Introduction

A consistent gap in measures of mortality has been observed for people of different races in the United States (US). The observed large variations by race in measures of mortality have been hypothesized to be attributable in part to differences in exposure to modifiable risk factors, such as alcohol consumption, tobacco smoking, and being overweight or obese [1]. In particular, alcohol consumption has been hypothesized to contribute substantially to this disparity, as volume and patterns of alcohol consumption have been shown to vary greatly by race [2].

Mortality and Potential Years of Life Lost Attributable to Alcohol Consumption by Race and Sex in the United States in 2005

Kevin D. Shield1,2*, Gerrit Gmel1, Tara Kehoe-Chan1,3, Deborah A. Dawson7,8, Bridget F. Grant7, Jürgen Rehm1,2,4,5,6

1 Centre for Addiction and Mental Health, Toronto, Ontario, Canada, 2 Institute of Medical Science, University of Toronto, Toronto, Ontario, Canada, 3 Department of Mathematics, University of Toronto, Toronto, Ontario, Canada, 4 Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada, 5 Institute for Clinical Psychology and Psychotherapy, Technische Universität Dresden, Dresden, Saxony, Germany, 6 Department of Psychiatry, University of Toronto, Toronto, Ontario, Canada, 7 Laboratory of Epidemiology and Biometry, National Institute on Alcohol Abuse and Alcoholism, National Institutes of Health, Bethesda, Maryland, United States of America, 8 Kelly Government Services, Bethesda, Maryland, United States of America

Abstract

Background: Alcohol has been linked to health disparities between races in the US; however, race-specific alcohol-attributable mortality has never been estimated. The objective of this article is to estimate premature mortality attributable to alcohol in the US in 2005, differentiated by race, age and sex for people 15 to 64 years of age.

Methods and Findings: Mortality attributable to alcohol was estimated based on alcohol-attributable fractions using indicators of exposure from the National Epidemiologic Survey on Alcohol and Related Conditions and risk relations from the Comparative Risk Assessment study. Consumption data were corrected for underreporting (the observed underreporting of alcohol consumption when using survey as compared to sales data) using adult per capita consumption from WHO databases. Mortality data by cause of death were obtained from the US Department of Health and Human Services. For people 15 to 64 years of age in the US in 2005, alcohol was responsible for 55,974 deaths (46,461 for men; 9,513 for women) representing 9.0% of all deaths, and 1,288,700 PYLL (1,087,280 for men; 201,420 for women) representing 10.7% of all PYLL. Per 100,000 people, this represents 29 deaths (29 for White; 40 for Black; 82 for Native Americans; 6 for Asian/Pacific Islander) and 670 PYLL (673 for White; 808 for Black; 1,808 for Native American; 158 for Asian/Pacific Islander). Sensitivity analyses showed a lower but still substantial burden without adjusting for underreporting.

Conclusions: The burden of mortality attributable to alcohol in the US is unequal among people of different races and between men and women. Racial differences in alcohol consumption and the resulting harms explain in part the observed disparities in the premature mortality burden between races, suggesting the need for interventions for specific subgroups of the population such as Native Americans.

Citation: Shield KD, Gmel G, Kehoe-Chan T, Dawson DA, Grant BF, et al. (2013) Mortality and Potential Years of Life Lost Attributable to Alcohol Consumption by Race and Sex in the United States in 2005. PLoS ONE 8(1): e51923. doi:10.1371/journal.pone.0051923

Editor: Aditya Bhushan Pant, Indian Institute of Toxicology Research, India

Received July 13, 2012; Accepted November 13, 2012; Published January 2, 2013

Copyright: © 2013 Shield et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: Financial support for this study was provided to Jürgen Rehm by the National Institute for Alcohol Abuse and Alcoholism (NIAAA) with contract # HHSN267200700041C to conduct the study titled “Alcohol- and Drug-attributable Burden of Disease and Injury in the US”. In addition, Jürgen Rehm received a salary and infrastructure support from the Ontario Ministry of Health and Long-Term Care. Kevin Shield had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: Kevin.shield@utoronto.ca

Alcohol use is a major risk factor for mortality, with more than 30 International Classification of Diseases (ICD)-10 three digit codes containing alcohol in their name, and more than 200 ICD-10 three-digit codes where alcohol is a component cause [3,4]. Currently, alcohol is the eighth leading cause of mortality globally, and in 2004 alcohol was responsible for 2.3 million deaths, representing 3.8% of all deaths [4]. For the US in 2005 alcohol consumption has been estimated to be responsible for 64,000 deaths (approximately 43,000 for men and 20,000 for women) for all ages [however, this estimate is based on out of date methodology] [5]. To lessen the burden of disease and injury attributable to alcohol, a global strategy to reduce the harmful use
of alcohol was agreed upon at the World Health Organization’s (WHO) 63rd World Health Assembly [6]. A key part of this strategy is to accurately monitor alcohol consumption and the resulting attributable harms, as reliable health data are the foundation of health policies, strategies, and evaluation. Despite the magnitude of mortality attributable to alcohol consumption, alcohol-attributable burden estimates have yet to be calculated by race for any country.

Previous estimates of the burden of mortality attributable to alcohol in the US were limited by being differentiated by sex but not by race [7–9], used older and less accurate methods of estimating the burden of mortality [3], and did not include data for alcohol-related diseases such as colon cancer, rectal cancer, and tuberculosis [7–9]. Thus, up-to-date, accurate estimates of the alcohol-attributable burden of disease in the US differentiated by race, age and sex are necessary to formulate effective policies and programs to ameliorate health inequalities and to identify cost-effective health interventions that would make the biggest difference to those in the worst health [10,11].

Accordingly, this paper provides an updated estimate of premature mortality, i.e., the number of deaths and Potential Years of Life Lost (PYLL) below age 65 years attributable to alcohol consumption for the US in 2005 differentiated by race, age and sex.

Methods

To estimate the number of deaths and PYLL attributable to alcohol consumption, we restricted our analysis to people aged 15 to 64 years for two reasons. First, premature mortality is the most important indicator for public health, as most of the PYLLs can be found in this age category. Second, deaths that occur after the age of 64 are often complicated in pathology and often are miscoded [12], thus contributing to potential bias in comparisons over the full life span. The cut-off of 65 years of age has also been used in other studies that calculate the burden of disease attributable to alcohol consumption [13–16]. When comparing alcohol-attributable harms with harms caused by other risk factors based on published studies, we made sure that the same age categories are used.

Calculation of the Alcohol-Attributable Fractions by Race, Age and Sex

The number of deaths caused by alcohol consumption was calculated using an Alcohol-Attributable Fraction (AAF), which is defined as the fraction of mortality that would not be present if exposure to alcohol was 0 (in this case, if every person was a lifetime abstainer) [17,18].

The method to calculate the number of deaths and PYLL attributable to alcohol consumption has two main steps: (1) calculation of the race-, age-, sex-, and consumption-specific AAFs, and then (2) application of these AAFs to the corresponding mortality and PYLL data.

