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Author manuscript
Hepatology. Author manuscript; available in PMC 2020 May 01.

Published in final edited form as:
Hepatology. 2019 May ; 69(5): 1916–1930. doi:10.1002/hep.30315.

COLDER WEATHER AND FEWER SUNLIGHT HOURS INCREASE ALCOHOL CONSUMPTION AND ALCOHOLIC CIRRHOSIS WORLDWIDE

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Abstract

Risk of alcoholic cirrhosis is determined by genetic and environmental factors. Although it is generally accepted that colder weather predisposes to alcohol misuse, no studies have investigated its impact on alcohol intake and alcoholic cirrhosis. We aimed to investigate if climate has a causal effect on alcohol consumption and its weight on alcoholic cirrhosis. We collected extensive data from 193 sovereign countries as well as 50 states and 3,144 counties in the United States. Data sources included World Health Organization, World Meteorological Organization, and the Institute on Health Metrics and Evaluation. Climate parameters comprised Koppen-Geiger classification, average annual sunshine hours, and average annual temperature. Alcohol consumption data, pattern of drinking, health indicators, and alcohol-attributable fraction (AAF) of cirrhosis were

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Potential competing interests: None.

obtained. The global cohort revealed an inverse correlation between mean average temperature and average annual sunshine hours with liters of annual alcohol consumption per capita (Spearman's rho −0.5 and −0.57, respectively). Moreover, the percentage of heavy episodic drinking and total drinkers among population inversely correlated with temperature −0.45 and −0.49 ($P < 0.001$) and sunshine hours −0.39 and −0.57 ($P < 0.001$). Importantly, AAF was inversely correlated with temperature −0.45 ($P < 0.001$) and sunshine hours −0.6 ($P < 0.001$). At a global level, all included parameters in the univariable and multivariable analysis showed an association with liters of alcohol consumption and drinkers among population once adjusted by potential confounders. In the multivariate analysis, liters of alcohol consumption associated with AAF. In the United States, colder climates showed a positive correlation with the age-standardized prevalence of heavy and binge drinkers.

Conclusion: These results suggest that colder climates may play a causal role on AAF mediated by alcohol consumption.

Keywords

alcoholic liver disease; alcohol intake; climate; temperature; daylight hours

Introduction

Alcohol use is the most prevalent cause of advanced liver disease worldwide.[1–3] The World Health Organization (WHO) reports approximately 5.9% of all global mortalities in 2014 were attributable to alcohol misuse, up from 4% in 2004.[4] In the United States, not only is alcohol the most commonly used drug among adults, but direct economic implications are also hefty.[5] According to a recent report by the Centers for Disease Control and Prevention, direct and indirect costs of alcohol misuse in the United States alone exceeded US $249 billion per year.[6] As an increasing number of cirrhosis deaths worldwide are attributable to alcohol, the risk factors and associated variables with alcohol misuse need to be identified in order to establish preventative measures.[7]

Previous studies have demonstrated the link between patterns of alcohol use and an individual's probability for developing liver cirrhosis and associated morbidity and mortality at a population level.[8] Furthermore, recent epidemiological studies have established a relationship between ambient temperature and all-cause mortality.[9,10] For example, Gasparrini et al. demonstrated that most of the temperature-related mortality burden was attributable to the contribution of cold rather than hot temperatures.[10] Very few studies have investigated the possible link between alcohol consumption and climate parameters (temperature and sunshine hours), moreover, these studies have been performed in selected populations. Kupari et al. suggests a possible relationship between admission for atrial fibrillation and cold weather is due to an increase in alcohol sales and consumption.[11] A more recent study with Irish students points to low sunshine hours and high rainfalls as one of the multiple parameters influencing high alcohol intake.[12] Globally, Eastern Europe had the highest annual per capita consumption, with 15.7 L per person.[13,14] In contrast, North Africa/Middle East had the lowest adult per capita consumption, with 1.0 L per person. Not only climate-related variables, but also cultural and religious regions, could be suitable explanations for these differences.

To our knowledge, no studies have critically examined the potential compounding factors associated with annual average temperature, alcohol abuse, and mortality-related burden from alcoholic cirrhosis. Because meteorological patterns such as temperatures and daily sunlight hours vary considerably across the globe, we sought to investigate a possible causal relationship between colder temperatures and patterns of alcohol misuse and consumption in order to determine if climatic variables can be a predictive measure for the burden of alcohol-attributable cirrhosis worldwide.

Materials and Methods

We conducted a worldwide comprehensive, cross-sectional data analysis on 193 countries. To complement our global analysis, we conducted a detailed analysis in the United States (50 states and 3,144 counties).

Data Sources

Using the WHO Global Information System on Alcohol and Health (WHO-GISAH) database established in 2014,[4] we extracted country-specific data on patterns and levels of alcohol consumption, as well as our main outcome variable, the fraction of cirrhosis attributable to alcohol use (alcohol-attributable fraction [AAF]). Data from the U.S. alcohol consumption patterns of binge, heavy, and any drinkers were recorded from the Institute for Health Metrics and Evaluation (IHME) for the years 2002–2012.[15] Climatic variables were collected using multiple, validated databases. Average annual sunshine hours and average temperature data were retrieved from the World Meteorological Organization, the Climatic Research Unit of the University of East Anglia (http://www.cru.uea.ac.uk/data), and the World Bank Data Bank (http://databank.worldbank.org/data/home.aspx and https://www.currentresults.com.The predominate Koppen-Geiger Climate Classification was gathered from the Global Precipitation Climatology Centre of Germany (https://www.dwd.de/EN/ourservices/gpcc/gpcc.html)(16) and the University of Veterinary Medicine Vienna (http://koeppen-geiger.vu-wien.ac.at) (Supplementary Fig. S1). At a U.S. county level, we only had data from the Koppen-Geiger Climate Classification. Data of known factors that can play a role in both alcohol consumption and AAF of cirrhosis were also collected. Predominant religious data by country were compiled from the Central Intelligence Agency (CIA) World Factbook (https://www.cia.gov/library/publications/the-world-factbook/). Prevalence statistics on potentially predisposing factors for cirrhosis, including cigarette smoking and obesity, were abstracted from the WHO Global Health Observatory (GHO).[17] Data on diabetes prevalence were obtained from the International Diabetes Federation, and the Inequality-Adjusted Human Development Index (IHDI) was obtained from the United Nations Development Report. Finally, data on seroprevalence of hepatitis C virus (HCV) and hepatitis B virus (HBV) were obtained from published data by systematic reviews reporting HBV and HCV prevalence.[18,19] Information from all the data sets was the most comprehensive and up to date at the time of analysis.

