Russia-specific relative risks and their effects on the estimated alcohol-attributable burden of disease

Kevin D. Shield¹,²,³* and Jürgen Rehm¹,²,³,⁴,⁵,⁶

Abstract

Background: Alcohol consumption is a major risk factor for the burden of disease globally. This burden is estimated using Relative Risk (RR) functions for alcohol from meta-analyses that use data from all countries; however, for Russia and surrounding countries, country-specific risk data may need to be used. The objective of this paper is to compare the estimated burden of alcohol consumption calculated using Russia-specific alcohol RRs with the estimated burden of alcohol consumption calculated using alcohol RRs from meta-analyses.

Methods: Data for 2012 on drinking indicators were calculated based on the Global Information System on Alcohol and Health. Data for 2012 on mortality, Years of Life Lost, Years Lived with Disability, and Disability-Adjusted Life Years (DALYs) lost by cause were obtained by country from the World Health Organization. Alcohol Population-Attributable Fractions (PAFs) were calculated based on a risk modelling methodology from Russia. These PAFs were compared to PAFs calculated using methods applied for all other countries. The 95 % Uncertainty Intervals (UIs) for the alcohol PAFs were calculated using a Monte Carlo-like method.

Results: Using Russia-specific alcohol RR functions, in Russia in 2012 alcohol caused an estimated 231,900 deaths (95 % UI: 185,600 to 278,200) (70,800 deaths among women and 161,100 deaths among men) and 13,295,000 DALYs lost (95 % UI: 11,242,000 to 15,348,000) (3,670,000 DALYs lost among women and 9,625,000 DALYs lost among men) among people 0 to 64 years of age. This compares to an estimated 165,600 deaths (95 % UI: 97,200 to 228,100) (29,700 deaths among women and 135,900 deaths among men) and 10,623,000 DALYs lost (95 % UI: 7,265,000 to 13,754,000) (1,783,000 DALYs lost among women and 8,840,000 DALYs lost among men) among people 0 to 64 years of age caused by alcohol when non-Russia-specific alcohol RRs were used.

Conclusions: Results indicate that if the Russia-specific RRs are used when estimating the health burden attributable to alcohol consumption in Russia, then the total estimated burden will be more than if RRs from meta-analyses are used. Furthermore, additional research is needed to understand which aspects of the Russian style of drinking cause the most harm.

Keywords: Alcohol, Russia, Eastern Europe, Relative risk, Risk factor, Burden of disease, Population-attributable fraction

* Correspondence: Kevin.david.shield@gmail.com

1Social and Epidemiological Research department, Centre for Addiction and Mental Health (CAMH), CAMH 33 Russell Street, Room T528, Toronto, ON M5S 2S1, Canada

2WHO/PAHO Collaborating Centre in Addiction and Mental Health, CAMH, Toronto, Canada

Full list of author information is available at the end of the article

© 2015 Shield and Rehm. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.
Background
Alcohol has been shown to cause a considerable burden of disease [1, 2]. Historically, estimates of the alcohol-attributable burden have been based on a conceptual Population-Attributable Fraction (PAF) model that combines Relative Risks (RRs) taken from meta-analyses [3, 4] with alcohol exposure estimates [5, 6]. However, estimates based on this model may not accurately reflect the true proportion of disease caused by alcohol for countries with extreme and varying drinking patterns. For example, consumption patterns found in Russia include long bouts of continuous heavy drinking alternating with days of abstention [7–9], which negatively impact on ischemic heart disease (IHD), ischemic stroke and injuries [10–13].

Historically, alcohol has had a great impact on health in Russia [14, 15]. Furthermore, the overall health of the Russian population is considered poor by Western European standards, and Russians, and in particular Russian men, have a low life expectancy: the 2012 life expectancy was 63 years for men and 75 years for women [16]. Alcohol has been found to be the most important factor responsible for the low life expectancy for men [15, 17–20]. Indeed, when alcohol consumption dropped markedly as a result of the Gorbachev reforms, mortality rates dropped by 11.4 % [18, 21], exemplifying the negative impact of alcohol consumption on the health of the Russian population. Less dramatic, but still visible, were the more recent impacts of alcohol policy on mortality and life expectancy [22].

The production and consumption of alcohol is heavily ingrained in Russian society [7, 23]. Russia and other Eastern European countries consume more alcohol than any other countries in the world [2, 24]. Additionally, Russians consume alcohol in the comparatively most harmful manner, namely irregular very heavy drinking, mostly outside of meals and associated with intoxication (for associations between these patterns of drinking and health see [4, 8, 25, 26]). Russia and surrounding Eastern European countries received pattern of drinking scores (a measure of the way alcohol is consumed, rather than the amount of alcohol that is consumed) of 5, indicating the most detrimental way of drinking [2]. As people in these countries consume alcohol in a very detrimental manner, the application of global RRs may be problematic for these countries.

Accordingly, the 2010 Global Burden of Disease (GBD) study used Russia-specific RRs based on average consumption of alcohol data obtained from a large cohort study in Russia [14] in order to model the burden of disease attributable to alcohol in Russia and countries with similar drinking patterns [1]. To date, there has been no systematic comparison of the resulting estimated burden of disease attributable to alcohol consumption using Russia-specific RRs compared to using the RRs from meta-analyses that combined risk information from multiple countries; however, the most recent World Health Organization (WHO) alcohol burden of disease study for 2012 [2] provides the data to make this comparison. This paper: (i) presents a method used to calculate the alcohol PAFs for Russia based on Russia-specific RR functions, (ii) uses this method to estimate and describe the burden of disease attributable to alcohol in Russia, and (iii) compares this estimated burden of disease to the estimated burden calculated using RRs that combined data from all studies.

