0145-6008/05/29010-1884$03.00/0
Alcoholism: Clinical and Experimental Research

Vol. 29, No. 10
October 2005

The Composition of Surrogate Alcohols Consumed in Russia

Martin McKee, Sándor Sűzcs, Attila Sárváry, Roza Ádany, Nikolay Kiryanov, Ludmila Saburova, Susannah Tomkins, Evgeny Andreev, and David A. Leon

Background: In the course of a case-control study examining determinants of premature death among working age men, it became clear that a significant percentage of the population (7.3%) were drinking a variety of surrogate alcohol products (products not legally sold for consumption). In this population, where there is a high death rate from alcohol-related causes, including acute alcohol poisoning, it was important to know what these products contained.

Methods: The identity of products being consumed was identified from the survey of controls. Representative samples were obtained and subjected to analysis using gas chromatography and mass spectrometry to determine their composition.

Results: Three broad groups of product were identified: samogon (home-produced spirits); medicinal compounds; and other spirits (mainly sold as aftershaves). Commercially produced vodkas were used for comparison. Samogon contained lower quantities of ethanol than vodka [mean, 39 vs. 44 volumetric percentage (v/v%), respectively] but in addition contained certain toxic long-chain alcohols. Medicinal compounds contained only ethanol, at a higher concentration that vodka (mean, 66 v/v%), while the other spirits, which were also essentially pure ethanol, contained a mean of 94 v/v%.

Conclusions: A significant number of Russian men are drinking products that have either very high concentrations of ethanol or contaminants known to be toxic. These products are untaxed and thus much less expensive than vodka. There is an urgent need for policy responses that target their production and consumption.

Key Words: Russia, Surrogate Alcohol, Alcohol Poisoning.

THE IZHEVSK FAMILY Study is a unique case-control study of deaths from all causes among male residents aged 25-54 years of the city of Izhevsk registered over a 20-month period (2003–2005). Izhevsk is the capital of the Udmurt Republic, a region of the Russian Federation ≈1,000 km east of Moscow. Cases are individuals who have died, and information about them, including their drinking behavior, is obtained from interviews with surviving proxy informants (mostly relatives) who live in the same household. Interviews are also undertaken with controls; controls are selected at random from computerized voter lists and frequency matched to cases by age group. In addition, interviews are undertaken with proxy informants living in the same household who provide information on the controls. When complete, the study will collect data on >1700 cases and the same number of controls.

During the course of the study, it became apparent that a high proportion of subjects consumed surrogate alcohols, a group of products containing ethanol but ostensibly not intended for drinking. On the basis of the control proxy responses from 865 interviews, we estimate that among men aged 25–54 years living in households with others in Izhevsk 7.3% have drunk surrogate alcohols in the past year, with 2.1% drinking them daily and a further 2.6% drinking them weekly or more often.

Once the scale of this problem became apparent, we started to collect at interview information on the precise substances consumed. The surrogate alcohols being drunk fall into two broad categories: alcohol containing medicines and other spirits (including fluids for lighting fires and aftershaves). In addition to the surrogate alcohols, there was evidence of widespread consumption of homemade spirits (samogon), although this appears to be somewhat interchangeable with commercial spirits. Of 112 controls reporting consumption of surrogates, 43 (38%) reported drinking only aftershaves, and 19 (17%) reported drinking alcohol containing medicines only; 50 (45%) drank a combination of products [of whom 38 (34%) drank aftershaves and medicines but not technical spirits]. In addition, a few

From London School of Hygiene and Tropical Medicine (MM, ST, DAL), London, United Kingdom; School of Public Health (SS, AS, RA), Debrecen, Hungary; Izhevsk Medical Academy (NK), Izhevsk, Russia; Social Technologies Institute (LS), Izhevsk, Russia; Max Planck Institute (EA), Rostock, Germany.

Received for publication June 12, 2005; accepted July 27, 2005.