Parameters for climate-related determinants of alcohol consumption

For the global analysis, we considered three parameters indicative of alcohol consumption: liters of annual alcohol intake per capita, percentage of drinkers among populations (the proportion of those in the population aged 15 years and older who consumed alcohol), and percent of heavy episodic drinking among population (consumers of 60 g or more of pure alcohol on at least one occasion in the past 30 days). We considered the following variables as potential climate-related determinants of alcohol consumption: average hours of annual sunshine, average yearly temperature, and Koppen-Geiger Climate Classification. This system divides climates into five main groups: A (tropical), B (dry), C (temperate), D (continental), and E (polar). If a country had more than one type of classification, the more predominant one or the classification with the higher population density was used in the analysis. Given that religion can be a confounding factor in the association between climate and alcohol consumption, we performed a subset of analyses excluding countries in which Islam is the predominant religion (countries with more than 50% of the population identified as Muslims according to the Center of Intelligence Agency).

For the U.S. analysis, we considered three outcomes of alcohol consumption: liters of annual alcohol intake per capita (available only at state level), age-standardized prevalence of any drinking (1 drink of any alcoholic beverage in the past 30 days), age-standardized prevalence of binge drinkers (5 or more alcoholic drinks for males or 4 or more alcoholic drinks for females on the same occasion, at least once in the past 30 days), and age-standardized prevalence of heavy drinking among population (consumption on average of more than 1 drink per day for women or 2 drinks per day for men in the past 30 days).

Parameters for climate-related determinants on cirrhosis burden

For the global analysis, we considered two parameters to measure the global burden of cirrhosis attributable to alcohol use. The primary outcome, AAF, is defined as the proportion of cirrhosis attributable to alcohol use in each country. This definition, set by the WHO, reflects the relative risk function of cirrhosis for alcohol consumption in both former and current drinkers. Supplementary Table S1 and Table S2 describe all variables included in the database and sources. For the U.S. analysis, we obtained alcohol-attributable years of potential life lost (YPLL) and AAF as the main outcomes of each individual state (Supplementary Table S3).

Statistical Analysis

Results are presented as means and standard deviations for normal continuous variables and median and interquartile range (IQR) for noncontinuous variables. Correlations between climate variables and alcohol consumption variables as well as health indicators were obtained with nonparametric correlations tests (Spearman’s Rho) for non-continuous variables. For Koppen Climate Classification (ordinal variable with ascending sort categories, from the hottest to the coldest climate), we used the Kendall’s tau test.

We conducted an analysis to investigate the potential causal relationship between climate parameters and health indicators of alcoholic cirrhosis burden, AAF, mediated by alcohol consumption (Supplementary Fig. S2). For this analysis, we considered several other potential confounding factors: religion, existence of a written national policy for alcohol consumption and IHDI. In the particular case of AAF, since this parameter quantifies the contribution of alcohol as a risk factor to cirrhosis (Supplementary Fig. S3) and the percentage of drinkers among population, the risk of a relative alcohol consumption in g/day was used to calculate this health indicator. We only included alcohol consumption variables not used to calculate the AAF. We considered the following variables as a potential climate-related determinant of AAF: average hours of annual sunshine and average yearly temperature. We also incorporated those factors known to be potential cofactors of alcoholic cirrhosis progression, such as seroprevalence of HCV and HBV, obesity (Body Mass Index >30), diabetes, IHDI, percentage of smokers, religion and inequality index. For this purpose, we used a proportional odds model that utilizes only the ranks of Y (with no binning). The proportional odds assumption is more likely to be satisfied than the assumptions of linear regression, and thus provides robust inference. Analysis was conducted in R, with the rms package (http://cran.r-project.org/web/packages/rms/index.htlm). The significance level was set at $p < 0.05$. We performed all analyses with both R and IBM SPSS software (Version 21). We used the https://public.tableau.com/en-us/s/software software to build the maps figures.

Results

Worldwide results

Impact of climate parameters on alcohol consumption.—We first analyzed whether there is any correlation between the average temperature, the annual hours of sunshine, and the annual per capita liters of alcohol consumption across 193 countries worldwide. We found a negative correlation between average temperature and liters of alcohol consumption (Spearman's Rho −0.502; $P < 0.001$) (Fig. 1). The average temperature also showed a negative correlation between the percentage of heavy episodic drinking (Spearman's Rho −0.45; $P < 0.001$) and the proportion of drinkers among the population (Spearman's Rho −0.48; $P < 0.001$). Moreover, the annual hours of sunshine exhibited a negative correlation with liters of alcohol consumption (Spearman's Rho −0.57; $P < 0.001$), percentage of heavy episodic drinking among the population (Spearman's Rho −0.38; $P < 0.001$), and of drinkers among the population (Spearman's Rho −0.57; $P < 0.001$). Given that religion can be a confounder factor on the association between climate and alcohol consumption, we reanalyzed the data excluding countries in which Islam is the predominant religion (>50% of the population) (Supplementary Figure S4). The correlation between climate parameters and alcohol consumption was found stronger in this subanalysis (Supplementary Table S4). Figure 2 shows a world map illustrating the inverse relationship between average annual temperatures, number of annual sunshine hours, and annual liters of alcohol intake per capita.

We then performed a focused analysis across the different Koppen classification climates (from hottest to coldest). We analyzed the correlation between the Koppen classification and liters of alcohol consumption, percentage of heavy episodic drinking among population, and percentage of drinkers among population. We found an inverse correlation between Koppen classification and the three variables (Table 1). We next plotted alcohol consumption and climate parameters by Koppen classification to visualize the progressive increase in alcohol consumption and the synchronic decrease of temperature through the different Koppen classification categories, except for polar countries represented only by Iceland (Fig. 3). For this analysis, we excluded Muslim countries, which are overrepresented within the dry

Koppen classification. The analysis for the whole cohort is shown in Supplementary Figure S5 and S6. Notably, we found a significant increase in the main alcohol consumption parameters, liters of alcohol consumption/year, and grams/day of alcohol consumption across the Koppen climates (Table 1). Variables related with the drinking pattern and drinking population (percentage of heavy episodic drinking among population percentage of heavy episodic drinking among drinkers, and percentage of drinkers among population) also showed similar behaviors across the Koppen classification (Table 1; Fig. 4). By contrast, the distribution of the type of preferred alcohol across the Koppen classification did not follow any specific pattern. The correlation between climate parameters, hepatitis seroprevalence, geographic characteristics, diabetes, IHDI, and traffic and homicide death rates by Koppen Climate Classification is depicted in Supplementary Table S5. Collectively, these results suggest the colder weather and fewer sunshine hours correlate inversely with heavier alcohol consumption at a global scale.