Step 1: Calculation of the AAFs by Race, Age and Sex, and of the Alcohol Consumption Exposure Estimates

Alcohol consumption, measured in grams per day, was obtained from the Wave 1 2001–2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC 2001–2002) [2]. NESARC 2001–2002 employed a complex, multi-stage sampling that oversampled 18 to 24 year olds, Blacks and Hispanics. Computer-assisted personal interviews were conducted in face-to-face household settings. Individuals living in non-institutionalized group housing, such as military personnel living off base, and residents of institutionalized group housing, such as boarding houses, shelters, and dormitories, were also recruited [19]. In total, 43,993 respondents aged 10 years and older were recruited, with an overall response rate for the survey of 61%.

Summed across estimates for four separate beverage types, volume was estimated based on overall frequency of drinking, usual and largest quantities consumed, frequency of consuming the largest quantity, frequency of consuming 5+ drinks, usual drink size, and ethanol content by volume of the brand usually consumed. The test-retest reliabilities for the various measures of alcohol consumption from the NESARC 2001–2002 were good to excellent, with intra-class correlation coefficients ranging from 0.60 to 0.84 [20]. A coverage rate of 53% between the NESARC 2001–2002 survey and adult per capita alcohol consumption for the US was found (estimated as 0.75 liters per capita for 2001/2002, the years during which sampling took place), based on the Global Information System for Alcohol and Health (GISAH) database [21]. This means that the survey data combined underestimated the sales and unrecorded data of the US by 47% for 2001/2002. This underestimate is partly due to sampling (some high consuming groups such as the homeless are not part of surveys [22]) or is due to underestimation of one’s own drinking [23].

Consumption estimates were calculated based on race, age and sex. Race in the NESARC 2001–2002 was defined by four categories 1) White (including most Hispanics), 2) Black, 3) Asian/Pacific Islander, and 4) Native American (see US Census Bureau 1991) for definitions). For individuals who did not identify their race or who identified themselves as multi-racial, the US Census Bureau used an algorithm to impute/assign a race. To correct for undercoverage (the observed underreporting of alcohol consumption when using survey data as compared to adult per capita consumption) alcohol consumption data was then triangulated with per capita consumption data for 2005 obtained from the GISAH database [16] (for definition and description of coverage rate see [23,24]). This method of triangulation is detailed elsewhere [25,26]. A detailed outline of the methods used to model alcohol consumption is outlined in Appendix S1.

Risk Relations

Sources for Relative Risk (RR) functions by ICD-10 code are outlined in Table S1 in Appendix S2. The RRs, in most cases, were obtained from meta-analyses reporting a continuous RR function by dose of exposure, i.e., by average daily grams of ethanol consumed. In the underlying meta-analyses, older ICD codes were transferred into ICD-10 via the algorithms of Global Burden of Disease study. An outline of the causal relationship between alcohol and these ICD-10 code categories is described in detail elsewhere [3].

AAF Calculations

For most chronic diseases associated with alcohol consumption, we estimated the number of alcohol-attributable fatalities by combining prevalence data on drinking status, average daily volume of alcohol consumed, and the RR estimates associated with the respective exposure category [3]. In order to estimate the number of fatalities from ischemic heart disease, we combined prevalence data on drinking status, binge drinking status, and average daily volume of alcohol consumed [27,28]. For alcohol-attributable HIV deaths, we could only estimate the effect of alcohol consumption on adherence to antiretroviral medication [29]. For injuries, volumes of consumption from both average drinking and heavy drinking occasions and frequency of consuming 5 standard drinks or more were combined with the respective
| Race          | Age      | Lifetime abstainers | Former drinkers | Prevalence of average alcohol consumption |
|--------------|----------|---------------------|-----------------|------------------------------------------|
|              |          |                     | >0–<40 grams    | 40 to <60 grams | 60 to <100 grams | 100+ grams |
| White        | 15 to 24 | 16.25%              | 7.55%           | 46.41%        | 10.18%          | 12.18%      | 7.43%       |
|              | 25 to 34 | 7.85%               | 9.13%           | 62.00%        | 9.41%           | 3.83%       | 3.23%       |
|              | 35 to 44 | 7.82%               | 14.73%          | 56.74%        | 9.01%           | 8.31%       | 3.38%       |
|              | 45 to 54 | 8.43%               | 16.35%          | 55.57%        | 8.66%           | 7.8%        | 3.13%       |
|              | 55 to 64 | 9.10%               | 21.73%          | 54.43%        | 7.16%           | 5.72%       | 1.85%       |
|              | 65+      | 13.07%              | 30.10%          | 47.06%        | 5.19%           | 3.63%       | 0.95%       |
| Total        |          | 10.43%              | 10.43%          | 53.73%        | 8.41%           | 7.91%       | 3.48%       |
| Black        | 15 to 24 | 23.46%              | 6.25%           | 45.75%        | 9.10%           | 10.04%      | 5.41%       |
|              | 25 to 34 | 16.73%              | 10.81%          | 51.71%        | 8.70%           | 8.39%       | 3.66%       |
|              | 35 to 44 | 13.48%              | 19.07%          | 46.03%        | 8.44%           | 8.7%        | 4.25%       |
|              | 45 to 54 | 12.46%              | 27.01%          | 32.32%        | 8.32%           | 11.37%      | 8.53%       |
|              | 55 to 64 | 15.44%              | 30.65%          | 35.06%        | 6.98%           | 7.71%       | 4.16%       |
|              | 65+      | 20.61%              | 42.81%          | 30.78%        | 3.18%           | 2.12%       | 0.51%       |
| Total        |          | 17.14%              | 19.41%          | 42.02%        | 7.96%           | 8.69%       | 4.79%       |
| Native       | 15 to 24 | 24.11%              | 7.83%           | 51.24%        | 7.62%           | 6.69%       | 2.51%       |
|              | 25 to 34 | 24.02%              | 7.18%           | 59.97%        | 5.19%           | 3.05%       | 0.60%       |
|              | 35 to 44 | 31.29%              | 11.56%          | 44.74%        | 5.98%           | 4.83%       | 1.59%       |
|              | 45 to 54 | 13.79%              | 22.91%          | 50.42%        | 6.39%           | 4.96%       | 1.53%       |
|              | 55 to 64 | 43.82%              | 7.85%           | 47.41%        | 0.77%           | 0.15%       | 0.00%       |
|              | 65+      | 32.60%              | 17.87%          | 46.59%        | 2.08%           | 0.78%       | 0.07%       |
| Total        |          | 26.77%              | 12.14%          | 50.59%        | 5.28%           | 3.97%       | 1.25%       |
| Native       | 15 to 24 | 20.63%              | 9.34%           | 38.38%        | 9.60%           | 12.80%      | 9.25%       |
|              | 25 to 34 | 20.03%              | 16.44%          | 59.37%        | 7.78%           | 6.19%       | 1.99%       |
|              | 35 to 44 | 13.29%              | 14.29%          | 45.68%        | 9.54%           | 10.96%      | 6.28%       |
|              | 45 to 54 | 10.46%              | 25.31%          | 44.09%        | 8.00%           | 8.20%       | 3.94%       |
|              | 55 to 64 | 7.55%               | 41.83%          | 37.77%        | 5.75%           | 5.13%       | 1.98%       |
|              | 65+      | 18.91%              | 34.13%          | 45.08%        | 1.42%           | 0.43%       | 0.03%       |
| Total        |          | 14.05%              | 19.08%          | 45.55%        | 7.89%           | 8.57%       | 4.87%       |

