Journal of Clinical & Experimental Cardiology

Razvodovsky, J Clin Exp Cardiolog 2015, 6:2
DOI: 10.4172/2155-9880.1000359

Research Article Open Access

The Differential Effects of Beverage Type on Stroke Mortality

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Received date: September 11, 2014; **Accepted date:** February 09, 2015; **Published date:** February 17, 2015

Abstract

Background: Stroke is one of the major causes of death in the developed world and a top ten contributor to the global burden of disease. Russia has one of the world's highest stroke incidence and mortality rates. Several studies have emphasized the role of binge drinking as important determinant of high stroke mortality rate in Russia.

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

Method: Age-standardized male and female stroke mortality data for the period 1980-2005 and data on beverage-specific alcohol sales were obtained from Russian State Statistical Committee. Time-series analytical modelling techniques (ARIMA) were used to examine the relation between the sale of different alcoholic beverages (vodka, wine, beer) and stroke mortality rates.

Result: Vodka consumption as measured by sale was significantly associated with both male and female stroke mortality rate. The consumption of beer and wine were not associated with stroke mortality rate. The estimates of the age specific models for men were positive (except for the 75+ age group) and ranging from 0.038 (60-74 age group) to 0.98 (30-44 age group). The estimates for women were positive for the 30-44 age groups (0.074) and 45-59 age groups (0.053).

Conclusion: 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 cerebrovascular mortality rates in Russia.

Keywords: Stroke; Mortality; Beverage-specific alcohol sale; ARIMA time series analysis; Russia; 1980-2005

Introduction

Stroke is one of the major causes of death in the developed world and a top ten contributor to the global burden of disease [1]. Stroke burden is expected to be rising, especially in developing countries [2]. In relation to this, identification of the risk factors is high priority front the public health perspective.

The association between alcohol consumption and stroke risk remain controversial. Alcohol has been identified as both a risk and a protective factor for stroke [3,4]. Accumulated research evidence suggests that heavy alcohol consumption increases the relative risk of stroke, while light or moderate alcohol consumption may be protective against ischemic stroke [5,6]. The meta-analysis of 35 observational studies published between 1966 and 2002 revealed that compared with abstainers, consumption of more than 60 g of alcohol per day was associated with an increased relative risk of total stroke, 1.64 (95% CI, 1.39-1.93), ischemic stroke, 1.69 (95% CI, 1.34-2.15), and hemorrhagic stroke, 2.18 (95% CI, 1.48-3.20) [7].

Few studies have examined whether the effect of alcohol on risk of stroke depends on the type of alcoholic beverages consumed. Some authors have reported that wine consumption, but not beer or spirits consumption, was associated with a reduction of the risk of stroke [5,8]. It has been suggested that the protective effect of wine is merely related to favourable drinking pattern [8].

Russia has one of the world's highest stroke incidence and mortality rates [2]. In contrast to Western Europe (WE), where stroke rates are falling, in Russia stroke is rising a cause of disability and deaths [9,10]. The higher rates of stroke mortality observed in Russia as compared with WE were in the young and middle-age groups. In 2002 the stroke mortality rate in Russia among men age 45-54 years was ten times higher than in France, Germany or Italy [2]. It was concluded that these differences can only be partly accounted for by differences in quality of stroke care throughout Europe and might be attributed to different prevalence for risk factors [11-13]. In a population-based case-control study hypertension, ischemic heart disease, smoking and high body mass index were major risk factors for ischemic stroke in the Russian population [14].

Several studies have emphasized the role of binge drinking as important determinant of high stroke mortality rate in Russia. In particular, the results of a case-control study suggest that recent episodes of heavy drinking is associated with substantial increases in stroke mortality independently of long-term hazardous drinking [15]. More recent case-control study from western Siberia reported a positive association of stroke risk with amount of alcohol drunk on single occasion [16].

The level of alcohol consumption in Russia is among the highest in the world with an annual sales rate about 10 litres of pure alcohol per capita, while independent estimates show a figure as high as 17 litres [17]. The distinctive trait of Russian drinking culture is the preference for binge drinking of vodka, leading to an increase in deaths from alcohol poisoning and cardiovascular diseases [18-20]. 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 stroke mortality at the aggregate level. In this study we will test the hypothesis of beverage-specific effect on stroke mortality by analysing Russian's time series data between 1980 and 2005.