Impact of climate parameters on alcohol consumption and cirrhosis burden— Next, we sought to determine if climate parameters also influence the role of alcohol as a cause of cirrhosis. We first investigated the effect of climate parameters on alcohol consumption adjusted by possible confounders: IHDI, religion, and the existence of a national alcohol policy. In the univariate and multivariate analysis, all the included parameters showed an association with both liters of alcohol consumption and drinkers among population once adjusted by possible confounders. The exception was the association between climate parameters and percentage of heavy drinkers.

We next investigated if there was any impact of climate parameters and alcohol consumption parameters on AAF, incorporating the effect of possible confounders (HCV and HBV prevalence, percentage of obese population, and percentage of smokers among population, IHDI, and religion). In the univariable analysis, all included parameters showed a statistically significant association with AAF, except for diabetes and the highest prevalence of HBV. In the multivariable analysis, only liters of alcohol consumption (1.1; $P < 0.001$) (standardized coefficient; P values) and the lowest prevalence of HBV (−1.19; $P = 0.04$) remained as independent risk factors for AAF, while climate parameters did not. These results suggest that the effect of climate parameters on AAF of cirrhosis is mediated by alcohol intake (Table 2).

Finally, AAF presented a significant increase across the Koppen classification, although the AAF from tropical and dry countries was similar (Table 1).

U.S. Results

Impact of climate parameters on alcohol consumption at the county level.— We then studied the impact of climate parameters on alcohol consumption within the United States. We included data from 3,142 counties. Of importance, only 9 counties from Hawaii and Florida belonged to the tropical category in the Koppen classification and only 2 counties from Alaska to the polar category. We observed a positive, although less than 0.5, correlation between Koppen Climate Classification, the age-standardized prevalence of binge drinking (Kendall's tau_b −0.34; $P < 0.001$), the age-standardized prevalence of heavy drinking (Kendall's tau_b −0.35; $P < 0.001$), and the age-standardized prevalence of any drinking (Kendall's tau_b −0.34; $P < 0.001$) (Fig. 5). These results confirmed that colder weather also correlates with alcohol consumption at the U.S. level.

Impact of climate parameters on alcohol consumption and alcoholic liver disease at the state level—For this analysis, we included data from all 50 states from the United States. A negative correlation between age-standardized prevalence of heavy drinking (Spearman's Rho −0.57; $P < 0.001$), liters of alcohol consumption (Spearman's Rho −0.49; $P < 0.001$), age-standardized prevalence of binge drinking (Spearman's Rho −0.6; $P < 0.001$), and temperature was confirmed at the state level (Fig. 6). However, no correlation between sunshine hours and alcohol consumption parameters was observed. At the state level, we found a positive correlation between temperature and YPLL due to alcoholic liver disease. These results reinforced the data obtained at the global level.

Discussion

Globally, alcohol misuse is the most prevalent cause of advanced liver disease and liver-related mortality worldwide.[8] In clear contrast with the recent advances in the management of other common causes of cirrhosis (i.e., HCV and HBV), little attention has been paid to alcoholic liver disease. It is not surprising that the burden of liver diseases as a cause of mortality is steadily increasing.[20,21] We recently demonstrated that alcohol receives scant attention by the liver research community compared to other etiologies, such as viral hepatitis.[22] Identifying the main determinants of excessive alcohol consumption at a global scale can favor preventative measures at the public health level. Individual alcohol consumption is influenced by a vast range of phenomena, from genetic conditionings to historical and geographic characteristics. Traditionally, it has been widely accepted that colder countries have higher alcohol consumption and alcohol-related organ damage. However, this general assumption has not been decisively proven. In this study, we investigated a possible causal effect of climate parameters (temperature and sunshine hours) on alcohol consumption (quantity and patterns) at a population level. To address this question, we used a wide array of available data, including climate parameters from official sources, both globally and in the United States in order to minimize the risk of bias. We encountered some difficulties in collecting climate parameters at the local level, especially at the county level in the United States. This study is based on a secondary analysis of preexisting data. We attempted to ensure consistency by using the same time frame for all abstracted data. Whenever possible, we used the same alcohol health indicators related to alcohol consumption at the U.S. and worldwide levels, but available variables were not always homogeneous.

We consistently found that sunshine hours and especially temperature, have an impact on alcohol consumption and, even more importantly, on the percentage of drinkers among a population. The proportion of heavy episodic drinkers among a population is not clearly affected by climate parameters when adjusted for possible confounders. It is important to highlight that although most alcohol consumption-related variables are intimately related, each variable has its own unique value. For example, heavy episodic drinking is known to exacerbate the effects of obesity in promoting advanced liver disease.[23–24]

Obviously, climate variables are not the only parameters that impact alcohol consumption at the population level. Other factors, such as religion, economic, educational, or cultural influences, may have a major impact in some countries. Therefore, we controlled the analysis by multiple possible confounders, such as religion (Muslim countries where the reported alcohol consumption is negligible) and IHDI. Even though we controlled for potential confounders, the role of other potential residual confounding factors, such as the type and number of alcohol policies by country, cannot be ruled out. Further studies should specifically investigate the impact of sociocultural parameters, including religion, on the prevalence of alcohol use disorder and alcoholic cirrhosis.

In addition to a global analysis, we performed a focused study at a lower geographical scale. Although the United States is an enormous country comprising several different climate types, it shares many sociocultural aspects. Therefore, it was not surprising that the correlations between climate and alcohol consumption parameters were somehow weaker than in the global study. It is important to take into consideration that the IQR for temperature and annual sunshine hours in the United States was 7.8°C and 460 hours, respectively much lower than 14.8°C and 866 hours in the global study. Moreover, the warmest regions in the United States (Hawaii and Florida) are recreational areas, so cultural factors may have a deep impact on alcohol consumption parameters within those areas. Religious beliefs could be a contributing factor in the United States where areas with the least alcohol intake, such as Utah or states in the southeast, are densely populated by believers in different branches of the Christian religion that do not condone alcohol intake. Another quality of the United States is the high interstate mobility of its population. Unfortunately, we did not have specific data regarding interstate mobility. In addition, in some states, alcohol policies are particularly strict. Independently of the confounding factors, however, a strong correlation between temperature and age-standardized prevalence of heavy and binge drinking, as well as liters of alcohol consumption, reinforces the role of temperature. It is plausible that other large countries with climate diversity have similar behaviors in terms of climate influence on alcohol consumption.