Table 1. Key alcohol consumption indicators for the United States for 2005 by race, age and sex.
Table 2. Deaths attributable to alcohol consumption by cause, race, age and sex for the US in 2005.

| Race          | Men (15 to 24) | Men (25 to 34) | Men (35 to 44) | Men (45 to 54) | Men (55 to 64) | Men (15 to 64) | Women (15 to 24) | Women (25 to 34) | Women (35 to 44) | Women (45 to 54) | Women (55 to 64) | Women (15 to 64) | Total (15 to 64) |
|---------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| All causes of death (total) | 25,509         | 29,283         | 53,309         | 114,472        | 165,429        | 388,002        | 8,725            | 12,642           | 31,476           | 69,058           | 109,872          | 231,773          | 8,725            |
| All causes of death (alcohol attributable) | 10,995         | 7,785          | 10,044         | 11,444         | 6,193          | 46,461         | 1,030            | 747              | 1,876            | 3,729            | 2,131            | 9,513            | 55,974           |
| All causes of death (% alcohol attributable) | 43.1%          | 26.6%          | 18.8%          | 10.0%          | 3.7%           | 12.0%          | 11.8%            | 5.9%             | 6.0%             | 5.4%             | 1.9%             | 4.1%             | 9.0%             |
| White         |                |                |                |                |                |                | 619,775          |                  |                  |                  |                  |                  |                  |
| All causes of death (total) | 18,792         | 21,232         | 40,824         | 88,882         | 134,272        | 304,002        | 6,618            | 8,871            | 22,760           | 51,342           | 87,946           | 177,537          | 481,539          |
| All causes of death (alcohol attributable) | 9,626          | 6,616          | 8,654          | 8,228          | 46,211         | 37,745         | 835              | 556              | 1,364            | 2,374            | 1,760            | 6,889            | 44,634           |
| All causes of death (% alcohol attributable) | 51.2%          | 31.2%          | 21.2%          | 9.3%           | 12.4%          | 12.6%          | 12.6%            | 5.9%             | 6.0%             | 4.6%             | 2.0%             | 3.9%             | 9.3%             |
| Communicable, maternal, perinatal, and nutritional conditions |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| Infectious and parasitic diseases | 2              | 2              | 6              | 10             | 9              | 29             | 1                | 1                | 1                | 1                | 4                | 2                | 33               |
| HIV/AIDS      | 1              | 8              | 37             | 36             | 12             | 94             | 0                | 3                | 8                | 7                | 2                | 20               | 114              |
| Respiratory infections | 13             | 16             | 46             | 104            | 143            | 322            | 4                | 9                | 21               | 48               | 75               | 157              | 479              |
| Noncommunicable diseases |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| Malignant neoplasms | 10             | 32             | 206            | 1,054          | 1,650          | 2,952          | 4                | 37               | 252              | 709              | 1,025            | 2,027            | 4,979            |
| Diabetes      | -1             | -7             | -22            | -61            | -130           | -221           | -9               | -27              | -92              | -244             | -465             | -837             | -1,058           |
| Neuro-psychiatric conditions | 95             | 193            | 870            | 1,755          | 1,395          | 4,308          | 17               | 57               | 234              | 527              | 370              | 1,205            | 5,513            |
| Cardiovascular disease | 27             | 14             | 29             | -650           | -1,710         | -2,290         | 14               | 4                | 58               | 132              | 18               | 226              | -2,064           |
| Digestive diseases | 10             | 100            | 773            | 2,030          | 1,584          | 4,497          | 3                | 36               | 342              | 703              | 484              | 1,568            | 6,065            |
| Injuries      |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| Unintentional injuries | 7,569          | 4,894          | 5,010          | 3,213          | 1,378          | 22,064         | 733              | 393              | 469              | 411              | 217              | 2,223            | 24,287           |
| Intentional injuries | 1,900          | 1,362          | 1,696          | 733            | 287            | 5,978          | 67               | 42               | 68               | 77               | 33               | 287              | 6,265            |
| Undetermined intent | 0              | 2              | 3              | 4              | 3              | 12             | 1                | 2                | 3                | 3                | 0                | 9                | 21               |
| Black         |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| All causes of death (total) | 5,709          | 6,843          | 10,626         | 22,248         | 26,711         | 72,137         | 1,662            | 3,193            | 7,560            | 15,501           | 18,705           | 46,621           | 118,758          |
| All causes of death (alcohol attributable) | 930            | 936            | 1037           | 2833           | 1421           | 7,177          | 112              | 150              | 409              | 1240             | 314              | 2,225            | 9,402            |
| All causes of death (% alcohol attributable) | 16.3%          | 13.7%          | 9.8%           | 12.8%          | 3.3%           | 9.9%           | 6.7%             | 4.7%             | 5.4%             | 8.0%             | 1.7%             | 4.8%             | 7.9%             |
| Communicable, maternal, perinatal, and nutritional conditions |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| Infectious and parasitic diseases | 1              | 1              | 3              | 6              | 6              | 17             | 0                | 1                | 0                | 2                | 1                | 4                | 21               |
| HIV/AIDS      | 1              | 10             | 31             | 34             | 12             | 88             | 1                | 7                | 14               | 12               | 3                | 37               | 125              |
| Respiratory infections | 3              | 5              | 16             | 46             | 39             | 109            | 1                | 3                | 7                | 21               | 12               | 44               | 153              |
| Noncommunicable diseases |                |                |                |                |                |                |                  |                  |                  |                  |                  |                  |                  |
| Malignant neoplasms | 4              | 11             | 53             | 325            | 396            | 789            | 3                | 18               | 98               | 336              | 168              | 623              | 1,412            |
| Diabetes      | -1             | -2             | -4             | 7              | -4             | -4             | -3               | -12              | -24              | -44              | -89              | -172             | -176             |
Table 2. Cont.