Methods
The estimates for the burden of disease attributable to alcohol consumption are limited by inaccuracies in the cause of death [27–29], and this error increases for the elderly as pathologies may become more complicated [30, 31]. Accordingly, this study was limited to Russians 0 to 64 years of age.

Estimating the alcohol population-attributable fractions
A PAF is the proportion of mortality or morbidity that would not have occurred if the exposure of every person in the population to a risk factor were at the theoretical minimum risk exposure level [1, 32, 33]. Even though protective effects of alcohol can be observed for ischemic diseases and diabetes for people who consume little alcohol and do not engage in Heavy Episodic Drinking (HED) [10, 34, 35], the PAFs for alcohol use the theoretical minimum risk exposure of lifetime abstention and are calculated for most chronic diseases (except IHD and injuries) (see appendix for methodology) using Formula 1.

(Formula 1)

\[
\text{PAF} = \frac{P_{abs} + P_{former}RR_{former} + \int_{>0}^{150} P_{current}(x)RR_{current}(x)dx - 1}{P_{abs} + P_{former}RR_{former} + \int_{>0}^{150} P_{current}(x)RR_{current}(x)dx}
\]

where \(P_{abs}\) is the prevalence of lifetime abstainers, \(P_{former}\) is the prevalence of former drinkers, \(RR_{former}\) is the RR for former drinkers, \(P_{current}\) is the prevalence of current drinkers who consume on average \(x\) grams of alcohol, and \(RR_{current}\) is the RR given an average daily consumption of \(x\) grams of alcohol. The full methods for the calculation of the alcohol PAFs are outlined in Additional file 1 (HED is used in the estimation of the PAFs for injuries and IHD when using the 2010 GBD and 2012 WHO alcohol burden of disease study methodologies).

Mortality, morbidity and population data
Data for 2012 on mortality (deaths and Years of Life Lost (YLL)), morbidity (Years Lived with Disability (YLD)), and Disability-Adjusted Life Years (DALYs) lost (a combination of YLL and YLD) were obtained from
the WHO [2]. Population data by age and sex were obtained from the United Nations population division [36].

**Indicators of alcohol consumption**

Data for the drinking status indicators for 2012, namely lifetime abstainers (those who have not consumed at least one standard drink of alcohol within their lifetime), former drinkers (those who have consumed at least one standard drink of alcohol, but have not done so in the past year), and current drinkers (those who have consumed at least one standard drink of alcohol in the past year), the prevalence of HED, the relative amount of alcohol consumed among drinkers differentiated by sex and age groups (15 to 34, 35 to 64 and 65 years of age and older) were obtained from the Global Information System on Alcohol and Health, which inputs country-specific data (for Russia: [37]) into a regression equation with the following variables: alcohol consumption (from survey data and *per capita* data), year, Gross Domestic Product (adjusted for purchase power parity), population age structure and the prevalence of people who identify themselves as Muslims (see [2] for more information). This regression method adjusted for inconsistencies between country-specific data for 2012 and data from surveys of the same nature conducted in similar countries, thereby bringing data on the prevalence of HED and the prevalence of different drinking statuses in line with those of other similar countries. This is especially important for Russia, as the data outlined in [37] have been criticized for being substantial underestimates of the prevalence of HED [38, 39].

These survey-based data were triangulated with data on recorded and unrecorded alcohol *per capita* consumption (estimated based on data obtained from the government of Russia [40] and Nemtsov [21]). Adult *per capita* consumption of alcohol is considered the best measure of alcohol consumption as surveys often underestimate alcohol consumption [41, 42]. This is especially important for Russia, as the data outlined in [37] have also been criticized for being substantial underestimates of the volume of alcohol consumed [38, 39]. The distribution of alcohol consumption among current drinkers by age and sex for Russia in 2012 was estimated using methodology developed by Rehm and colleagues and Kehoe and colleagues [6, 43]. (See Additional file 1 for more details).

**Risk relations**

For this study we modelled the burden caused by alcohol consumption using RRs specific to Russia (which were based on average consumption) and RRs based on meta-analyses. The RR functions used for Russia were obtained from the study by Zaridze and colleagues [14] for tuberculosis, acute and chronic pancreatitis, pneumonia, stroke (ischemic and hemorrhagic), IHD, liver cirrhosis, suicide, homicide and assaults, injuries of undetermined intent, and other injuries. The RRs for Russia were based on the following weekly alcohol consumption categories (the equivalent daily alcohol consumption figures in pure alcohol are given in parentheses): 1) greater than one half but less than one bottle (>12.68 and < 25.36 grams (g) of pure alcohol per day (the lower bound was not used in our calculations)), 2) one to less than three bottles (equivalent to ≥25.36 grams to < 76.08 grams of pure alcohol per day), and 3) three or more bottles (≥76.08 grams of pure alcohol per day). The reference category for these RRs was current drinkers who consume less than one half of a bottle of vodka on a weekly basis; to adjust for this we applied the RR for people who consume greater than one half but less than one bottle of vodka a week to people who consume less than one half of a bottle of vodka per week. These Russia-specific categorical RRs were then transformed into a piecewise function and were then used in Formula 1 as $RR_{current}$ to estimate the alcohol PAFs. Data on the RRs for former drinkers were obtained from the meta-analyses used for other countries and data on the RRs for other diseases were obtained from other sources (see Additional file 2). See Additional file 3 for a comparison of the meta-analysis RRs with the Russia-specific RRs.

The study by Zaridze and colleagues calculated data on 48,557 adult deaths for people 15 to 74 years of age, and obtained details of alcohol consumption from proxy information provided by family members. The RRs controlled for age, smoking (“did smoke” or “did not smoke”) and city of residence [14].