Finally, we want to highlight that our results suggest a potential causal effect of climate parameters on health indicators, including AAF of cirrhosis, mediated by an increase in alcohol consumption. Certainty, observational studies cannot definitely prove causation. Different studies have assessed the potential influence of cold weather on alcohol consumption and on the consequences of alcohol and its main intermediate, acetaldehyde.[25,26] This mediator contributes to the etiology of liver cirrhosis by altering nervous and endocrine system functions, resulting in reduced perception of cold and simultaneous sensation of euphoria following ingestion. Reinforcing “warm” sensations, in part accomplished through the inhibition of shivering thermogenesis, vasodilation, and hormonal disturbances, can be potentially harmful in the setting of lower temperatures.[27–29] Chronic alcohol ingestion also leads to dysregulation of physiological functions, with ramifications ranging from psychological stress and impairment to permanent pathological alterations.[30] Finally, it has been proposed that cold temperature might increase alcohol toxicity through its effects on different oxidative mechanisms.[31–35] Based on these biological and behavioral properties, it has been proposed that countries exposed to colder climates have an increased incidence of alcohol consumption and, subsequently, an amplified prevalence of alcohol-induced organ damage, such as alcoholic liver disease. Cofactors known to exacerbate the risk of alcohol abuse include depression and the change of seasons for which a causal relationship has been well established.[36–38] Conversely, sunlight exposure has been associated as a possible protective factor for mood-related disorders, such as seasonal affective disorder.[38] Any combination of mental health disorders with patterns of excessive alcohol misuse could prove to be especially detrimental if accompanied with lower temperatures and reduced sunlight hours. Not only mental disorders, but also myocardial ischemia, have been associated with the power of daylight to entrain and resynchronize circadian rhythms.[39] These studies, along with our results, suggest that countries with colder weather and fewer hours of sunshine should enhance their alcohol preventive polices. Nevertheless, further studies are needed to confirm the impact of seasonal variability on alcohol consumption in a given country.

In conclusion, colder weather and fewer sunshine hours are possible causal agents for higher alcohol consumption worldwide and correlate with the pattern of alcohol consumption within the United States. Our results suggest that weather parameters may play a role on AAF mediated by alcohol consumption and by the variation in the number of drinkers. Public health measures aimed at preventing excessive alcohol consumption should focus on regions with colder climates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Conflict of interest and financial support:

Financial support: R.B is a recipient of NIAAA U01AA021908 and U01AA020821. M.C.L. and J.A. are supported by the National System of Researchers (SNI) of the Mexican National Council for Science and Technology (CONACyT). M.V.C. and C.F.C. are recipients of a scholarship grant for study extension abroad, sponsored by the Spanish Association for the Study of the Liver (AEEH).

Abbreviations:

AAF	alcohol-attributable fraction
HBV	hepatitis B virus
HCV	hepatitis C virus
IHDI	Inequality-Adjusted Human Development Index
WHO	World Health Organization

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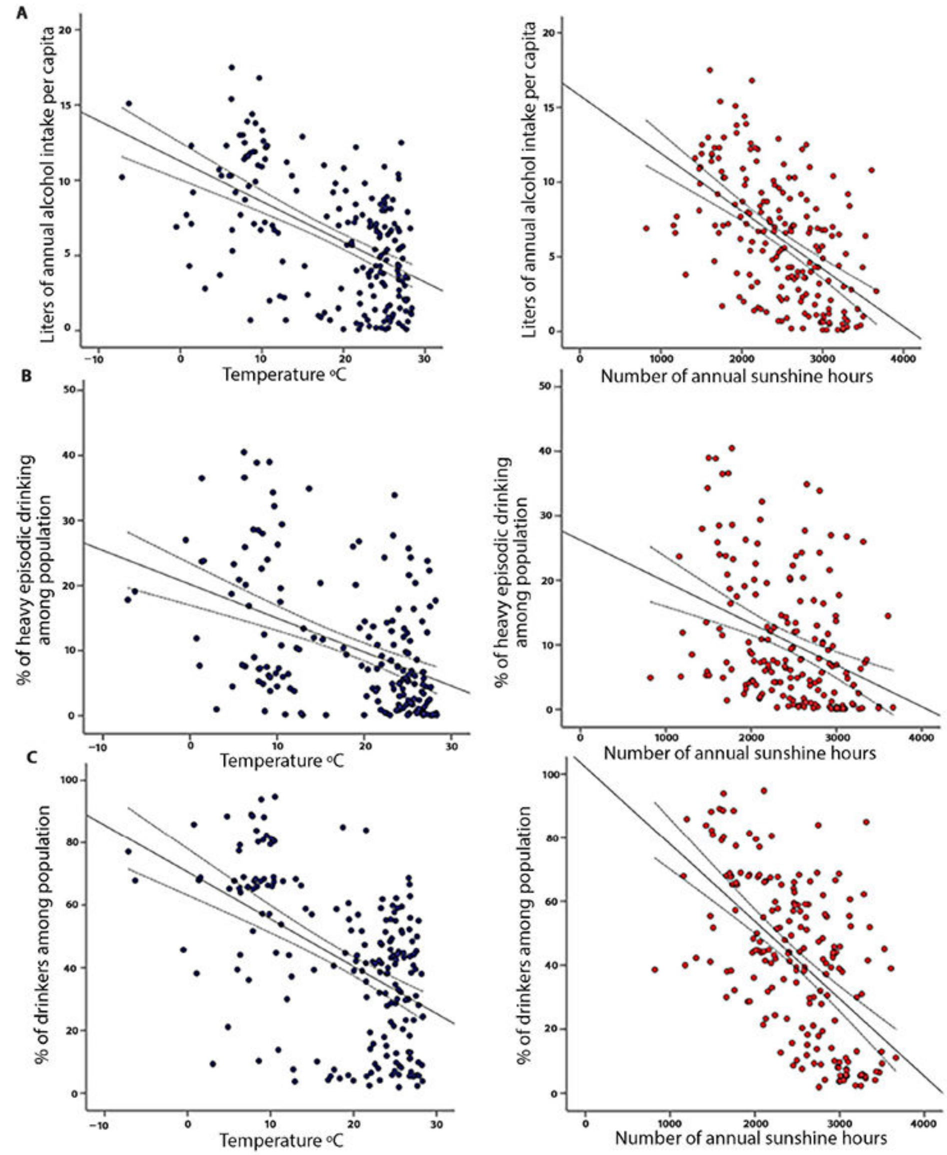

FIG. 1. Correlations between climate parameters and alcohol consumption.