Reprint requests: Martin McKee, European Centre on Health of Societies in Transition, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, United Kingdom; E-mail: martin.mckee@lshtm.ac.uk

DOI: 10.1097/01.alc.0000183012.93303.90

Table 1. Composition of Alcohol Products (v/v) With Container Sizes and Prices

Name of alcohol product	Ethanol (v/v%)	1-Propanol (v/v%)	Isobutanol (v/v%)	Isoamyl alcohol (v/v%)	Container size (ml)	Price (rubles)
Samogon						
Mozhga-1	39.96	0.007	0.067	0.107	n/a	n/a
Mozhga-2	33.82	0.008	0.049	0.109	n/a	n/a
Mozhga-3	38.35	0.009	0.129	0.134	n/a	n/a
Mozhga-4	35.22	0.013	0.088	0.148	n/a	n/a
Senteg	34.03	0.006	0.017	0.039	n/a	n/a
Babino	39.08	0.010	0.070	0.133	n/a	n/a
Yakshur	38.36	0.010	0.068	0.118	n/a	n/a
Sharkan-1	43.38	0.025	0.200	0.216	n/a	n/a
Sharkan-2	37.86	0.014	0.113	0.172	n/a	n/a
Sharkan-3	41.15	0.011	0.063	0.095	n/a	n/a
M-Purga	46.97	0.013	0.073	0.183	n/a	n/a
Mean ± SD	38.92 ± 3.95	0.01 ± 0.01	0.09 ± 0.05	0.13 ± 0.05	n/a	n/a
Other spirits						
Liquid for kindling fire	91.80	n.d.*	n.d.	n.d.	n/a	n/a
Mozhevelovka	97.29	n.d.	n.d.	n.d.	240	15
Yason	95.27	n.d.	n.d.	n.d.	240	15
Kompozitsiya	94.83	n.d.	n.d.	n.d.	240	15
Troyar	89.70	n.d.	n.d.	n.d.	240	15
Mean ± SD	93.78 ± 3.01					
Vodka						
Izhevsky oruzheinik	44.92	n.d.	n.d.	n.d.	250	33
Ot vsey dushi	40.48	n.d.	n.d.	n.d.	100	15
Zolotaya korona	41.64	n.d.	n.d.	n.d.	100	14
Rus Matushka	43.53	n.d.	n.d.	n.d.	100	15
Glazov	45.20	n.d.	n.d.	n.d.	100	13
Tost Gusara	48.28	n.d.	n.d.	n.d.	100	15
Kalashnikov	43.16	n.d.	n.d.	n.d.	100	14
Sarapul	43.93	n.d.	n.d.	n.d.	100	15
Kavalerist Devitsa	44.45	n.d.	n.d.	n.d.	100	15
Mean ± SD	43.95 ± 2.23					
Medicine						
Tinctura Absinthii	67.16	n.d.	n.d.	n.d.	25	4.9
Tinctura Innonoti	71.57	n.d.	n.d.	n.d.	40	5.5
Tinctura Leonuri	69.44	n.d.	n.d.	n.d.	25	4
Tinctura Zhensen	74.49	n.d.	n.d.	n.d.	50	14
Tinctura Crataegi	72.65	n.d.	n.d.	n.d.	25	4.2
Tinctura Valerianae	61.16	n.d.	n.d.	n.d.	25	4.8
Tinctura Echinacea	43.19	n.d.	n.d.	n.d.	50	29
Mean ± SD	65.67 ± 10.83					

n/a, not available; n.d., not detected.

individuals were unable to specify which surrogate that they drank, consumed multiple products, or drank products such as cleaning fluid.

Given the frequency with which these products are consumed, it is important to know what is in them. There are two reasons for concern. First, because these products are untaxed, they are much cheaper (volume for volume) than commercial vodka. If they contain high concentrations of ethanol, then the price differential becomes even greater when expressed in terms of pure alcohol, providing a powerful economic incentive to consume them. Second, it is possible that they contain other toxic substances, in particular aliphatic alcohols that are by-products of production. These are especially toxic to a number of organs, in particular the liver. In a study undertaken in Hungary, where there is widespread consumption of homemade spirits, we reported that many of these products contain significant quantities of these toxic alcohols (Szűcs et al., 2005).

In this report, we describe the findings of a series of analyses by means of gas chromatography and mass spectrometry (GC/MS) of alcoholic substances that are drunk in Russia.

MATERIALS AND METHODS

Sample Collection

Responses by controls in the Izhevsk Family Study, supplemented with narrative accounts of drinking patterns of cases (supplied by proxy informants) as well as local knowledge, were used to identify the common forms of alcoholic product consumed in Izhevsk. Products were then purchased from a variety of commercial outlets and, in the case of samogon, were obtained from informal sources. Samples of each product were decanted into sterile glass bottles, allocated codes by one of the investigators (MM) to enable blind testing, and taken to Hungary for analysis. The products purchased consisted of 11 types of samogon (from six locations), five other spirits [four are products sold as "odekolon" (literally eau de cologne) that are ostensibly sold as skin disinfectants/aftershaves; one is for lighting fires], seven medicines, and nine commercial vodkas.