**Estimating the 95 % uncertainty intervals for the PAFs**

The 95 % Uncertainty Intervals (UIs) were estimated using a Monte Carlo-type approach [44]. To estimate the 95 % UIs for each alcohol PAF, we used a set of 2,000 generated lowest level parameters; these sets of parameters were then used to calculate 2,000 alcohol PAFs. The calculated variances of the resulting 2,000 alcohol PAFs were used to estimate the 95 % UIs.

All statistical analyses and modelling were performed using R version 3.1.0 [45].

**Results**

In Russia in 2012, the adult *per capita* consumption of alcohol was 14.8 litres of pure alcohol (23.4 litres of pure alcohol per adult male and 7.6 litres of pure alcohol per adult female), with recorded adult *per capita* consumption of alcohol being 11.2 litres of pure alcohol and unrecorded adult *per capita* consumption of pure alcohol being 3.6 litres of alcohol. Table 1 outlines alcohol consumption in Russia for 2012. In that year, more men than women were current drinkers and engaged in HED. Furthermore, more men than women were heavy consumers of alcohol.
(a daily consumption of greater than 76.08 grams of pure alcohol per day).

In 2012, for people 0 to 64 years of age, using Russia-specific alcohol RRs, alcohol caused an estimated 231,900 (95 % UI: 185,600 to 278,200) deaths in Russia (70,800 deaths among women and 161,100 deaths among men), and 13,295,000 DALYs were lost (95 % UI: 11,242,000 to 15,348,000) (3,670,000 DALYs lost among women and 9,625,000 DALYs lost among men) due to alcohol consumption. Adjusting these figures for population size results in 187 deaths per 100,000 people (118 and 251 deaths per 100,000 women and men respectively) and 10,694 DALYs lost per 100,000 people (6,091 and 15,023 DALYs lost among women and men respectively).

This burden represents 29.4 % of all deaths for this age group (31.2 % and 28.7 % of all deaths for women and men respectively in this age group), and 27.5 % of all DALYs lost (21.9 % of all DALYs lost for women and 30.5 % of all DALYs lost for men). See Tables 2 and 3 for the burden of alcohol consumption by cause for deaths and DALYs lost respectively based on Russia-specific alcohol RRs.

Furthermore, in Russia in 2012, for people 0 to 64 years of age, alcohol-attributable communicable, maternal, neonatal and nutritional disorders contributed to 7.0 % of all alcohol-attributable deaths and 6.0 % of all alcohol-attributable DALYs lost. Alcohol-attributable non-communicable diseases contributed to 58.9 % of all alcohol-attributable deaths and 60.4 % of all alcohol-attributable DALYs lost, and alcohol-attributable injuries contributed to 34.1 % of all alcohol-attributable deaths and 33.6 % of all alcohol-attributable DALYs lost. Self-harm and personal violence as well as mental and behavioural disorders (the burden of this category stemmed mainly from alcohol use disorders) were impacted the most by alcohol; 61.0 % of all deaths and 60.4 % of all DALYs lost caused by self-harm and personal violence and 70.5 % of all deaths and 42.8 % of all DALYs lost

Table 1 Alcohol consumption characteristics of the Russian population in 2012

| Gender | Alcohol consumption | Age         |
|--------|---------------------|-------------|
|        |                     | 15 to 34 years of age | 35 to 64 years of age | 65 years of age and older | Total (15 years of age and older) |
| Men    | Lifetime abstainers | 6.6 %       | 5.4 %       | 11.5 %       | 6.5 %       |
|        | Former drinkers     | 15.0 %      | 20.4 %      | 24.2 %      | 18.7 %      |
|        | Current drinkers    | 78.4 %      | 74.2 %      | 64.3 %      | 74.8 %      |
|        | <12.68 g/day*       | 23.2 %      | 22.8 %      | 22.8 %      | 22.9 %      |
|        | >12.68 g/day and < 25.36 g/day | 12.9 % | 12.5 % | 11.7 % | 12.5 % |
|        | ≥25.36 g/day to < 76.08 g/day | 27.5 % | 25.9 % | 21.5 % | 26.0 % |
|        | ≥76.08 g/day        | 14.9 %      | 13.1 %      | 8.3 %       | 13.3 %      |
|        | Heavy episodic drinkers** | 31.2 % | 29.5 % | 25.6 % | 29.8 % |
| Women  | Lifetime abstainers | 14.7 %      | 16.0 %      | 32.5 %      | 18.8 %      |
|        | Former drinkers     | 18.4 %      | 18.5 %      | 24.7 %      | 19.7 %      |
|        | Current drinkers    | 66.9 %      | 65.4 %      | 42.8 %      | 61.5 %      |
|        | <12.68 g/day        | 32.7 %      | 33.8 %      | 30.2 %      | 32.8 %      |
|        | >12.68 g/day and < 25.36 g/day | 12.6 % | 12.5 % | 7.5 % | 11.6 % |
|        | ≥25.36 g/day to < 76.08 g/day | 17.5 % | 16.0 % | 5.0 % | 14.4 % |
|        | ≥76.08 g/day        | 4.1 %       | 3.1 %       | 0.2 %       | 2.9 %       |
|        | Heavy episodic drinkers** | 11.1 % | 10.8 % | 7.1 % | 10.2 % |
| Total  | Lifetime abstainers | 10.6 %      | 11.1 %      | 25.9 %      | 13.2 %      |
|        | Former drinkers     | 16.7 %      | 19.4 %      | 24.5 %      | 19.2 %      |
|        | Current drinkers    | 72.7 %      | 69.5 %      | 49.6 %      | 67.6 %      |
|        | <12.68 g/day        | 27.9 %      | 28.7 %      | 27.8 %      | 28.3 %      |
|        | >12.68 g/day and < 25.36 g/day | 12.7 % | 12.5 % | 8.8 % | 12.0 % |
|        | ≥25.36 g/day to < 76.08 g/day | 22.5 % | 20.5 % | 10.2 % | 19.7 % |
|        | ≥76.08 g/day        | 9.5 %       | 7.7 %       | 2.8 %       | 7.6 %       |
|        | Heavy episodic drinkers** | 21.2 % | 19.4 % | 12.9 % | 19.1 % |

*Measured in grams of pure alcohol per day

**Monthly consumption of at least 60 grams of pure alcohol on at least one drinking occasion
caused by mental and behavioural disorders were attributable to alcohol consumption. Transport injuries, unintentional non-transport injuries, cirrhosis of the liver, cardiovascular and circulatory diseases, and lower respiratory infections were also greatly impacted by alcohol.