(A) Correlation between average temperature, number of annual sunshine hours, and annual liters of alcohol intake per capital. **(B)** Correlation between average temperature, number of annual sunshine hours, and percentage of heavy episodic drinking among population. **(C)** Correlation between average temperature, number of annual sunshine hours, and percentage of drinkers among population.

Legend: %, percentage; °C, Celsius.

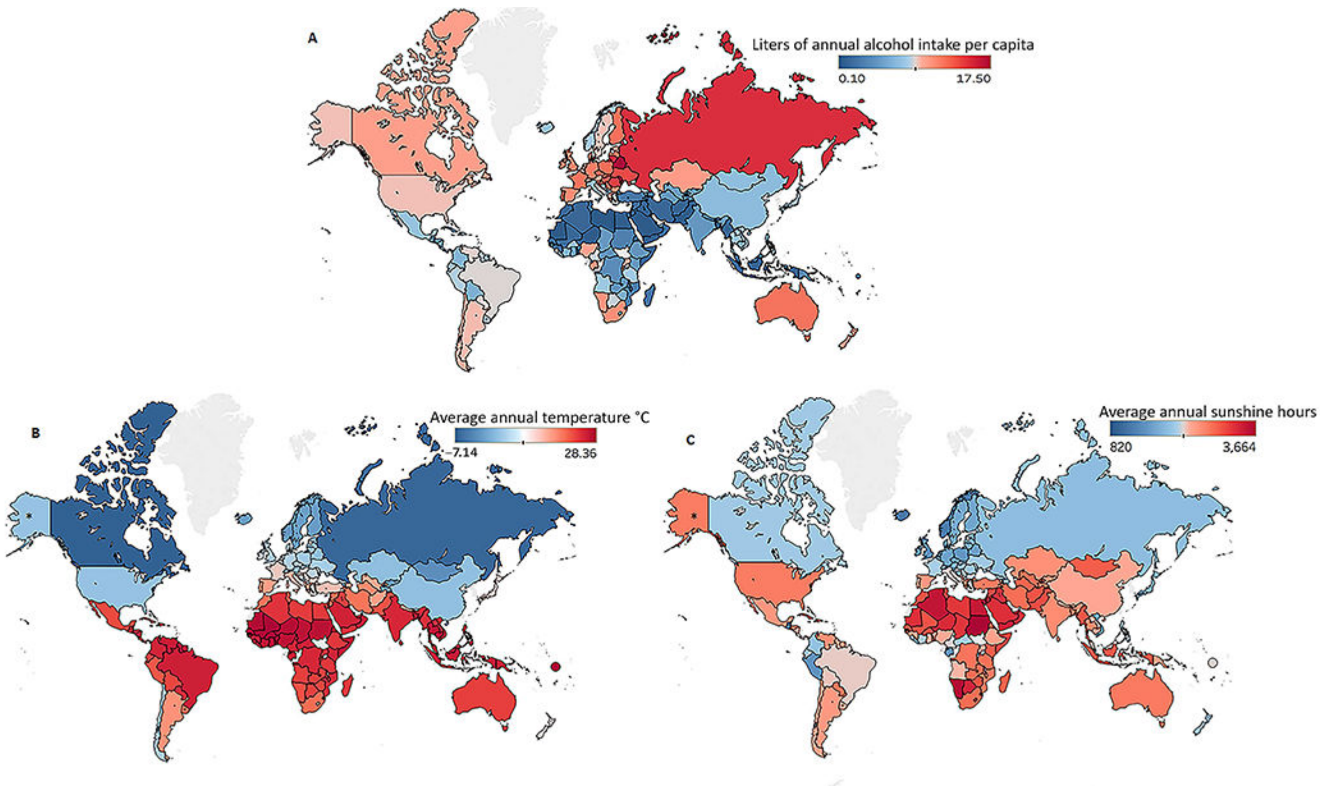

FIG. 2. Worldwide map showing an inverse relationship between average annual temperature, number of annual sunshine hours, and annual liters of alcohol intake per capital.

(A) Annual liters of alcohol intake per capital by country. (B) Average annual temperature by country. (C) Annual sunshine hours by country.

Legend: *Alaska as part of the United States has been assigned the same mean temperature and sunshine hours as the rest of the country. Abbreviations: °C, Celsius.

