udesima kod muške i 7.5% povećanjem mortaliteta u nesretnim udesima kod ženske populacije. Zaključci: Nalazi ovog ispitivanja sugeriraju da bi se nastojanja javnog zdravstva trebala usmjeriti kako na smanjivanje ukupne razine potrošnje alkohola, tako i na promjenu preferiranog alkoholnog pića, da bi se reducirala incidencija fatalnih nesretnih udesa u Rusiji.

Ključne riječi: nesretni udesi, mortalitet, razina prodaje određenih tipova pića, ARIMA analiza vremenskih serija, Rusija, 1970-2010