Compared to the 231,900 deaths based on country specific data (see above), an estimated 165,600 deaths (95 % UI: 97,200 to 228,100) (29,700 deaths among women and 135,900 deaths among men) were caused by alcohol based on using the alcohol RR functions from the meta-analyses used for other countries. These differences in the estimated numbers of deaths stem primarily from differences in the number of deaths estimated to be caused by injuries, ischemic strokes and IHD attributable to alcohol; there was little observed difference in the mortality burdens for pneumonia, hemorrhagic and other non-ischemic strokes, and cirrhosis of the liver attributable to alcohol; there was little observed difference in the mortality burdens for pneumonia, hemorrhagic and other non-ischemic strokes, and cirrhosis of the liver attributable to alcohol.

When using the alcohol RR functions from the meta-analyses, 10,623,000 DALYs (95 % UI: 7,265,000 to 13,754,000) were lost (1,783,000 DALYs lost among women and 8,840,000 DALYs lost among men) for people 0 to 64 years of age. This compares to an estimated 13,295,000 DALYs lost (95 % UI: 11,242,000 to 15,348,000) (3,670,000 DALYs lost among women and 9,625,000 DALYs lost among men) caused by alcohol consumption for people 0 to 64 years of age when using the Russia-specific alcohol RR functions. These differences in the numbers of DALYs lost stem primarily from differences in the number of DALYs lost caused by injuries, ischemic strokes and IHD attributable to alcohol consumption. See Additional file 5 for the burden of disease modelled for all ages.

Discussion

This study presents data that suggests that modelling the burden of alcohol consumption using RR functions based on meta-analyses from all countries may not be appropriate, especially for diseases and injuries where the risk is determined in part by drinking patterns and other factors such as drink-driving laws [12, 13]. Specifically, this study found that the alcohol-attributable burden of transport injuries was moderately higher when non-Russia-specific RRs were used and that alcohol-attributable ischemic disease

---

Table 2 Burden of deaths attributable to alcohol consumption in Russia for people 0 to 64 years of age in 2012 based on Russia-specific alcohol RR functions

| Cause*                                      | Women Deaths | % of all deaths AA | Men Deaths | % of all deaths AA | Total Deaths | % of all deaths AA |
|---------------------------------------------|--------------|--------------------|------------|--------------------|--------------|--------------------|
| Total                                       | 70,800       | 31.2 %             | 161,100    | 28.7 %             | 231,900      | 29.4 %             |
| Communicable, maternal, neonatal and nutritional disorders | 3,510        | 13.4 %             | 12,620     | 16.8 %             | 16,130       | 15.9 %             |
| HIV/AIDS and tuberculosis                   | 1,470        | 8.5 %              | 7,950      | 14.0 %             | 9,420        | 12.7 %             |
| Lower respiratory infections                | 1,960        | 42.8 %             | 4,550      | 35.3 %             | 6,510        | 37.2 %             |
| Neonatal conditions                         | 80           | 3.3 %              | 120        | 3.4 %              | 200          | 3.3 %              |
| Non-communicable diseases                   | 51,810       | 29.9 %             | 84,850     | 22.8 %             | 136,660      | 25.1 %             |
| Neoplasms                                   | 3,810        | 6.8 %              | 8,120      | 10.1 %             | 11,930       | 8.8 %              |
| Diabetes mellitus                           | -280         | -13.9 %            | -10        | -0.5 %             | -290         | -7.8 %             |
| Cirrhosis of the liver                      | 11,750       | 76.2 %             | 11,750     | 50.0 %             | 23,500       | 60.4 %             |
| Digestive diseases (except cirrhosis)       | 970          | 16.1 %             | 3,210      | 18.1 %             | 4,180        | 17.6 %             |
| Neurological disorders                      | 90           | 4.5 %              | 210        | 8.4 %              | 300          | 6.7 %              |
| Mental and behavioural disorders            | 3,580        | 67.1 %             | 14,850     | 71.3 %             | 18,430       | 70.4 %             |
| Cardiovascular and circulatory diseases     | 31,900       | 42.0 %             | 46,720     | 22.4 %             | 78,620       | 27.7 %             |
| Injuries                                    | 15,510       | 53.3 %             | 63,600     | 55.5 %             | 79,110       | 55.5 %             |
| Transport injuries                          | 2,120        | 41.0 %             | 8,230      | 47.7 %             | 10,350       | 46.1 %             |
| Unintentional non-transport injuries**      | 8,990        | 57.1 %             | 35,380     | 55.8 %             | 44,370       | 56.0 %             |
| Self-harm and personal violence***          | 4,400        | 62.7 %             | 20,000     | 60.7 %             | 24,400       | 61.0 %             |

*See Additional file 2 for ICD categories included in each cause
**Includes poisonings, falls, fires, drowning and other unintentional injuries
***Includes self-inflicted injuries and homicide
was markedly underestimated when non-Russia-specific RRs were used. This study also found that the alcohol-attributable burdens of acute and chronic pancreatitis, unintentional injuries (other than transport injuries), self-harm and personal violence were lower when using non-Russia-specific RRs, and that the burdens of hemorrhagic and other non-ischemic strokes, and cirrhosis of the liver were higher when using non-Russia-specific RRs (see Additional file 3 for a comparison of the Russian RRs with categorically transformed RRs from meta-analyses).