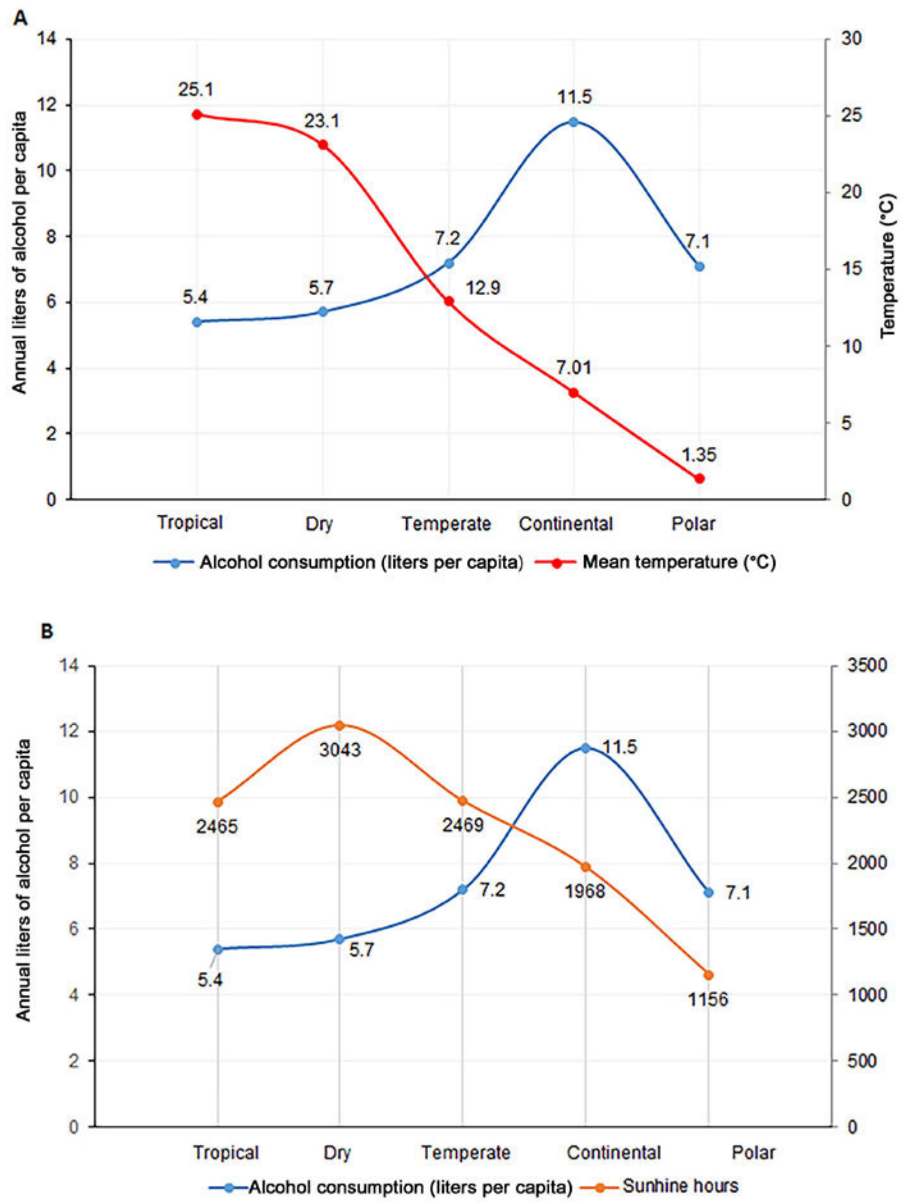

FIG. 3. Evolution of alcohol consumption and climate parameters according to the Koppen classification.

(A) Temperature and alcohol consumption evolution by Koppen classification in non-Muslim majority countries. **(B)** Number of annual sunshine hours and alcohol consumption evolution by Koppen classification in non-Muslim majority countries.

Legend: *Non-Muslim countries: Countries with less than 51% of the population identified as Muslims according to the Center of Intelligence Agency.

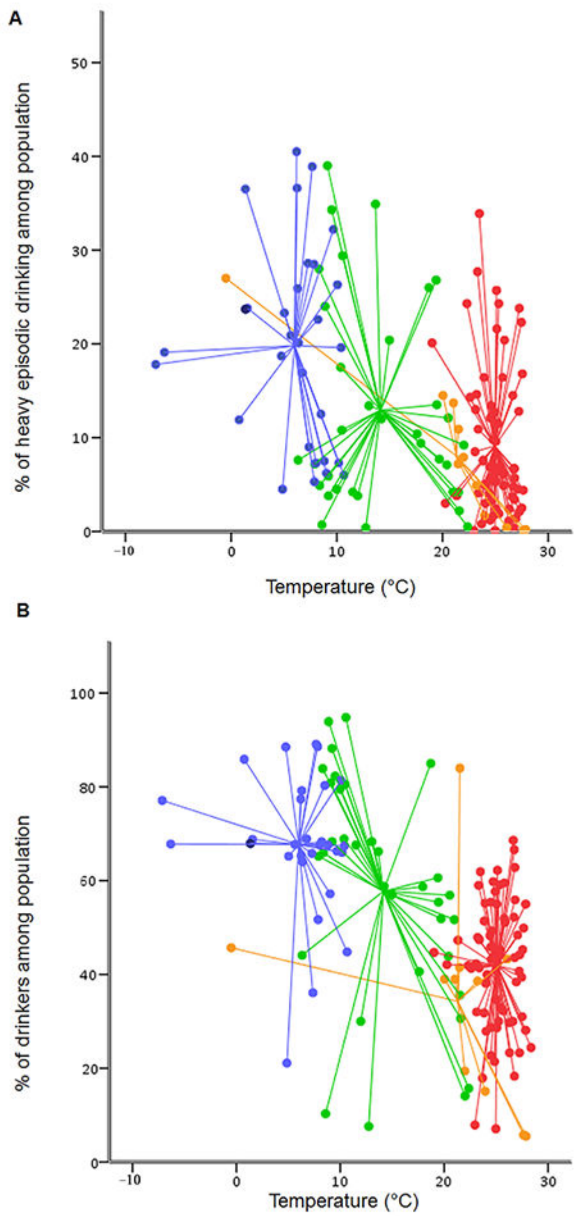

FIG. 4. Alcohol consumption patterns and temperature according to the Koppen classification.
(A) Temperature and percentage of heavy episodic drinking among population by Koppen classification within non-Muslim countries. **(B)** Temperature and percentage of drinkers among population by Koppen classification within non-Muslim countries.
Legend: %, percentage; °C, Celsius. Non-Muslim countries: Countries with less than 50% of the population identified as Muslims according to the Center of Intelligence Agency.