| Race               | Men 15 to 24 | Women 15 to 24 | Total 15 to 24 | Men 25 to 34 | Women 25 to 34 | Total 25 to 34 | Men 35 to 44 | Women 35 to 44 | Total 35 to 44 | Men 45 to 54 | Women 45 to 54 | Total 45 to 54 | Men 55 to 64 | Women 55 to 64 | Total 55 to 64 | Total 15 to 64 |
|--------------------|--------------|----------------|----------------|--------------|----------------|----------------|--------------|----------------|----------------|--------------|----------------|----------------|--------------|----------------|----------------|----------------|
| Neuro-psychiatric conditions | 11           | 7              | 18             | 30           | 9              | 39             | 295          | 233            | 528            | 685          | 46             | 74             | 55           | 104            | 189            | 288           |
| Cardiovascular disease | 10           | 9              | 19             | 26           | 26             | 52             | 104          | 93             | 197            | 305          | 93             | 196            | 538          | 128            | 660            | 788           |
| Digestive diseases | 4            | 0              | 4              | 9            | 7              | 16             | 78           | 196            | 274            | 295          | 196            | 491            | 82           | 51             | 133            | 234           |
| Injuries           |              |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| Unintentional injuries | 750          | 707            | 1,457          | 571          | 1,373          | 2,946          | 1,373         | 419            | 1,792          | 3,820        | 88             | 79             | 167           | 551           | 718           | 1,241          |
| Intentional injuries | 146          | 139            | 285            | 68           | 167            | 235            | 31           | 551            | 582            | 0            | 7              | 51             | 121           | 58             | 237           | 819           |
| Underdetermined intent | 1            | 0              | 1              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0              |
| Native American    |              |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| All causes of death (total) | 439          | 512            | 951            | 777          | 1,160          | 1,937          | 1,341         | 4,229          | 5,570          | 196          | 208            | 414            | 446           | 767            | 999           | 2,116         | 6,745         |
| All causes of death (alcohol attributable) | 268          | 167            | 435            | 278          | 255            | 533            | 119           | 1,087          | 1,206          | 64           | 30             | 94             | 87            | 87             | 22             | 290           | 1,377         |
| All causes of death (% alcohol attributable) | 61.0%         | 32.6%          | 22.0%          | 35.8%        | 32.0%          | 35.8%          | 20.0%         | 8.9%           | 25.7%          | 32.7%        | 14.4%          | 19.5%          | 11.3%         | 2.4%           | 11.5%          | 20.4%         |
| Communicable, maternal, perinatal, and nutritional conditions |                |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| Infectious and parasitic diseases | 0            | 0              | 0              | 0            | 0              | 0              | 1            | 0              | 1              | 0            | 0              | 0              | 0            | 0              | 0              | 1             |
| HIV/AIDS | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0             |
| Respiratory infections | 0            | 0              | 0              | 0            | 0              | 0              | 1            | 0              | 1              | 0            | 0              | 0              | 0            | 0              | 0              | 0             |
| Noncommunicable diseases |              |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| Malignant neoplasms | 0            | 0              | 0              | 4            | 9              | 13             | 26           | 0              | 2              | 5            | 4              | 11             | 37           | 0              | 2              | 46             |
| Diabetes | 0            | 0              | 0              | 0            | 0              | 0              | −1           | −1             | −2             | 0            | −1             | −2             | −3           | −8             | −14            | −16           |
| Neuro-psychiatric conditions | 5            | 6              | 11             | 47           | 61             | 128            | 28           | 147            | 438            | 3            | 3              | 16             | 23           | 7              | 36             | 71             |
| Cardiovascular disease | 1            | 1              | 2              | 5            | 1              | 6              | −8           | −2             | −10            | 1            | 0              | 4              | 5            | 5              | 2              | 8             |
| Digestive diseases | 1            | 12             | 13             | 46           | 63             | 163            | 41           | 163            | 224            | 0            | 6              | 33             | 32           | 16             | 87             | 250           |
| Injuries           |              |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| Unintentional injuries | 183          | 123            | 306            | 135          | 103            | 238            | 41           | 585            | 626            | 44           | 20             | 64             | 25           | 11             | 36             | 104           | 689           |
| Intentional injuries | 77           | 25             | 102            | 38           | 19             | 57             | 3           | 162            | 165            | 16           | 2              | 18             | 3            | 0              | 3              | 21           | 183           |
| Underdetermined intent | 1            | 0              | 1              | 1            | 0              | 1              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0             |
| Asian/Pacific Islander |              |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| All causes of death (total) | 569          | 696            | 1,265          | 1,082         | 2,182          | 3,264          | 3,105         | 7,364          | 10,530         | 249          | 370            | 619            | 710           | 1,448          | 2,322          | 5,099         | 12,733        |
| All causes of death (alcohol attributable) | 171          | 66             | 237            | 75           | 108            | 183            | 32           | 452            | 584            | 19           | 11             | 30             | 16           | 28             | 55             | 109           | 561           |
| All causes of death (% alcohol attributable) | 30.1%         | 9.5%           | 13.3%          | 6.9%         | 4.9%           | 9.5%           | 1.0%         | 5.9%           | 7.6%           | 3.0%        | 2.3%          | 1.9%          | 1.5%         | 2.1%          | 4.4%          |
| Communicable, maternal, perinatal, and nutritional conditions |                |                |                |              |                |                |              |                |                |              |                |                |              |                |                |                |
| Infectious and parasitic diseases | 1            | 0              | 1              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 1             |
| HIV/AIDS | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 0             |
| Respiratory infections | 0            | 0              | 0              | 2            | 1              | 3              | 0            | 0              | 0              | 0            | 0              | 0              | 0            | 0              | 0              | 4             |
RR functions to estimate fatalities (see Appendix S3 for additional details) [30,31].

Step 2: Application of the AAFs to Race-, Age- and Sex-specific Mortality, and to PYLL Data Estimates of Mortality

For our analysis, we used both incidence-based (mortality) and time-based (PYLL) measures of public health. Mortality data were obtained from the US Department of Health and Human Services for 2005 by ICD-10 codes, differentiated by age categories, race, and sex. Life expectancies for these age categories were also obtained from the US Department of Health and Human Services by sex for 2005 [32]. ICD-10 codes have been used since 1999 by the US Department of Health and Human Services to report mortality in the United States; however, estimates of deaths prior to 1999 by ICD-10 code are available from the US Department of Health and Human Services [33]. PYLL were calculated using a time-discounting (3%) methodology [34]. Time-discounting methods were used to account for peoples’ preference of a healthy year now, rather than a healthy year in the future. Population estimates for 2005 were based on the latest revisions from the US Census Bureau [2].

Standardized Rates of Mortality

To directly compare the number of deaths across races while controlling for any differences in age and sex structure of the White, Black, Native American and Asian/Pacific Islander populations, we calculated standardized rates of mortality per 100,000 people using the 2005 US population as the standard population.

All statistics and analyses were performed using R and STATA [35,36].