Differences in the estimated alcohol-attributable burden using the Russia-specific RR functions compared to when the general alcohol RR functions were used. This may be due to the different methodologies used in the two estimates (one based on average consumption and the other based on average and heavy drinking occasions).

When restricting our findings to people 15 to 64 years of age, this study found that 32.4 and 29.3 % of all deaths among women and men respectively were attributable to alcohol consumption. These findings are in contrast to those reported by Leon and colleagues [8] who found that 43 % of all premature deaths among men 25 to 54 years of age were attributable to hazardous drinking as defined by non-beverage alcohol consumption and/or problem drinking, and to Zaridze and colleagues’ findings that 52 % of all deaths among people 15 to 54 years of age were attributable to alcohol consumption [14]. One explanation for part of the observed differences is that in our study alcohol poisoning deaths (which constituted a large percentage of excess deaths in Leon and colleagues’ and Zaridze and colleagues’ studies) could not be modelled using a specific category RR, as data on alcohol poisonings were not available as a separate injury category. Furthermore, the percentage of all deaths attributable to alcohol consumption was greater for women than for men, even though men experienced more deaths

| Table 3 Burden of Disability-Adjusted Life Years lost attributable to alcohol consumption in Russia for people 0 to 64 years of age in 2012 based on Russia-specific alcohol RR functions |
|---------------------------------------------------------------|----------------|----------------|----------------|
| Cause*                                                      | Women | % of all DALYs | Men | % of all DALYs | Total | % of all DALYs |
| Total                                                      | 3,670,000 | 21.9 %         | 9,625,000 | 30.5 %         | 13,295,000 | 27.5 % |
| Communicable, maternal, neonatal and nutritional disorders | 183,200 | 8.5 %          | 620,100 | 14.3 %         | 803,300 | 12.4 % |
| HIV/AIDS and tuberculosis                                 | 87,600 | 9.3 %          | 434,600 | 15.0 %         | 522,200 | 13.6 % |
| Lower respiratory infections                               | 86,700 | 29.0 %         | 172,800 | 28.9 %         | 259,500 | 28.9 % |
| Neonatal conditions                                        | 8,900 | 3.1 %          | 12,600 | 3.2 %          | 21,500 | 3.2 % |
| Non-communicable diseases                                 | 2,541,000 | 19.8 %         | 5,487,700 | 26.4 %         | 8,028,700 | 23.9 % |
| Neoplasms                                                 | 145,400 | 6.8 %          | 291,800 | 10.0 %         | 437,200 | 8.7 % |
| Diabetes mellitus                                         | −45,700 | −13.7 %        | −1,500 | −0.5 %         | −47,200 | −7.8 % |
| Cirrhosis of the liver                                     | 494,900 | 76.1 %         | 510,000 | 49.8 %         | 1,004,900 | 60.0 % |
| Digestive diseases (except cirrhosis)                     | 43,600 | 15.1 %         | 152,900 | 19.0 %         | 196,500 | 17.9 % |
| Neurological disorders                                     | 16,600 | 3.2 %          | 32,400 | 8.3 %          | 49,000 | 5.4 % |
| Mental and behavioural disorders                          | 637,500 | 22.3 %         | 2,698,200 | 59.7 %         | 3,335,700 | 45.2 % |
| Cardiovascular and circulatory diseases                   | 1,248,800 | 41.1 %         | 1,803,700 | 22.1 %         | 3,052,500 | 27.2 % |
| Injuries                                                  | 946,000 | 53.5 %         | 3,517,100 | 54.4 %         | 4,463,100 | 54.2 % |
| Transport injuries                                        | 157,100 | 41.3 %         | 552,400 | 47.5 %         | 709,500 | 46.0 % |
| Unintentional non-transport injuries**                    | 555,700 | 55.4 %         | 1,890,700 | 54.6 %         | 2,446,400 | 54.8 % |
| Self-harm and personal violence***                        | 233,200 | 61.5 %         | 1,074,000 | 60.2 %         | 1,307,200 | 60.4 % |

*See Additional file 2 for ICD categories included in each cause
**Includes poisonings, falls, fires, drowning and other unintentional injuries
***Includes self-inflicted injuries and homicide
attributable to alcohol consumption. The factors that caused women to have such a high relative burden of alcohol consumption should be investigated in future research.

The current results underline the necessity to check on the applicability of global RR functions for individual countries. For Russia and some surrounding Eastern European countries, RR functions may underestimate true risk because of drinking patterns. Additionally, for other countries, prevalences of people with genotypes that influence the risk of alcohol consumption may also lead to incorrect burden estimates when global RR functions are applied [51].

**Limitations**

There are limitations to the Russia-specific RRs from Zaridze and colleagues’ study. First, these RRs are step functions, in contrast to continuous risk functions which are used for other countries. Second, the measurement of alcohol consumption for Zaridze and colleagues’ study