Materials

Methanol, ethanol, 1-propanol, 1-butanol, 2-butanol, 2-methyl-1-propanol (isobutanol), and 3-methyl-1-butanol (isoamyl alcohol) were

Table 2. Composition of Alcohol Products

Name of alcohol production	ethanol [mmol/l]	1-propanol [mmol/l]	isobutanol [mmol/l]	Isoamyl alcohol [mmol/l]
		Samogon		
Mozhga-1	6.85	0.88	7.24	9.82
Mozhga-2	5.80	1.08	5.31	9.99
Mozhga-3	6.58	1.14	13.97	12.34
Mozhga-4	6.04	1.76	9.46	13.62
Senteg	5.84	0.86	1.79	3.60
Babino	6.70	1.39	7.51	12.18
Yakshur	6.58	1.32	7.30	10.83
Sharkan-1	7.44	3.33	21.59	19.89
Sharkan-2	6.49	1.85	12.23	15.84
Sharkan-3	7.06	1.52	6.79	8.71
M-Purga	8.05	1.74	7.89	16.85
average	6.67	1.53	9.19	12.15
Standard deviation	0.68	0.69	5.23	4.41
		Other spirits		
Liquid for kindling fire	15.74	n.d.	n.d.	n.d.
Mozhevelovka	16.68	n.d.	n.d.	n.d.
Yason	16.34	n.d.	n.d.	n.d.
Kompozitsiya	16.26	n.d.	n.d.	n.d.
Troyar	15.38	n.d.	n.d.	n.d.
average	16.08			
Standard deviation	0.52			
		Vodka		
Izhevsky oruzheinik	7.70	n.d.*	n.d.	n.d.
Ot vsey dushi	6.94	n.d.	n.d.	n.d.
Zolotaya korona	7.14	n.d.	n.d.	n.d.
Rus Matushka	7.46	n.d.	n.d.	n.d.
Glazov	7.75	n.d.	n.d.	n.d.
Tost Gusara	8.28	n.d.	n.d.	n.d.
Kalashnikov	7.40	n.d.	n.d.	n.d.
Sarapul	7.53	n.d.	n.d.	n.d.
Kavalerist Devitsa	7.62	n.d.	n.d.	n.d.
average	7.54			
Standard deviation	0.38			
		Medicine		
Tinctura Absinthii	11.52	n.d.	n.d.	n.d.
Tinctura Innonoti	12.27	n.d.	n.d.	n.d.
Tinctura Leonuri	11.91	n.d.	n.d.	n.d.
Tinctura Zhensen	12.77	n.d.	n.d.	n.d.
Tinctura Crataegi	12.46	n.d.	n.d.	n.d.
Tinctura Valerianae	10.49	n.d.	n.d.	n.d.
Tinctura Echinacea	7.41	n.d.	n.d.	n.d.
average	11.26			
Standard deviation	1.86			

purchased from Merck (Darmstadt, Germany) and used as standards for qualitative and quantitative analyses of spirits. Acetone-D6 was used as internal standard (ISTD; Sigma-Aldrich Chemical Company, Stenheim, Germany). All chemicals were of HPLC grade.

GC/MS of Spirits

The spirit samples were analyzed on a Hewlett-Packard (Palo Alto, CA) GC/MS system consisting of an HP 5890 gas chromatograph, HP 5973 mass selective detector (MSD), and an Agilent 7683 automatic liquid sampler (Agilent Technologies, Palo Alto, CA). Separations of methanol, ethanol, 2-butanol, 1-propanol, isobutanol, 1-butanol, isoamyl alcohol (target compounds), and ISTD were accomplished using an HP-FFAP (inner diameter, 30 m $\times$ 0.2 mm; film thickness, 0.33 μm) cross-linked capillary column (Hewlett-Packard) as described previously with minor modifications (Hewlett-Packard, 1994). Briefly, the GC/MS parameters were as follows: carrier gas, helium; constant pressure, 3.0 bar; injection, split; inlet temperature, 200°C; oven ramps, 60°C for 4.0 min and 110°C, 5°C/min; GC/MS interface temperature, 280°C; MSD ion source temperature, 230°C; MSD quadrupole temperature, 150°C; and ionization energy, 70 eV. Quantitative analysis of the target compounds was carried out after calibration of the GC/MS system. The calibration curves were obtained by injections of 1 μl of the standard mixtures containing individual target compounds at concentrations of 1.0, 0.8, 0.6, 0.4, 0.2, and 0.1 volumetric percentage (v/v %) and 0.4 v/v% ISTD. The ethanol concentration of spirits was determined by a separate calibration curve obtained after injections of 1 μl of the standard mixtures consisting of 60.0, 54.0, 48.0, 42.0, 36.0, and 30.0 v/v% ethanol and 30.0 v/v% ISTD. Aliquots of 1.0 ml of the spirit samples were mixed with 4.0 μl of ISTD, and 1 μl of this mixture was injected. System control, data acquisition, and analysis were performed with the HP G1701BA MSD Productivity ChemStation Software (Hewlett-Packard). The concentration of target compounds in v/v% was calculated by the data analysis software according to the calibration curves. To compare our data with measures used in toxicological studies, v/v% was converted to mmol/liter using the specific gravity and molecular weight of aliphatic alcohols tested.