Method

Data

The data on age-adjusted sex-specific stroke mortality rates per 100.000 of the population are taken from the Russian State Statistical Committee (Rosstat). The Rosstat's cause of death classification has undergone several changes in recent decades. Until 1988 the cause of death classification was based upon the Soviet nomenclature which had a limited number of causes of death in comparison with the International Classification of Diseases (ICD) system. 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. Rosstat issued a table of correspondence between its classification system and ICD-9 and ICD-10 and it has been claimed that the Russian system of coding was and is compatible with the ICD. For example Soviet classification 90-95 "Ischemic and hemorrhagic stroke" corresponds with ICD-9 code E431-E434 and with ICD-10 code I60-I65. 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 stroke mortality across the study period a time-series analysis was performed using the statistical package "Statistica". The dependent variable was the annual stroke 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 [19]. 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 analysed 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 pre-whitened time series. It was Box and Jenkins who first proposed this particular method for undertaking a time series analysis and it is commonly referred to as ARIMA (Autoregressive Integrated Moving Average) modelling [21]. We used this model specification to estimate the relationship between the time series stroke mortality and alcohol consumption rates in this paper. In line with previous aggregate studies [19,22,23], we estimated semi-logarithmic models with logged output. The following model was estimated:

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

where ∇ means that the series is differenced, M is stroke mortality rates, a indicates the possible trend in stroke 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 stroke mortality rates associated with a 1-litre increase in alcohol sales is given by the expression: $[\exp(\beta 1)-1] \times 100$.

Results

The average per capita alcohol sales figure was 7.66 litres with vodka being the drink overwhelmingly consumed. However, these mean figures mask differing trends among the beverages across the period. While there has been a substantial drop in vodka sales from 5.96 litres in 1980 to 3.88 litres in 2005 and wine sales have remained at roughly the same level there has been a sharp growth in beer sales – especially in recent years. Between 1998 and 2005 the per capita sales figure for beer rose from 1.16 to 3.08 litres. It is also worth noting that beverage sales have experienced sharp fluctuations across the period. Thus, a brief Andropov's anti-alcohol campaign in the early 1980s resulted in a decline in vodka sales. An especially sharp fall was recorded in vodka and wine sales in 1985-1987 that coincided with Mikhail Gorbachev's anti-alcohol campaign. Similarly, the collapse of the Soviet Union and the ending of the state's alcohol monopoly in the early 1990s were accompanied by a sharp rise in vodka sales.

Across the whole period the male stroke mortality rate was 1.31 times higher than the female rate (321.2 vs. 245.1 per 100.000). Sex-specific stroke mortality rate yield patterns that vary little from each other over time (Figures 1 and 2). For both sexes the time series of stroke mortality rates fluctuated greatly over the period: increasing from 1982 to 1984, then decreasing substantially (by 10.2% and 7.9% for men and women respectively) between 1984-1991, than jumping dramatically during 1991 to 1994 (by 27.2% and 20.0% for men and women respectively). From 1995-1998 there was a fall in the rates before they again began to rise while a decrease in rates has been recorded in the most recent years.

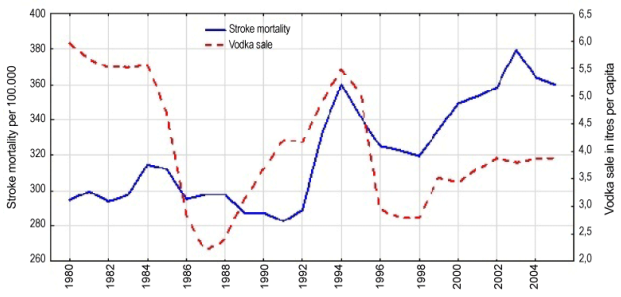

Figure 1: Trends in male stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005.

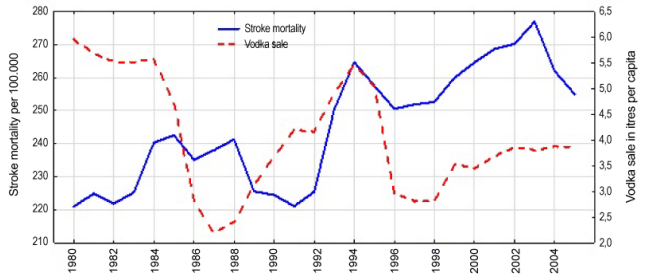

Figure 2: Trends in female stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005.