| Cause*                                             | Russia-specific alcohol RRs | Non-Russia-specific alcohol RRs |
|----------------------------------------------------|----------------------------|--------------------------------|
|                                                    | Women                      | Men                            | Total                      | Women                      | Men                            | Total                      |
|                                                     | Deaths | DALYs | Deaths | DALYs | Deaths | DALYs | Deaths | DALYs | Deaths | DALYs | Deaths | DALYs |
| Communicable, maternal, neonatal and nutritional disorders | 1,960 | 86,700 | 4,550 | 173,000 | 6,510 | 259,700 |
| Lower respiratory infection                         | 25,520 | 1,099,600 | 38,870 | 1,507,000 | 64,390 | 2,516,600 |
| Ischemic heart disease                              | 2,430 | 86,500 | 3,260 | 116,000 | 5,690 | 202,500 |
| Ischemic stroke                                     | 3,400 | 129,600 | 3,520 | 137,000 | 6,920 | 266,600 |
| Hemorrhagic and other non-ischemic strokes          | 11,750 | 494,900 | 11,750 | 510,000 | 23,500 | 1,004,900 |
| Cirrhosis of the liver                              | 970 | 43,600 | 3,210 | 153,000 | 4,180 | 196,600 |
| Acute and chronic pancreatitis                      | 2,120 | 157,100 | 8,230 | 552,000 | 10,350 | 709,100 |
| Transport injuries                                  | 8,990 | 555,700 | 35,380 | 1,891,000 | 44,370 | 2,446,700 |
| Unintentional injuries (other than transport injuries)** | 4,400 | 233,200 | 20,000 | 1,074,000 | 24,400 | 1,307,200 |
| Self-harm and personal violence***                 | 10,800 | 3,670,000 | 161,100 | 9,625,000 | 231,900 | 13,295,000 |
| Total (per 100,000 people)                          | 118 | 6,091 | 251 | 15,023 | 187 | 10,694 |
| Communicable, maternal, neonatal and nutritional disorders | 410 | 18,500 | 1,940 | 74,200 | 2,350 | 92,700 |
| Non-communicable diseases                          | 130 | −21,900 | −5,570 | −227,600 | −5,440 | −249,500 |
| Ischemic heart disease                              | −300 | −10,300 | 1,500 | 52,900 | 1,200 | 42,600 |
| Ischemic stroke                                     | 3,880 | 146,300 | 5,900 | 230,600 | 9,780 | 376,900 |
| Hemorrhagic and other non-ischemic strokes          | 10,070 | 425,800 | 18,680 | 811,900 | 28,750 | 1,237,700 |
| Cirrhosis of the liver                              | 360 | 16,200 | 2,920 | 139,600 | 3,280 | 155,800 |
| Acute and chronic pancreatitis                      | 1,440 | 96,900 | 15,110 | 961,200 | 16,550 | 1,058,100 |
| Transport injuries                                  | 2,960 | 161,500 | 40,930 | 2,085,700 | 43,890 | 2,247,200 |
| Unintentional injuries (other than transport injuries)** | 1,420 | 76,800 | 22,160 | 1,199,100 | 23,580 | 1,275,900 |
| Self-harm and personal violence***                 | 29,700 | 1,783,000 | 135,900 | 8,840,000 | 165,600 | 10,623,000 |
| Total (per 100,000 people)                          | 49 | 2,959 | 212 | 13,798 | 133 | 8,545 |

*See Additional file 2 for ICD categories included in each cause
**Includes poisonings, falls, fires, drowning and other unintentional injuries
***Includes self-inflicted injuries and homicide
was by proxy (in 2001–2005) and was measured years after the mortality of the individuals (1990–2001). Third, the data for Russia-specific RRs are based on one large study and, as a consequence, some RRs were not significant [14] and, thus, were not used. Fourth, the Russia-specific RRs are solely for mortality and not morbidity, whereas meta-analyses have recently started to assess morbidity separately [3]. Fifth, the Russia-specific alcohol RRs use only average alcohol consumption and use the reference category of ever-drinkers with weekly consumption of less than one half bottle of vodka. The use of this reference category may lead to a minor underestimation of the risk of mortality from alcohol-related diseases as we treated this category as lifetime abstainers within the alcohol PAF. The use of the RR for consumption of between less than one bottle but greater than one half of a bottle of vodka a week to all current drinkers that consumed less than one bottle of vodka a week should not cause an overestimation of the alcohol-attributable burden of IHD, as the protective effects of alcohol on IHD occur at moderate alcohol consumption [10]. Finally, Russia-specific RRs were measured for people who died from 1990 to 2001. This timeframe includes the Russian mortality crisis (from 1990 to 1994) where Russia experienced a 40 % increase in the crude mortality rate and alcohol poisoning also increased [52, 53]. Therefore, the RRs may not reflect the current situation in Russia as some 100 % alcohol-attributable mortalities, such as alcohol poisonings, have since decreased [53].

The estimates for the burden of disease attributable to alcohol consumption have general limitations. First, mortality and morbidity data contain inaccuracies, even when obtained from the most reliable sources [27–29], with the measurement of the burden of morbidity being commonly subject to more error than the burden of mortality [54]. For Russia and similar countries, the estimates of YLD are very provisional and uncertain in nature, making estimates of the alcohol-attributable DALYs lost for Russia presented in this study less accurate than the estimates presented for alcohol-attributable mortality [55, 56]. Specifically, the databases which result from the collection of morbidity data from polyclinics and hospitals (the sources of most morbidity data) are problematic in terms of their diagnostic accuracy [55]. Additionally, even data collected in Russia in a systematic manner and on a large scale (such as cancer registries) have problems with accuracy and detail [55]. Second, the estimates presented are based on RR functions that were adjusted for age and smoking status, and in some cases for a variety of other risk factors, which may introduce bias [33, 57, 58]. Third, the estimates for alcohol consumption are cross-sectional, and past alcohol consumption would be a better risk measure for chronic diseases such as cancer and liver cirrhosis which develop over time [3]; however, for diseases such as liver cirrhosis, changes in alcohol consumption have been observed to have an immediate impact on mortality [18, 59].

Conclusions
Russia-specific RRs produce different estimates of the alcohol-attributable burden of disease when compared to estimates obtained using the RRs from meta-analyses of global data. Further investigation into the reasons for these differences should be undertaken, as country-specific RRs may be needed in cases where countries have very detrimental drinking patterns.