Results

Table 1 outlines the prevalence of “current drinkers,” “former drinkers,” and “lifetime abstainers,” and levels of consumption among current drinkers. In general, average daily consumption, frequency of binge drinking (data not shown), and number of drinks per binge drinking occasion (data not shown) were highest in the youngest age categories, and among men in all age categories. With the exception of Black men, who had a higher average daily consumption than did Native American men, Native Americans had the highest daily consumption, frequency of binge drinking, and number of drinks per binge drinking occasion.

For people aged 15 to 64 years, alcohol was responsible for 55,974 deaths in 2005 representing 9.0% of all deaths in that age range. This number can be broken down by sex into 46,461 representing 12.0% of all deaths of men, and 9,513 representing 4.1% of all deaths of women (see Table 2 for the number of deaths attributable to alcohol by sex and by cause, Figure 1 for the percentage of deaths attributable to alcohol consumption by sex and race, and Appendix S4 for the percentage of deaths attributable to alcohol consumption by major causes of death). These are net deaths, where the beneficial effects of alcohol, such as the protective effects of low to moderate drinking on ischemic disease and diabetes, have already been subtracted.

Most of the deaths attributable to alcohol were due to injuries, with 36,622 such deaths (53,485 for men; 3,137 for women). In terms of the number of deaths attributable to alcohol, the net effect was highest for the older age groups, peaking in the age range of 45 to 54 years; however, this was dependent on the cause of death, with people in younger age categories experiencing much more...
mortality attributable to injuries than was experienced by people in older age groups.

In the US in 2005 for people aged 15 to 64 years, 1,288,700 PYLL, representing 10.7% of all PYLL, were attributable to alcohol. This number can be broken down by sex into 1,087,280 representing 14.7% of all PYLL for men, and 201,420 PYLL representing 4.3% of all PYLL for women (see Table 3 for the number of PYLL attributable to alcohol by race, age, sex and cause, and Figure 2 for the percentage of PYLL attributable to alcohol consumption by sex and race). As with mortality, the biggest contributor to PYLL attributable to alcohol was injuries, which constituted 7.2% of all PYLL (10.6% for men and 1.6% for women) for people aged 15 to 64 years. Overall, alcohol was responsible for a greater percentage of all PYLL for men when compared to women. Native Americans had the highest percentage of PYLL attributable to alcohol consumption (22.8%) when compared to any other group, with people who identified as White having the second highest percentage of PYLL attributable to alcohol consumption (11.2%).

In the US in 2005 the standardized rates of alcohol-attributable mortality and PYLL per 100,000 people varied by sex and race (see Figure 3 for population standardized mortality rates and Figure 4 for population standardized PYLL rates, in each case for 2005), reflecting a difference in both drinking patterns and causes of mortality while controlling for population structure. Men experienced 49 alcohol-attributable deaths and 1,142 alcohol-attributable PYLL, and women experienced 10 alcohol-attributable deaths and 207 alcohol-attributable PYLL, in each case per 100,000 people. In terms of race, Native Americans experienced many more harms for both sexes, with 82 deaths per 100,000 people (130 for men; 35 for women) and 1,808 PYLL per 100,000 people (2,838 for men; 798 for women). This rate of mortality for Native Americans represented more than ten times the rate experienced by Asian/Pacific Islanders. Asian/Pacific Islanders experienced the lowest rates of harms for both mortality and PYLL. In terms of the two largest populations in the US, people who identified themselves as White experienced fewer harms in terms of mortality and PYLL per 100,000 people when compared to people who identified as Black; people who identified themselves as White experienced 29 deaths (49 for men; 9 for women) and 673 PYLL (1,172 for men; 185 for women) per 100,000, and people who identified as Black experienced 40 deaths (61 for men; 19 for women) and 808 PYLL (1,252 for men; 374 for women) per 100,000.

**Comment**

This is the first report which outlines the burden of mortality and PYLL attributable to alcohol consumption in the US differentiated by race, age and sex, and it reveals that alcohol...
Table 3. Potential Years of Life Lost attributable to alcohol consumption by cause, race, age and sex for the US in 2005.

| Race          | 15 to 24 | 25 to 34 | 35 to 44 | 45 to 54 | 55 to 64 | 15 to 64 | Total       |
|---------------|----------|----------|----------|----------|----------|----------|-------------|
| **Men**       |          |          |          |          |          |          |             |
| All causes of death (total) | 682,340  | 738,580  | 1,205,700 | 2,217,950 | 2,572,180 | 7,416,750 |             |
| All causes of death (alcohol attributable) | 295,060  | 205,500  | 283,470  | 213,170  | 90,080   | 1,087,280 |             |
| All causes of death (% alcohol attributable) | 43.2%    | 27.8%    | 23.5%    | 9.6%     | 3.5%     | 14.7%    |             |
| White         |          |          |          |          |          |          |             |
| All causes of death (total) | 502,670  | 535,520  | 923,330  | 1,722,130 | 2,087,730 | 5,771,380 |             |
| All causes of death (alcohol attributable) | 258,110  | 172,750  | 245,350  | 214,590  | 90,080   | 898,480   |             |
| All causes of death (% alcohol attributable) | 51.3%    | 32.3%    | 26.6%    | 9.0%     | 3.2%     | 15.6%    |             |
| **Women**     |          |          |          |          |          |          |             |
| All causes of death (total) | 152,710  | 172,600  | 240,330  | 431,060  | 415,320  | 1,412,020 |             |
| All causes of death (alcohol attributable) | 25,170   | 26,560   | 287,70   | 518,20   | 20,110   | 201,100   |             |
| All causes of death (% alcohol attributable) | 16.9%    | 15.4%    | 12.0%    | 12.0%    | 6.0%     | 8.9%     |             |
| **Total**     |          |          |          |          |          |          |             |
| All causes of death (total) | 240,970  | 313,550  | 750,970  | 1,439,190 | 1,881,150 | 4,643,830 |             |
| All causes of death (alcohol attributable) | 32,620   | 18,510   | 42,500   | 71,050   | 36,740   | 201,420   |             |
| All causes of death (% alcohol attributable) | 13.5%    | 5.6%     | 5.7%     | 4.9%     | 2.0%     | 4.3%     |             |