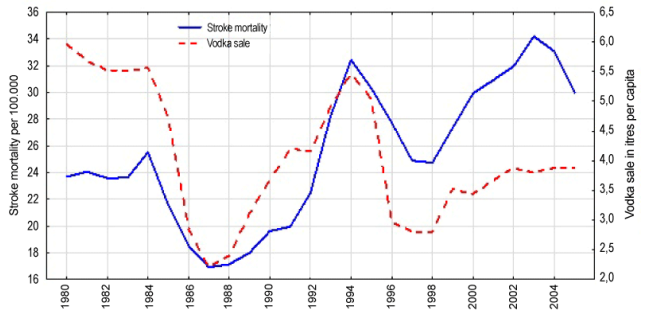

Figure 3: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for men age group of 30-44 years.

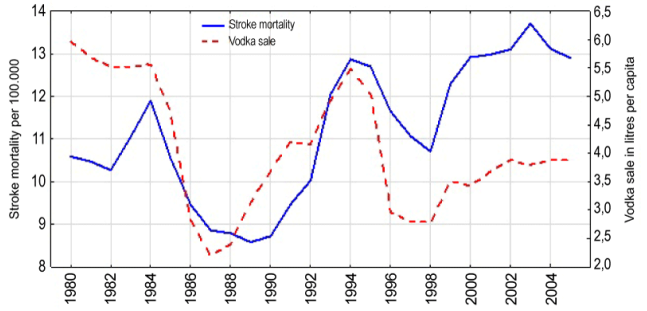

Figure 4: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for women age group of 30-44 years.

It is important to point out, however, that the pattern of stroke mortality for men and women was not uniform. Stroke mortality rate dropped more sharply for males than for females during the anti-alcohol campaign. Further, the rates of stroke mortality increased for both sexes during the transition, but it appears that males were more adversely affected during this period. In general, the male stroke mortality rate tends to fluctuated across time series to a greater extent than the female rate. It should be also emphasis that working-age males and females showed greater decrease in stroke mortality in the mid-1980s, while fluctuations in stroke mortality rates for oldest age groups of both men and women were more pronounced during the 1990s (Figures 3-8). The graphical evidence also suggests that the trends for stroke mortality and vodka sales are rather similar over the time series for both sexes in the age groups 30-44 and 45-59 (Figures 3-6).

As can be seen, there were sharp trends in the beverage-specific alcohol sales and stroke mortality time series 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.

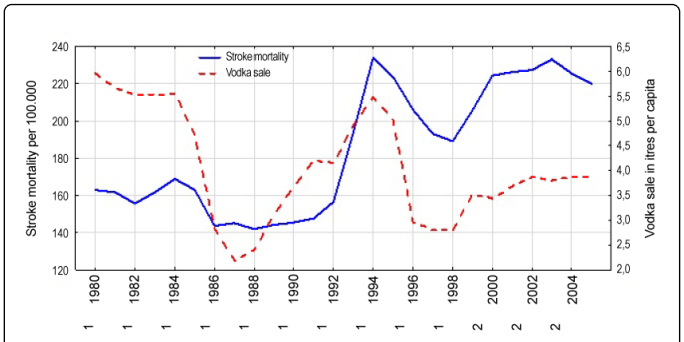

Figure 5: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for men age group of 45-59 years.

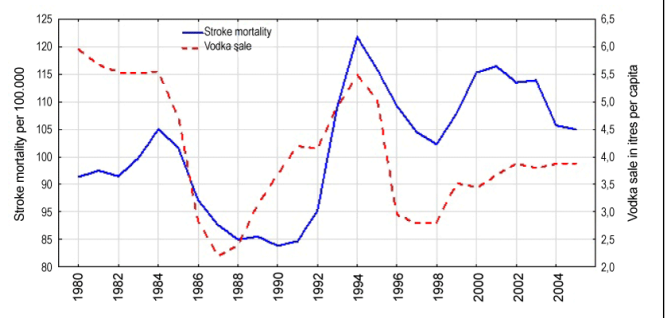

Figure 6: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for men age group of 45-59 years.

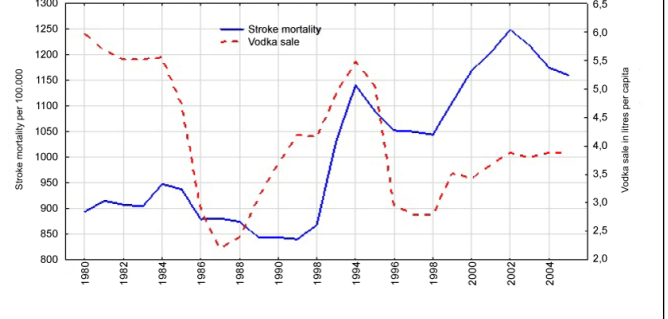

Figure 7: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for men age group of 60-74 years.