Additional files

Additional file 1: Methods used to model alcohol Population-Attributable Fractions and methods used to model the distribution of alcohol consumption.

Additional file 2: Sources of Relative Risk functions and of Relative Risk function plots.

Additional file 3: Comparison of the RR functions from meta-analyses to those obtained from Zaridze et al., [14].

Additional file 4: YLL and YLD attributable to alcohol consumption in Russia in 2012 using Russia-specific alcohol RR functions and general population alcohol RR functions for people 0 to 64 years of age.

Additional file 5: Deaths, YLL, YLD and DALYs lost attributable to alcohol consumption using Russia-specific alcohol RR functions and general population alcohol RR functions for people of all ages.

Abbreviations
BAC: Blood alcohol content; DALYs: Disability-adjusted life years; GBD: Global burden of disease; HED: Heavy episodic drinking; IHD: Ischemic heart disease; PAFs: Population-attributable fractions; YLL: Years of life lost; RR: Relative risk; Uls: Uncertainty intervals; WHO: World health organization; YLD: Years lived with disability.

Competing interests
The authors declare that they have no competing interests.

Authors’ contributions
KS and JR conceptualized the overall article, acquired all data, and contributed to the methodology. KS performed all statistical analyses. KS and JR contributed to the writing of the manuscript and approved the final version. All authors read and approved the final manuscript.

Acknowledgements
This work was supported by the World Health Organization as provided to the World Health Organization-Pan American Health Organization Collaborating Centre for Addiction and Mental Health located at Toronto, Canada.

Author details
1Social and Epidemiological Research department, Centre for Addiction and Mental Health (CAMH), CAMH 33 Russell Street, Room T528, Toronto, ON M5S 2S1, Canada. 2WHO/PAHO Collaborating Centre in Addiction and Mental Health, CAMH, Toronto, Canada. 3Institute of Medical Science (IMS), University of Toronto, Toronto, Canada. 4Dalla Lana School of Public Health (DLSPH), University of Toronto, Toronto, Canada. 5Institute of Clinical Psychology and Psychotherapy, TU Dresden, Germany. 6Department of Psychiatry, University of Toronto, Toronto, Canada.

Received: 15 August 2014 Accepted: 5 May 2015
Published online: 10 May 2015
References

1. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 678 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study. Lancet. 2012;380(9863):2223–60.

2. World Health Organization. Global status report on alcohol and health. Geneva, Switzerland: World Health Organization; 2014.

3. Rehm J, Balliuñas D, Borges GQ, Graham K, Irving HM, Kehoe T, et al. The relation between different dimensions of alcohol consumption and burden of disease - an overview. Addiction. 2010;105(S3):817–43.

4. Rehm J, Room R, Monterio M, Gmel G, Graham K, Rehm N, et al. Alcohol Use. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization; 2004. p. 959–1109.

5. Rehm J, Kotsche P, Patra J. Comparative quantification of alcohol exposure as risk factor for global burden of disease. Int J Methods Psychiatr Res. 2007;16(2):76–95.

6. Rehm J, Kotsche P, Gmel G, Stinson F, Grant B, Gmel G. Statistical modeling of volume of alcohol exposure for epidemiological studies of population health: the example of the US. Popul Health Metr. 2010;8:3.

7. Nemtsov AV. A Contemporary History of Alcohol in Russia. Stockholm, Sweden: Södertörns högskola; 2011.

8. Leon DA, Saburova L, Tomkins S, Andreev E, Kiryanov N, McKee M, et al. Alcohol-related harm losses in Russia in the 1980s and 1990s. Alcohol Alcohol. 2013;48(2):222–9.

9. Zaridze D, Lewington S, Boroda A, Scelò G, Lazarev A, et al. Alcohol consumption and the risk of morbidity and mortality from different stroke types - a systematic review and meta-analysis. BMC Public Health. 2010;10(1):258.

10. Rosenthal KS, Greenland S, Lash TL. Modern Epidemiology. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008.

11. Sundell L, Salomaa V, Vartiainen E, Poikolainen K, Laatikainen T. Increased cardiovascular disease - a review. J Intern Med. 2010;268:257–65.

12. World Health Organization. Global status report on alcohol and health. Geneva, Switzerland: World Health Organization; 2014.

13. Zaridze D, Lewington S, Lazarev A, Scelò G, Karpov R, Lazarev A, et al. Alcohol consumption and mortality: the Italian risk factor and life expectancy pooling project. Ann Epidemiol. 2001;11:312–9.

14. James G, Patton RE, Heslin S. Accuracy of cause-of-death statements on death certificates. Publ Health Rep. 1955;70(1):39–51.

15. Nashelsky MB, Lawrence CH. Accuracy of cause of death determination without forensic autopsy examination. Am J Forensic Med Pathol. 2003;24(3):313–9.

16. Rehm J, Kotsche P, Boreham J, Boroda A, Scelò G, Karpov R, Lazarev A, et al. Alcohol consumption level in Russia: a viewpoint on monitoring health conditions in the Russian Federation (RLMS). Addiction. 2003;98:369–70.

17. Kehoe T, Gmel Jr G, Shield K, Rehm J. Determining the best population-level alcohol consumption model and its impact on estimates of alcohol-attributable harms. Popul Health Metr. 2012;10(1):16.

18. Rehm J, Kotsche P, Gmel G, Scelò G, Karpov R, Lazarev A, et al. Alcohol poisoning is a main determinant of recent mortality trends in Russia: evidence from a detailed analysis of mortality statistics and autopsies. Int J Epidemiol. 2009;38:143–53.

19. Leon DA, Saburova L, Tomkins S, Andreev E, Kiryanov N, McKee M, et al. Hazardous alcohol drinking and premature mortality in Russia: a population based case–control study. Lancet. 2007;369(9578):2001–9.