Communicable, maternal, perinatal, and nutritional conditions

| Cause                      | Men          | Women         | Total         |
|----------------------------|--------------|---------------|---------------|
| Infectious and parasitic diseases | 60  60  200 | 140  590   | 10  10  20  20  80  670 |
| HIV/AIDS                    | 20  840  190 | 190  1,970  | 10  70  180  140  30  430  2,400 |
| Respiratory infections      | 350  1,030 2,230 | 6,020  | 100  220  490  990  1,290  3,090  9,110 |
| Noncommunicable diseases    |              |               |               |
| Malignant neoplasms         | 270  4,660 20,420 | 51,800  | 110  980  6,020 14,780 17,540 39,430 91,230 |
| Diabetes                    | -20  -180  -500 | -1,190  | -2,020  -3,910  -240  -720  -2,200  -5,080  -7,960  -16,200  -20,110 |
| Neuro-psychiatric conditions| 2,540 19,670 34,010 | 82,780  | 470  1,510  5,580  10,990  6,340  24,890 107,670 |
| Cardiovascular disease      | 1,340 6,230 50,320 | -17,450 | -30,770 9,690  2,920  -2,040  260  420  350  1,910  11,600 |
| Digestive diseases          | 260 2,520 17,470 39,320 | 84,200  | 70  930  8,170 14,660 8,280 32,110 116,310 |
| Injuries                    |              |               |               |
| Unintentional injuries      | 202,460 132,430 113,310 | 62,260 | 21,430 522,890 20,230 10,300 11,200 8,560 3,710 54,000 576,890 |
| Intentional injuries        | 50,830 34,360 38,350 14,200 | 4,460 | 142,200 1,860 1,110 1,610 1,610 570 6,760 148,960 |
| Underdetermined intent      | 0 50 50 70 80 | 50 250   | 30 50 70 60 0 210 460 |
| Black                      |              |               |               |
| All causes of death (total) | 152,710 172,600 240,330 | 431,060 | 415,320 1,412,020 | 45,900 83,740 180,370 323,050 320,250 953,310 2,365,330 |
| All causes of death (alcohol attributable) | 25,170 26,560 287,70 | 518,20 | 201,100 152,430 | 4350 5040 8640 21590 5560 45,180 197,610 |
| All causes of death (% alcohol attributable) | 16.5% 15.4% 12.0% | 12.0% | 10.8% 9.5% 6.0% 4.8% 6.7% 1.7% 4.7% 8.4% |

Communicable, maternal, perinatal, and nutritional conditions

| Cause                      | Men          | Women         | Total         |
|----------------------------|--------------|---------------|---------------|
| Infectious and parasitic diseases | 70  250  1,200 | 6,300  | 80  460 2,330 7,000 2,870 12,740 26,800 |
| HIV/AIDS                    | 20  70  140 | 60  90  -100 320 580 910 1,530 3,440 3,530 |

Mortality from Alcohol in the US in 2005
### Table 3. Cont.

| Race                  | Men                  | Women                | Total           |
|-----------------------|----------------------|----------------------|-----------------|
|                       | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Neuro-psychiatric conditions | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Cardiovascular disease | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Digestive diseases    | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Injuries              | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Native American       | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Asian/Pacific Islander| 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |

#### Neuro-psychiatric conditions

|                    | Men                  | Women                | Total           |
|--------------------|----------------------|----------------------|-----------------|
| Cardiovascular disease | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Digestive diseases | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Injuries           | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Native American    | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Asian/Pacific Islander | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |

#### Communicable, maternal, perinatal, and nutritional conditions

|                    | Men                  | Women                | Total           |
|--------------------|----------------------|----------------------|-----------------|
| Infectious and parasitic diseases | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Respiratory infections | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Malignant neoplasms | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Diabetes            | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Neuro-psychiatric conditions | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Cardiovascular disease | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Digestive diseases | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Injuries           | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Native American    | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Asian/Pacific Islander | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |

#### Communicable, maternal, perinatal, and nutritional conditions

|                    | Men                  | Women                | Total           |
|--------------------|----------------------|----------------------|-----------------|
| Infectious and parasitic diseases | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Respiratory infections | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Malignant neoplasms | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Diabetes            | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Neuro-psychiatric conditions | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Cardiovascular disease | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Digestive diseases | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Injuries           | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Native American    | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
| Asian/Pacific Islander | 15 to 24             | 25 to 34             | 35 to 44        | 45 to 54        | 55 to 64 | 15 to 64 |
consumption is a large contributor to the burden of mortality. As previously hypothesized, this variation in premature mortality provides evidence that a health disparity in alcohol-attributable harms exists across races in the US. In particular, Native Americans, and to a lesser extent Black Americans, when compared to other races, have a higher standardized rate of alcohol-attributable mortality and PYLL. Thus, alcohol consumption can be seen as a main contributor underlying the known health disparities in the US [1]. In addition to racial differences in alcohol-attributable mortality, men in every racial group experienced more than three times the amount of mortality when compared to women.

The observed differences in alcohol-attributable mortality across races may not be attributable to alcohol consumption alone as health-care utilization and the underlying population risk for alcohol-related diseases, injuries and conditions also impact on differences in the burden of alcohol-attributable mortality across races [17,18]. Thus, effective interventions and policies aimed at addressing this disparity should address race differences in health plan coverage and health-care utilization for alcohol-related conditions [1], and should include race-specific interventions aimed at reducing the volume of alcohol consumed and deterring harmful alcohol consumption patterns [37,38].

This analysis has certain limitations, such as the quality of health outcomes data [39]. Information concerning cause of death has long been seen as containing inaccuracies [40], and more recent studies still confirm considerable degrees of error in such information [41,42]. Additionally, the exposure estimates for drinking status and binge drinking patterns used in our analysis were measured in 2001, whereas the outcomes were measured in 2005; however, the length of time between 2001 and 2005 should not greatly affect the alcohol-attributable mortality and PYLL estimates as alcohol consumption in the US remained relatively stable from 2001 to 2005 [43]. The estimates of alcohol consumption used in our analysis were also cross-sectional, i.e., measured more or less concurrently with deaths and PYLL, whereas long-term patterns of alcohol consumption impact the risk of some chronic diseases such as cancer [44].

Furthermore, our analysis did not include all aspects of harms to others (such as motor vehicle accidents, and assaults), which recently have been shown to constitute a large proportion of the burden of injury attributable to alcohol [45]; this exclusion was due to an absence of a methodology to calculate these harms by race, age and sex [15].

We also did not estimate the number of deaths for people in the US over the age of 64 due to the unreliability of data relating to cause of death in the elderly [12]. If the age group above 64 years had been included in our analysis, we estimated that the number of deaths and PYLL attributable to alcohol would have increased from 55,974 deaths and 1,288,700 PYLL to 82,213 deaths and 1,557,030 PYLL. Our analysis focused on premature mortality; however, in a case where all alcohol-attributable mortality is examined, injury may play a smaller part, as its role in causing death in people 65 years of age and older is relatively smaller than its same role in younger age groups [32].

This analysis was based on race and does not provide alcohol-attributable estimates by ethnicity or socio-economic status. Alcohol consumption has been shown to vary by both ethnicity and socio-economic status [2] and, thus, the alcohol-attributable harms are expected to vary by these variables as well [46]. The exclusion from this paper of analyses of these variables was due to the unavailability of data differentiated by ethnicity and socio-economic status.
This analysis is also based on RR functions that were usually differentiated by sex and adjusted for age and smoking status, and in some cases for a variety of other risk factors. While the use of adjusted RR functions may introduce bias (see [47–49]), most of the published literature on risk factors only report adjusted RRs and, thus, they are the basis of almost all comparative risk analyses ([39]; for alcohol see the publications outlined in Appendix S2). For the risk estimates for alcohol in particular, most analyses show no marked differences after adjustment for the usual confounders and effect measure modifiers tested (see [3], and the meta-analyses cited there). However, there may be a need for adjustment to the RRs for alcohol if future research indicates that other dimensions of alcohol consumption, such as irregular heavy drinking occasions, impact the risk estimates.