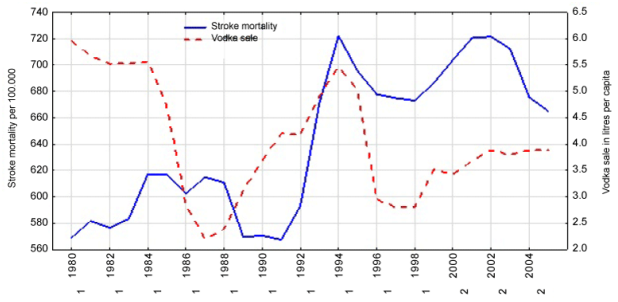

Figure 8: Trends in stroke mortality rate and vodka sales per capita in Russia between 1980 and 2005 for men age group of 60-74 years.

The analysis suggests that of the three beverages vodka alone was associated with stroke mortality in Russia. The consumption of beer and wine were not associated with stroke mortality rate. The estimated effects of vodka sales on the stroke mortality rate are clearly statistically significant for both sexes: a 1 litre increase in vodka sales would result in a 3.1% increase in the male stroke mortality rate and in 1.7% increase in female stroke mortality rate (Table 2). The estimates of the age specific models for men were positive (except for the 75+ age group) and ranging from 3.8% (60-74 age groups) to 9.8% (30-44 age groups). The estimates for women were positive for the 30-44 age groups (7.4%) and 45-59 age groups (5.3%).

Discussion

According to the results of time-series analysis there was a positive and statistically significant effect of per capita vodka sales on stroke mortality in Russia. It is important to point out that the size of the bivariate association between the level of vodka sale and stroke mortality rate for men is substantially greater than for women. Beverage preference might be partially responsible for the gender difference in stroke mortality rate as vodka continues to be the drink of choice for the majority of men in Russia, while women consume vodka less frequently than men [24].

Parameter	Vodka sales			Wine sales			Beer sales		
	Model	Estim.	SE	Model	Estim.	SE	Model	Estim.	SE
Mortality males	0.1.0	0.031**	0.011	0.1.0	0.007	0.012	0.1	0.016	0.052
Mortality females	0.1.0	0.017*	0.01	0.1.0	0.006	0.011	0.1.0	0.045	0.043

Table 1: Estimated beverage-specific effects of alcohol sales on stroke mortality rates. SE, standard error, *p<0.05, **p<0.01. 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.

	Males				Females			
Age	**Model**	**Estimates**	**SE**	**p**	**Model**	**Estimates**	**SE**	**p**
15-29	0.1.1	0.051	0.025	0.050	0.1.1	0.035	0.032	0.288
30-44	0.1.1	0.098	0.019	0.000	0.1.1	0.074	0.015	0.000
45-59	0.1.0	0.071	0.017	0.000	0.1.0	0.053	0.015	0.002
60-74	0.1.0	0.038	0.013	0.007	0.1.0	0.018	0.011	0.137
75+	0.1.0	0.019	0.013	0.170	0.1.0	0.010	0.010	0.339
15-75+	0.1.0	0.033	0.012	0.010	0.1.0	0.017	0.010	0.050

Table 2: Estimated effects of vodka sales on stroke mortality rates. ARIMA analysis. 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.

The effects of drinking spirits may also be exacerbated by the way they are drunk as a heavy episodic drinking pattern is widespread [17]. Moreover, this pattern of consuming alcohol is much more frequent when drinking spirits than other types of beverage among both men and women in Russia [24]. According to a recent study 28% of men and 4% of women consumed at least 200 g (86+ g of pure alcohol) on one occasion at least once every 2-3 weeks [24]. These findings provide indirect support for the binge drinking hypothesis, suggested that episodic heavy drinking of spirits is an important determinant of stroke mortality crisis in Russia.

We also found that the relationship between vodka sales and stroke mortality rate was stronger for working-age males. In principle, it's not surprisingly, given that the previous studies identified an unhealthy lifestyle among middle-age working class Russian males with the high level of alcohol consumption [25]. Moreover, it's a harmful pattern of drinking featuring big doses of vodka in a short period of time with a small snack. An analysis of frequency of drinking by male age groups indicates that the frequency climbs steadily to a peak between ages 30-39, before decreasing slightly in the 40-44 and 45-49 year-old and from age 50 declines significantly [25].