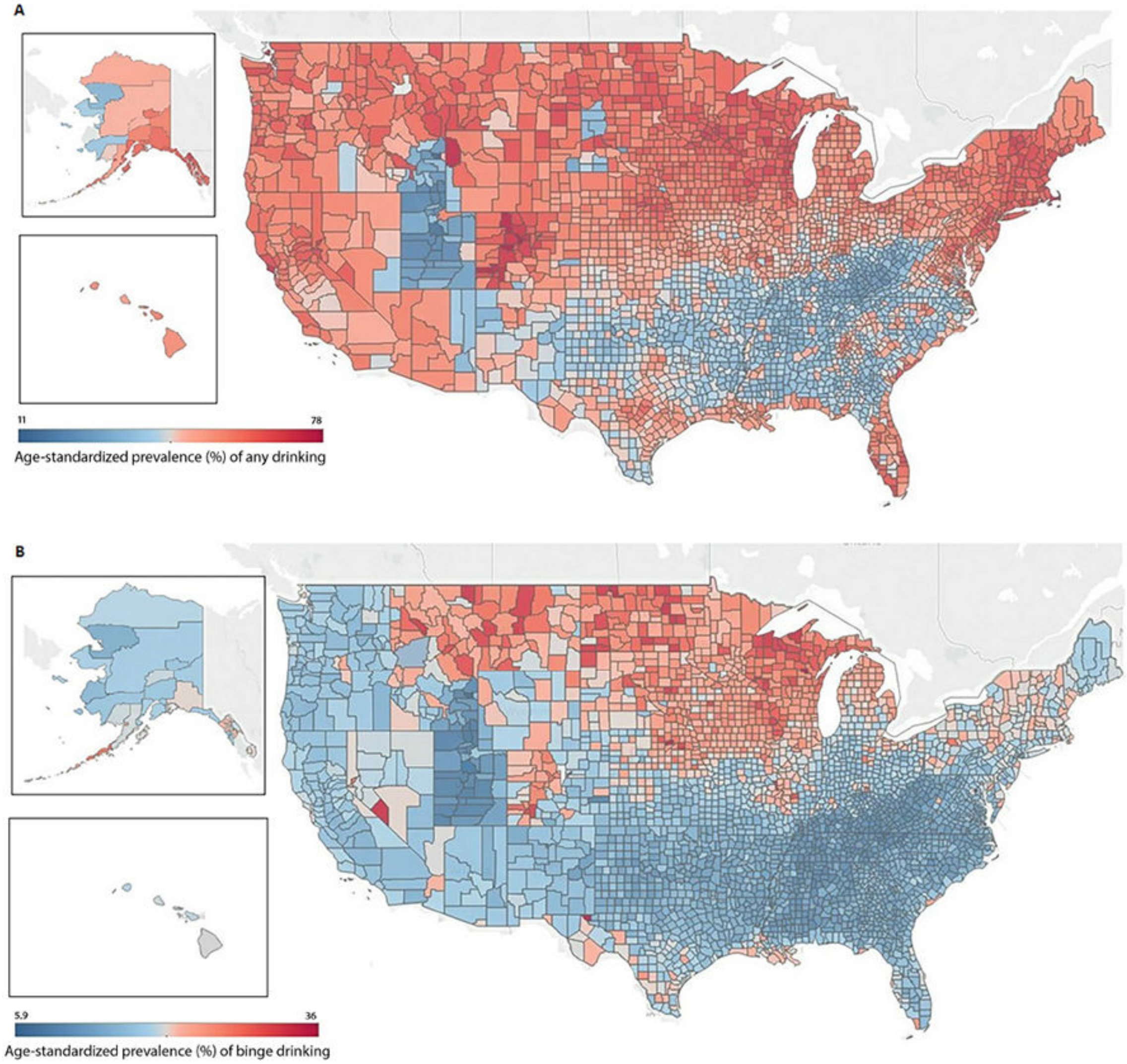

FIG. 5. U.S. county map according to alcohol consumption patterns.

(A) Age-standardized prevalence of any drinking expressed as percentage. **(B)** Age-standardized prevalence of binge drinking expressed as percentage.

Legend: %, percentage.

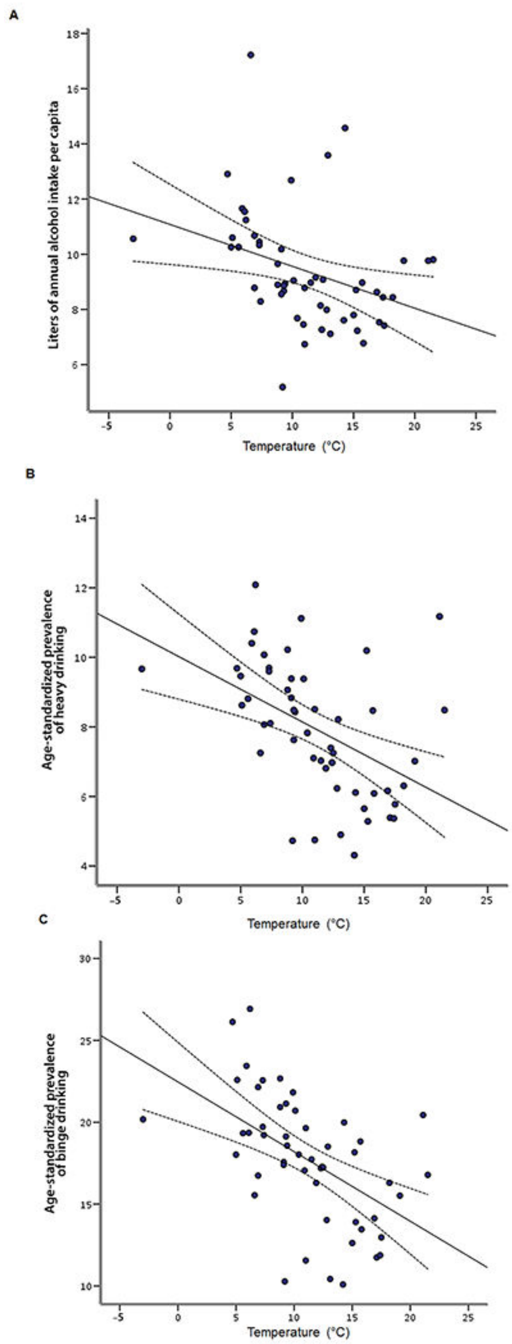

FIG. 6. Correlation between climate parameters and alcohol consumption at the state level in the United States.

(A) Correlation between average temperature and liters of annual alcohol intake per capita. **(B)** Correlation between average temperature and age-standardized prevalence of heavy drinking. **(C)** Correlations between average temperature and age-standardized prevalence of binge drinking.

Legends: %, percentage; °C, Celsius.

TABLE 1.

Koppen Climate Classification and parameters related to alcohol drinking and etiology factors for cirrhosis worldwide

.