RESULTS

The composition of the products is shown in Tables 1 (v/v) and 2 (Molarity). Table 1 also shows the size of container in which the products are sold and the prices. Samogons were sold in a variety of containers, frequently

milk bottles, and were obtained without payment (they are often bartered). For the purposes of the study, 100-ml miniatures of vodka were purchased, although they are more often sold as 500-ml bottles.

Commercial vodka contained, on average, 44% ethanol v/v, with no other alcohols detected. Homemade spirit (Samogon) contained, on average, 39% ethanol, but in addition, all samples contained detectable amounts of 1-propanol, isobutanol, and isoamyl alcohol (with the latter reflecting production from grain). The nonmedicinal surrogate spirits contained, on average, 94% ethanol but were otherwise extremely pure. Medicines contained, on average, 66% ethanol, but there was considerable variation, with some containing up to 74%. There was a trace amount of limonene in one sample (Mozhevelovka). Limonene is a plant-derived terpene that is frequently used in cosmetics. Other volatile compounds used frequently in the cosmetics industry (flavonoids and methylantranilate), as well as ethers, were also not detectable.

DISCUSSION

Few doubt that the consumption of surrogate and home-produced alcohol is an important problem in Russia. White (1996), in his account of the response to the 1985 antialcohol campaign, illustrated the multifaceted nature of this issue, ranging from MiG fighters crashing because the contents of their deicing tanks had been drunk to villages where police raids found that almost every house had a still, with a bewildering variety constructed from milk churns, washing machines, and samovars. In these villages, the extent of illegal production was so great that "even the chickens walked around drunk." However, despite the widespread recognition of this problem, there has been remarkably little research on the health effects of these products. To our knowledge, this is the first such study.

Generalization of this study, performed in a single Russian city, must be undertaken with caution. Izhevsk is an average Russian city in terms of economic performance and mortality, except that it has an especially high suicide rate. Russia is, however, a vast country containing much diversity. Accounts by journalists in particular describe a wide variety of alcohol-containing products that are being consumed in Russia, such as antifreeze and other technical products. Access to such products will be easier for those working in certain occupations; thus, it is likely that there will be a degree of variation across Russia in the precise substances consumed. For example, one niche that we have become aware of is the widespread consumption of small quantities of surgical spirit by operating theater staff at the end of the working day. In addition, we encountered individual accounts of an extremely diverse range of other products that are drunk (such as domestic cleaning fluids) that we did not test. Our study is being undertaken in a city, and there is much anecdotal evidence to suggest that consumption of samogon will be much higher, and other surrogates correspondingly lower, in rural areas. Because samogon is produced from whatever source of sugar is most easily available, its precise composition will vary. Thus, in our samples, there were high levels of isoamyl alcohol, reflecting the use of grain as a precursor, whereas in the aftermath of the 1985 antialcohol campaign, granulated sugar virtually disappeared because it was used for alcohol production in urban areas. Samogon produced from it would contain a different spectrum of alcohols. In this respect, it is notable that we did not detect any methanol. Methanol is commonly produced by the action of pectin esterase on pectin found in fruit (especially berries), explaining its presence in home-produced alcohol in our earlier Hungarian study. It would not be expected to be found in significant quantities in grain-based spirits.