For our analysis, we corrected the survey estimates of consumption so that the coverage of the alcohol consumption data used was equal to 80% of the US per capita consumption for 2005 (the per capita consumption of alcohol in 2005 was 9.5 liters of pure alcohol per person). If we had not triangulated the survey data based on total adult per capita consumption, the survey coverage rate would have been 49.7% for 2005. If unadjusted alcohol consumption survey data were used to calculate the burden of alcohol consumption, we estimated that alcohol would be responsible for 49,788 deaths and 1,120,740 PYLL for people aged 15 to 64 years. These results are similar to those which we calculated using a coverage rate of 80%, where it was estimated that 55,974 deaths and 1,228,700 PYLL were attributable to alcohol consumption.

The incomplete coverage of per capita consumption in the NESARC 2001–2002, typical of survey-based consumption estimates, may have been due to disproportionately high levels of consumption among non-responders and to not capturing the sampling frame people who were homeless and not living in shelters (about half of all people who are homeless in the US) [50]. This may be a concern as a relatively small proportion of the population is responsible for the majority of the alcohol consumed. For instance, in the NESARC 2001–2002 sample, 6.7% of White male drinkers consumed 33% of the overall consumption, so excluding or undersampling of small groups with high consumption may result in a large degree of undercoverage [51]. However, given that the unsheltered, homeless population represents a small fraction of the total population (0.1% of those people 15 years of age and older), their inclusion in the NESARC 2001–2002 would have increased the survey coverage rates by less than 1% (on the basis of the assumptions in Shield and Rehm [22]). Thus, almost all of the undercoverage results from incomplete reporting of consumption among survey respondents and disproportionately
high levels of consumption among the non-responders who were part of the sampling frame.

It should be noted that our analysis did not take into account morbidity attributable to alcohol consumption. As alcohol consumption has a greater impact on morbidity (as measured by Years Lived with Disability (YLD)), a metric which combines the duration lived with a disease or injury and the severity of the disease or injury) than on mortality or premature mortality (as measured in PYLL), metrics such as Disability Adjusted Life Years (DALYs) (a measure that combines PYLL and YLD) are required to accurately characterize the burden of alcohol consumption.

Danaei and colleagues estimated that alcohol consumption was responsible for 64,000 deaths (45,000 for men and 20,000 for women) for all ages in the US in 2005 [5]. These estimates are substantially lower than our study’s estimates of 82,213 deaths (61,539 for men and 20,674 for women) for all ages. Our updated estimates of the burden of alcohol consumption show that alcohol is a greater risk factor for mortality in the US than was previously thought. Differences between our estimates and those of Danaei and colleagues may be explained by our use of better modeling methods for alcohol consumption and its associated risks, and our use of alcohol consumption data corrected for undercoverage. In addition, we included alcohol-attributable causes of death not included in the study by Danaei and colleagues, such as infectious diseases [52].

Comparison to Other Risk Factors

Our updated estimate of the burden of alcohol consumption in terms of mortality for the US is still lower than the burden estimated for tobacco, and poor diet and physical inactivity [53]; tobacco use was responsible for an estimated 435,000 deaths, and poor diet and physical inactivity were responsible for an estimated 400,000 deaths in the US in 2000 (there were no age restrictions used when calculating these estimates).

Conclusion

This is the first study which compares alcohol-attributable mortality and PYLL across different races in the US. However, since alcohol consumption also has effects on social harms, more research is needed to quantify the alcohol-attributable social harms differentiated by race, age and sex. Since there is a disparity in alcohol-attributable harms in the US between racial groups, research is required to identify the mechanisms that give rise to and sustain these disparities in order to effectively develop and target alcohol policy strategies.
Appendix S1 Alcohol consumption modeling methodology.

Appendix S2 Categories of alcohol-related diseases and sources used for determining alcohol-attributable fractions.

Appendix S3 Alcohol-attributable fraction modeling methodology.

References

1. Murray CJ, Kulkarni SC, Michaud C, Tomijima N, Bulzacchelli MT, et al. (2006) Eight Americas: investigating mortality disparities across races, counties, and race-counties in the United States. PLoS Medicine 3: e260.

2. US Department of Health and Human Services (2011) National epidemiologic survey on alcohol and related conditions (NESARC). Department of Health and Human Services.

3. Danaei G, Ding E, Mozaffarian D, Taylor B, Rehm J, et al. (2009) The preventable causes of death in the United States: comparative risk assessment of lifestyle, dietary, and metabolic risk factors. PLoS Medicine 6: e1000050.

4. World Health Organization (2009) Global Health Risks. Geneva, Switzerland.

5. Mokdad AH, Marks JS, Stroup DF, Gerberding JL (2000) Actual causes of death in the United States, 2000. Journal of American Medical Association 291: 1238–1245.