20. Nemtsov M, Rehm J. Alcohol consumption and mortality in Russia since 2000. Lancet. 2013;10(3):912–22.

21. Rehm J, Sempos C, Trevisan M. Average volume of alcohol consumption, patterns of drinking and risk of coronary heart disease - a review. J Cardiovasc Risk. 2003;10(1):15–20.

22. Trevisan MT, Schisterman E, Menniotti A, Farchi G, Conti S. Drinking pattern and mortality: the Italian risk factor and life expectancy pooling project. Ann Epidemiol. 2001;11:312–9.

23. Zaridze D, Boroda A, Scelò G, Lazarev A, et al. The contribution to the Comparative Risk Assessment for the 2010 Global Burden of Disease Study. Addiction. 2013;108(5):912–22.

24. Rehm J, Shield K, Rehm J. Alcohol consumption and mortality: the Italian risk factor and life expectancy pooling project. Ann Epidemiol. 2001;11:312–9.

25. James G, Patton RE, Heslin S. Accuracy of cause-of-death statements on death certificates. Publ Health Rep. 1955;70(1):39–51.

26. Rothenberg KJ, Greenland S, Lash TL. Modern Epidemiology. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008.

27. Rockhill B, Newman B. Use and misuse of population attributable fractions. Am J Public Health. 1998;88:815–9.

28. Patra J, Taylor B, Irving H, Roerecke M, Balliuñas D, Mohapatra S, et al. Alcohol consumption and the risk of morbidity and mortality from different stroke types - a systematic review and meta-analysis. BMC Public Health. 2010;10(1):258.

29. Balliuñas D, Taylor B, Irving H, Roerecke M, Patra J, Mohapatra S, et al. Alcohol as a risk factor for type 2 diabetes - a systematic review and meta-analysis. Diabetes care. 2009;32(11):2123–32.

30. Rothenberg KJ, Greenland S, Lash TL. Modern Epidemiology. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008.

31. Seron DJ, Lewington S, Boroda A, Scelò G, Lazarev A, et al. Alcohol consumption and the risk of morbidity and mortality from different stroke types - a systematic review and meta-analysis. BMC Public Health. 2010;10(1):258.

32. Nashelsky MB, Lawrence CH. Accuracy of cause of death determination without forensic autopsy examination. Am J Forensic Med Pathol. 2003;24(3):313–9.

33. Kehoe T, Gmel Jr G, Shield K, Rehm J. Determining the best population-level alcohol consumption model and its impact on estimates of alcohol-attributable harms. Popul Health Metr. 2012;10(1):16.

34. Gmel GI, Shield KD, Frick H, Kehoe T, Gmel G, Rehm J. Estimating uncertainty of alcohol-attributable fractions for infectious and chronic diseases. BMC Med Res Methodol. 2011;11:48.

35. Development Core Team R. R: A Language and Environment for Statistical Computing (version 3.1.0). In: Vienna, Austria: R Foundation for Statistical Computing, 2014.

36. Roerecke M, Rehm J. Chronic heavy drinking and ischaemic heart disease: a systematic review and meta-analysis. Open Heart. 2014;1:e000135.

37. Roerecke M, Rehm J. Cause-specific mortality risk in alcohol use disorder treatment patients: a systematic review and meta-analysis. Int J Epidemiol. 2014;43(3):906–19.

38. Holmes MV, Dale CE, Zuccolo L, Silverwood RJ, Guo Y, Ye Z, et al. Association between alcohol and cardiovascular disease: Mendelian randomisation analysis based on individual participant data. BMJ. 2014;349:g4164.
49. Roerecke M, Rehm J. Alcohol and ischaemic heart disease risk—finally moving beyond interpretation of observational epidemiology. Addiction. 2015; Epub ahead of print.

50. Knott CS, Coombs N, Stamatakis E, Biddulph JP. All cause mortality and the case for age specific alcohol consumption guidelines: pooled analyses of up to 10 population based cohorts. BMJ. 2015;350:h384.

51. Roerecke M, Shield KD, Higuchi S, Yoshimura A, Larsen E, Rehm MX, et al. Correcting estimates of alcohol-related oesophageal cancer burden in Japan: a systematic review and meta-analyses. Bull World Health Org. In press.

52. Bhattacharya J, Gathmann C, Miller GJ. The Gorbachev anti-alcohol campaign and Russia’s mortality crisis. Am Econ J Appl Econ. 2013;5(2):232–60.

53. Shkolnikov VM, Comià GA, Leon DA, Meslé F. Causes of the Russian mortality crisis: evidence and interpretations. World Dev. 1998;26(11):1995–2011.

54. Nolte E, McKee M, Gilmore A. Morbidity and mortality in the transition countries of Europe. In: United Nations, editor. The new demographic regime Population challenges and policy responses. New York, USA: United Nations; 2005. p. 153–76.

55. Jaakkola JJ, Chemiack M, Spengler JD, Ozkaynak H, Wojtyniak B, Egorov A, et al. Use of health information systems in the Russian federation in the assessment of environmental health effects. Environ Health Perspect. 2000;108(7):589.

56. National Center for Health Statistics. Vital and health statistics: Russian Federation and United States, selected years 1980–93. Vital Health Stat. 1995; 5(9).

57. Korn EL, Graubard BI. Analysis of Health Surveys. New York, NY: John Wiley & Sons Inc; 1999.

58. Flegal KM, Williamson DF, Graubard BI. Using adjusted relative risks to calculate attributable fractions. Am J Public Health. 2006;96(3):398.

59. Zatonski W, Sulikowska U, Mancauz M, Rehm J, Lowenfels AB, La Vecchia C. Liver cirrhosis mortality in Europe, with special attention to central and eastern Europe. Eur Addict Res. 2010;16:193–201.