This study has identified a variety of products, each with differing compositions. Samogon is, in terms of ethanol concentration, roughly equivalent to vodka. However, it also contains aliphatic alcohol congeners at levels that have been shown in animal studies to cause hepatic damage. For example, Strubelt et al. (1999) compared the levels of glutamate pyruvate transaminase and glutamate dehydrogenase enzymes released from isolated rat livers perfused with solutions containing 23 different aliphatic alcohols. In comparison with ethanol, leakage of cytosolic glutamate pyruvate transaminase into the perfusate was found to be 2.0, 4.0, 3.6, 3.5, and 5.4 times higher when induced by 1-propanol, 1-butanol, 2-butanol, isobutanol, and isoamyl alcohol, respectively. The release of mitochondrial glutamate dehydrogenase, which indicates a more serious degree of hepatotoxicity, was 2.1, 2.8, 1.9, 2.0, and 2.7 times greater after exposure to 1-propanol, 1-butanol, 2-butanol, isobutanol, and isoamyl alcohol, respectively.

We are unaware of any studies that have examined the effects of long-term low-level exposure to alcoholic beverages containing aliphatic alcohols in high concentrations. However, the UK Food Additives and Contaminants Committee (UK MAFF, 1978) and the Council of Europe (1981) recommend that residues of isobutanol in beverages and food should not exceed 2.5 mg/100 g. With a mean of 38.7 mg/100 ml, all of the samogon samples exceeded this limit by a large margin.

The situation with regard to other spirits and medicines is rather different. These are pure sources of ethanol but contain high concentrations of it. It is a matter of common knowledge that these are often drunk, and both are very easily accessible through numerous sales outlets. They are sold in 240-ml plastic bottles bearing colorful labels, in contrast with similar products sold in the West that are typically packaged in 30- or 50-ml containers. Unlike their western equivalents, the aftershaves do not have a discernibly pleasant scent, and despite bearing, in small writing, the inscription "for external use only," it is difficult to avoid the conclusion that they are primarily produced for drinking. Although further research on the marketing and distribution of these products is needed, those purchased in

Izhevsk had been produced in St. Petersburg and Vladikavkaz (a city in the North Caucasus), and the products were well known to colleagues from other parts of Russia, suggesting that a relatively small number of manufacturers may be involved.

The dangers associated with these products are twofold. First, the combination of low cost (with 240 ml costing the same as 100 ml of vodka) and the high ethanol concentration means that the relative price difference for a given amount of pure alcohol is about sixfold. This creates a strong incentive for heavy drinkers and those dependent on alcohol who have limited financial resources to consume surrogates. Second, the high concentration of ethanol means that the products must be diluted to make them drinkable. However, this requires a degree of dexterity that is unlikely to be possessed by those already in an advanced state of intoxication. It is also possible that some of the pharmacological substances present in the medicines may also be toxic, but we have not been able to explore this possibility.

This study provides grounds for concern about what is being drunk by an appreciable number of Russian citizens. The ease of production of homemade spirits is such that effective action to reduce their consumption will always be difficult, although, as we have argued elsewhere, not impossible. These findings do, however, suggest an easier course of action. They have identified a series of products containing very high concentrations of ethanol that are easily accessible at low cost and, contrary to their labels, appear to be produced primarily for consumption. The retailing of surrogate alcohols effectively circumvents alcohol taxation; therefore, restrictions on their sale, as well as introducing substances making them unpalatable to drink, are obvious policy targets. As part of the policy engagement that forms part of this project, preliminary results were shared with senior advisors in the presidential administration, leading to the explicit recognition of the problem of surrogate alcohols in the 2005 State of the Nation address (Putin, 2005). The remaining challenge is to ensure that this recognition is translated into action.

REFERENCES

Council of Europe (1981) *Flavouring Substances and Natural Sources of Flavourings.* 3rd ed. Council of Europe: Strasbourg.

Putin, V (2005) State of the Nation Address. Federal Assembly of the Russian Federation. Moscow, 25th April, 2005.

Strubelt O, Deters M, Pentz R, Siegers, C-P, Younes M (1999) The toxic and metabolic effects of 23 aliphatic alcohols in the isolated perfused rat liver. Toxicol Sci 49:133–142.

Szűcs S, Sárváry A, McKee M, Ádány R (2005) Could the high level of cirrhosis in central and eastern Europe be due partly to the quality of alcohol consumed? An exploratory investigation, Addiction 100:536–542.

Hewlett-Packard (1994) Analytical columns and supplies 1994/1995. Capillary columns. Palo Alto, CA. p. 137.

UK MAFF (1978) *Food Additives and Contaminants. Committee Report on the Review of Solvents in Food*. United Kingdom Ministry of Agriculture, Fisheries and Food, London.

White S (1996) *Russia Goes Dry*. Cambridge University Press, Cambridge.