The dramatic stroke mortality fluctuations in Russia during the last decades are unprecedented in an industrialized country. There is evidence that the stroke mortality trends in Russia influenced by the four major factors: the long-standing mortality crisis that began in the USSR in the 1960s, Gorbachev's anti-alcohol campaign 1985-88, severe socioeconomic crisis imposed by rapid societal transformation in the early 1990s and financial crisis and worsening economic situation in 1998. A fairly close aggregate-level match between vodka sales and stroke mortality during the Gorbachev's anti-alcohol campaigns may be used as evidence for the hypothesis suggesting that alcohol is responsible for a substantial number of stroke deaths in Russia. This empirical evidence also indicates that a restrictive alcohol policy can be considered as an effective measure of stroke prevention.

It seems plausible that alcohol is a key variable in explaining of Russian stroke mortality crisis in the early-1990s. An increase of alcohol consumption in this period was to a great extent due to increase of alcohol availability following the repeal of the state alcohol monopoly in January 1992 [17]. The country was practically flooded by a wave of homemade, counterfeit, and imported alcohol, mainly spirits [18]. The negative outcomes of an increase of alcohol consumption during this period included a sharp rise in alcohol-related and cardiovascular mortality [20,26]. It might be the case that mortality crisis in the mid-1990s was to a great extent due to changed alcohol consumption structure, when 80-90% of all alcohol in Russia was consumed in the form of spirits [17,27]. It should be noted that wine became less available, compared to vodka in Russia during anti-alcohol campaign with the destroying most of the vineyards across the country and then the break-up of the Soviet Union cutting off wine supplies from Moldova, Ukraine, Georgia and other former Soviet republics [17].

There are several potential factors behind the decrease in alcohol consumption and stroke mortality rate between 1994 and 1998. They include better regulation of the alcohol market that may have resulted in a relative increase in prices for vodka compared to those for food products [17]. Another possible factor in the decrease in alcohol consumption was impoverishment and decrease in the purchasing capacity of the population due to unpaid or delayed salaries [18].

Before concluding, several potential limitations of this study must be mentioned. In particular, 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 [18]. Further, there was also the risk of omitted variable bias in this work. It should be emphasized that vodka sales per capita before the start of anti-alcohol campaign exceeded the level recorded in the early 1990s, while stroke mortality rates in the early 1990s exceeded the level of early 1980s significantly. This means that some additional factors came into play in the yearly 1990s.

At a population level, high blood pressure and tobacco use are the most important modifiable risk factors for stroke [14]. According to the results of blood pressure measurement, the prevalence of hypertension among Russian men and women was 57% and 55% respectively [28]. However, the findings highlighting that heavy drinking is associated with increased blood pressure support an alcohol-related hypothesis and suggests that rather than playing major causal role, hypertension may represent a confounding factor [29]. The high prevalence of smoking among Russian men (about 60%) probably explains a fact of the high stroke mortality rate among young middle-aged men compared with the female mortality rate [30]. However, use of tobacco products was relatively stable during 1970s-1980s and has fallen substantially in Russia over the 1990s, suggesting that stroke mortality crisis is not a result of a long-term response to smoking trends [31].

Some experts have underlined the importance of to the effect of the psychosocial distress of economic and political reforms as the main reason for the cardiovascular mortality crisis in Russia in the early 1990s [32]. In this period Russia faced a deep socioeconomic crisis accompanied by unemployment grows, hyperinflation, dramatic decline in the well-being of the majority of the population [33]. The turmoil associated with socioeconomic and political transition affected Russian peoples and lead to the relatively high prevalence of depression, anxiety and sleeping disorders that were strongly associated with low socioeconomic status, poor nutrition and adverse health behavior such as binge drinking and smoking [34]. It seems plausible that the psychosocial distress was the main cause of increased demand for alcohol at this time. This demand was met by factors that increased supply following the repeal of state alcohol monopoly in 1992 [17].

Finally, it is likely that increase in stroke mortality in Russia in the mid-1990s is a consequence of deterioration in the quality of health care system, following the collapse of Soviet Union in late 1991. As command economy collapsed, the public health system faced a financial crisis. Left without proper funding, health care system was unable to maintain needed level of medical care [32]. However, the importance of this confounding factor is clearly modest compared to alcohol, thus limiting their potential influence.

In conclusion, the present study suggests that stroke mortality tend to be more responsive to changes in spirits consumption per capita than to the wine or beer consumption. Assuming that drinking vodka is usually associated with intoxication episodes, these findings provide indirect evidence that that substantial proportion of stroke deaths in Russia are due to acute effect of binge drinking. The findings from the present study have important implications as regards alcohol policy in Russia suggesting that any attempts to reduce overall consumption should also be linked with efforts through differential taxation to shift beverage preference away from spirits.

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