6. Hollingsworth W, Ebel BE, McCarty CA, Garrison MM, Christakis DA, et al. (2006) Prevention of deaths from harmful drinking in the United States: the potential effects of tax increases and advertising bans on young drinkers. Journal of Studies on Alcohol 67: 300–308.
9. McGinnis JM, Foege WH (1995) Actual causes of death in the United States. The Journal of the American Medical Association 270: 2207–2212.
10. Mackenbach JP, Bakker MJ (2003) Tackling socioeconomic inequalities in health: analysis of European experiences. Lancet 362: 1409–1414.
11. Otten MW, Jr., Teutsch SW, Williamson DF, Marks JS (1996) The effect of known risk factors on the excess mortality of black adults in the United States. Journal of American Medical Association 276: 436–439.
12. Allen GC, Mileen J (2012) The value of autopsies for determining the cause of death. Tidsskr Nor Laegeforen 132: 147–151.
13. Zatonski W, Manchuk M, Sulkowska U, Didkowska J, Wojcieszowska U, et al. (2011) Epidemiological analysis of health situation development in Europe and its causes until 1990. Annals of the Agricultural and Environmental Medicine 18: 194–202.
14. Shield K, Keloe T, Taylor B, Patra J, Rehm J (2012) Alcohol-attributable burden of disease and injury in Canada, 2004. International Journal of Public Health 57: 391–401.
15. Shield KD, Gmel G, Jr., Patra J, Rehm J (2012) Global burden of injuries attributable to alcohol consumption in 2004: a novel way of calculating the burden of injuries attributable to alcohol consumption. Population Health Metrics 10: 9.
16. Rehm J, Shield KD, Rehm MX, Gmel G, Jr., Frick U (2012) Alcohol consumption, alcohol dependence, and attributable burden of disease in Europe: potential gains from effective interventions for alcohol dependence. Toronto, ON.
17. Murray C, Lopez A (1997) Global mortality, disability, and the contribution of risk factors: global burden of disease study. Lancet 349: 1346–1442.
18. Rothman KJ, Greenland S, Lash TL (2008) Modern Epidemiology, 3rd ed. PA, USA: Lippincott Williams & Wilkins.
19. Grant B, Moore T, Kaplan K (2003) Source and accuracy statement: Wave I National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism.
20. Grant BF, Dawson DA, Stinson FS, Chou PS, Kay W, et al. (2003) The Alcohol Use Disorder and Associated Disabilities Interview Schedule–IV (AUDADIS–IV): reliability of alcohol consumption, tobacco use, family history of depression and psychiatric diagnostic modules in a general population sample. Drug and Alcohol Dependence 71: 7–16.
21. World Health Organization (2011) Global Information System on Alcohol and Health. Geneva, Switzerland: World Health Organization.
22. Shield K, Rehm J (2012) Difficulties with telephone-based surveys on alcohol in high-income countries: the Canadian example. International Journal of Methods in Psychiatric Research 21: 17–28.
23. Miranik LT (1982) The validity of self-reported alcohol consumption and alcohol problems: a literature review. British Journal of Addiction 77: 557–562.
24. Rehm J, Klootche J, Patra J (2007) Comparative quantification of alcohol exposure as risk factor for global burden of disease. International Journal of Methods in Psychiatric Research 16: 66–76.
25. Rehm J, Keloe T, Gmel G, Simon E, Grant B, et al. (2010) Statistical modeling of volume of alcohol exposure for epidemiological studies of population health: the example of the US. Population Health Metrics 8: 3.
26. Keloe T, Gmel G, Jr., Shield K, Gmel G, Sr., Rehm J (2012) Modelling alcohol consumption as a distribution and determining the impact of the distribution on estimated alcohol-attributable harms. Population Health Metrics 10: 6.
27. Roercke M, Rehm J (2010) Irregular heavy drinking occasions and risk of ischemic heart disease: a systematic review and meta-analysis. American Journal of Epidemiology 171: 633–644.
28. Roercke M, Rehm J (2012) The cardioprotective association of average alcohol consumption and ischemic heart disease: a systematic review and meta-analysis. Addiction 107: 1246–1260.
29. Gmel G, Shield K, Rehm J (2011) Developing a methodology to derive alcohol-attributable fractions for HIV/AIDS mortality based on alcohol’s impact on adherence to antiretroviral medication. Population Health Metrics 9: 5.
30. Taylor B, Irving HM, Kanteres F, Room R, Borges G, et al. (2010) The more you drink, the harder you fall: a systematic review and meta-analysis of how acute alcohol consumption and injury or collision risk increase together. Drug and Alcohol Dependence 110: 105–116.
31. Taylor B, Shield K, Rehm J (2011) Combining best evidence: a novel method to calculate the alcohol-attributable fraction and its variance for injury mortality. BMC Public Health 11: 265.
32. Arias E, Rostron BL, Tejada-Vera B (2010) United States Life Tables, 2005 National Vital Statistics Reports. Vol. 58, No.10.
33. Centers for Disease Control (2012) International Classification of Diseases, Tenth Revision (ICD-10).
34. Mathers CD, Salomon JA, Ezzati M, Begg S, Lopez AD (2006) Sensitivity and uncertainty analyses for burden of disease and risk factor estimates. In: Lopez AD, Mathers CD, Ezzati M, Murray CJL, Jamison DT, editors. Global burden of disease and risk factors. New York: Oxford University Press. 399–426.
35. R Development Core Team (2011) R: A Language and Environment for Statistical Computing (version 2.13.0). Vienna, Austria.
36. StatA (2007) StatA Statistical Software: Release 10. College Station, U.S.: StataCorp LP.
37. Chartier K, Castano R (2010) Ethnicity and Health Disparities in Alcohol Research. Alcohol Research & Health 33: 152.
38. Babor T, Castano R, Casswell S, Edwards G, Giesbrecht N, et al. (2010) Alcohol: No ordinary commodity. Research and public policy. 2nd ed. edition. Oxford and London: Oxford University Press.
39. Ezzati M, Lopez AL, Rodgers A, Murray CJL (2004) Comparative quantification of health risks. Global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization.
40. James G, Patton KG, Estlin S (1955) Accuracy of cause-of-death statements on death certificates. Public Health Reports 70: 59–51.
41. Nashelsky MB, Lawrence CH (2003) Accuracy of cause of death determination without forensic autopsy examination. American Journal of Forensic Medicine and Pathology 24: 313–319.
42. Steijanis KG, Burton EC, McDonald KM, Goldman L (2003) Changes in rates of autopsy-detected diagnostic errors over time: a systematic review. Journal of American Medical Association 289: 2849–2856.
43. World Health Organization (2011) Global status report on alcohol and health. Geneva, Switzerland: World Health Organization.
44. Bagnardi V, Blangiardo M, La Vecchia C, Corrao G (2001) Alcohol consumption and the risk of cancer: a meta-analysis. Alcohol Research & Health 25: 263–270.
45. Ladell AM, Catalano P, Chikritzhs T, Dale C, Doran C, et al. (2010) The range and magnitude of alcohol's harm to others. Fitzroy, Vic: Turning Point Alcohol & Drug Centre.
46. Taylor B, Rehm J, Trinidad J, Abarto C, Bejarano J, et al. (2007) Alcohol, gender, culture and harms in the Americas: PAHO Multicentric Study final report. Washington, D.C.: Pan American Health Organization (PAHO). ISBN 978 92 75 12828 2 ISBN 978 92 75 12828 2.
47. Rockhill B, Newman B (1998) Use and misuse of population attributable fractions. American Journal of Public Health 88: 15–19.
48. Korn EL, Graubard BI (1999) Analysis of Health Surveys. New York, NY: John Wiley & Sons Inc.
49. Flegal KM, Williamson DF, Graubard BI (2006) Using adjusted relative risks to calculate attributable fractions. American Journal of Public Health 96: 398.
50. Cunningham M, Henry M (2006) Homelessness Counts. Washington, D.C: National Alliance to End Homelessness.
51. Taylor B, Rehm J, Trinidad J, Abarto C, Bejarano J, et al. (2007) Alcohol, gender, culture and harms in the Americas: PAHO Multicentric Study final report. Washington, D.C.: Pan American Health Organization (PAHO). ISBN 978 92 75 12828 2 ISBN 978 92 75 12828 2.
52. Nashelsky MB, Lawrence CH (2003) Accuracy of cause of death determination without forensic autopsy examination. American Journal of Forensic Medicine and Pathology 24: 313–319.
53. Steijanis KG, Burton EC, McDonald KM, Goldman L (2003) Changes in rates of autopsy-detected diagnostic errors over time: a systematic review. Journal of American Medical Association 289: 2849–2856.