Type of climate (number of countries)	Tropical n = 81	DryΔ n = 35	Temperate n = 44	Continental n = 32	Polar n = 1	Worldwide n = 193	Kendall's tau-b *P* Value*
Alcohol consumption and type median (IQR)							
Average consumption (g/day)	27.8 (18.4–38.9)	32.4 (11.8–48.7)	29.4 (24.3–36.6)	37.9 (29.1–47.6)	22.1	29.9 (22.8–41.7)	0.16 0.004
Average alcohol per capita (15+) consumption (in liters of pure alcohol)	5.4 (3.1–7.3)	1.5 (0.5–4.4)	7.2 (3.7–10.9)	11.5 (9.2–13)	7.1	6.5 (2.5–9.2)	0.29 <0.001
Wine consumption (%) as a percentage of recorded alcohol per capita consumption	2.9 (0.9–13.7)	3.4 (1.3–11.6)	26 (3.9–41.8)	17.4 (7.2–30.7)	21.2	7.3 (1.7–22.3)	0.29 <0.001
Beer consumption (%) as a percentage of recorded alcohol per capita consumption	41.8 (23.5–66.4)	32.7 (11.1–57.6)	39.5 (30.3–50)	39.9 (30.3–50)	61.8	40.5 (23.5–54.7)	−0.04 0.5
Spirits consumption (%) as a percentage of recorded alcohol per capita consumption	29.6 (6.3–54.9)	24.2 (3.7–68)	21 (14–38.1)	33.7 (18.9–46.9)	16.5	25.7 (12.5–51.1)	0.027 0.6
Other alcohol consumption (%) as a percentage of recorded alcohol per capita consumption	0.2 (0–1.8)	0.1 (0–17.2)	0.3 (0–5.2)	0 (0–3.3)	0.5	0.2(0–4.3)	−0.05 0.4
Drinking pattern and drinking population median (IQR)							
Heavy episodic drinking among population (%)	5.6 (2.4–12.8)	0.9 (0.2–10.7)	7.2 (3.8–15.5)	19.1 (7.7–26.3)	23.7	7.2 (2.6–16.6)	0.22 <0.001
Heavy episodic drinking among drinkers (%)	11.7 (8.1–29.2)	2.3 (0.5–27.7)	13.1 (6.5–25.6)	26.6 (14.3–34.1)	34.9	12.9 (6.1–34.1)	0.1 0.05
Drinkers among population (%)	42 (28.6–49.8)	9.7 (5.4–38.6)	56.9 (26.4–68.5)	67.6 (58.9–77.3)	67.9	43.5 (20.9–60.9)	0.24 <0.001
Health indicators related to alcohol consumption median (IQR)							
AAF (%)	50.3 (39.6–57.8)	20.2 (11–48.5)	57 (46.9–66.3)	62.2 (58.3–68.2)	55.5	54 (36–62)	0.24 <0.001

AAF, alcohol-attributable fraction of cirrhosis; g/day, grams per day; IQR, interquartile range. *Δ 24 out of the 35 countries with Dry Koppen Climate Classifications have Islam as the predominant religion.

Data for dry countries without predominant Muslim countries were: liters of alcohol consumption/year: 5.7 (1.3–8.4); grams of pure alcohol/day (average daily intake of alcohol per capita, 2010, in grams of pure alcohol; 15+ years): 32.4 (27.6.5–49.4); alcohol per capita consumption by type of alcoholic beverage (beer, wine, spirits, other), 2010 (as a percentage of recorded alcohol per capita consumption; 15+ years); wine consumption 2.8 (0.3–11.8); beer consumption 44 (23.2–63); spirits consumption 12.5 (3.6–69.6); other alcohol consumption 4.3 (0–36.3). Moreover, percentage of heavy episodic drinking among population: 7.2% (0.4–13.7); heavy episodic drinking among drinkers: 13% (3.4–37.2); drinkers among population: 39% (15.1–43.3), AAF 46.9 (32.7–58.5), and ASDR 29.6 (14.3–37.6).

TABLE 2.

Proportional odds analysis of the factors potentially influencing alcohol intake, alcohol consumption patterns, alcohol-attributable fraction (AAF) of cirrhosis, and age-standardized death rate (ASDR) for liver cirrhosis

.

Univariable						
	Liters of alcohol consumption		Drinkers among population		Heavy drinkers among population	
	Standardized coefficient	*P value*	*Standardized coefficient*	*P value*	*Standardized coefficient*	*P value*
Average temperature	−0.13	<0.001	−0.12	<0.001	−0.095	<0.001
Annual sunshine hours	−0.0010	<0.001	−0.002	<0.001	−0.0014	<0.001
Written national policy[**]	1.17	<0.001	1.2	<0.001	0.8	0.004
IHDI	6.4	<0.001	10.8	<0.001	5.7	<0.001
Non-Muslim countries	2.98	<0.001	3.47	<0.001	2.4	<0.001
Multivariable						
	Liters of alcohol consumption		**Drinkers among population**		**Heavy drinkers among population**	
	Standardized coefficient	*P value*	*Standardized coefficient*	*P value*	*Standardized coefficient*	*P value*
Average temperature	−0.09	0.0003	−0.05	0.04	−0.05	0.056
Annual sunshine hours	−0.0009	0.005	−0.0008	0.01	−0.0003	0.3
IHDI	3.3	0.005	9.6	<0.001	3.8	0.001
Non-Muslim countries	3.1	<0.001	3.62	<0.001	2.4	0.004

	Univariable		**Multivariable**	
	AAF[*]		**AAF**[*]	
	Standardized coefficient	*P value*	*Standardized coefficient*	*P value*
Liters of alcohol consumption	1.03	<0.001	1.1	<0.001
Average temperature	−0.11	<0.001	0.03	0.3
Annual sunshine hours	−0.0021	<0.001	0.00001	0.9
Drinkers among population	NI		NI	
Heavy drinkers among population	0.13	<0.001	−0.01	0.7
HCV prevalence (%)	0.95	<0.001	−0.46	0.3

HBV prevalence <2% 2%–4% 5%–7% >8%	1.34 −0.49 −0.29 −0.42	<0.001 0.09 0.3 0.3	Reference category for HBV −1.19 0.78 1.18	0.04 0.3 0.3
Obesity (% population BMI >30)	−1.66	0.001	−0.02	0.5
Smokers (% daily smokers among population)	0.079	<0.001	0.001	0.9
Diabetes (% population with diabetes)	−0.05	0.3	0.1	0.2
IHDI	4.9	<0.001	1.6	0.5
Non-Muslim countries	3.2	<0.001	−0.8	0.3

* Only factors not included in the calculation of AAF have been explored.

** The existence of a written national policy for the use and control of alcohol consumption was considered as a confounded factor because the existence of such policies could represent the response to a high alcohol consumption or in some cases the response to religious beliefs (complete ban of alcohol in some countries); for this reason, we have not included this variable in the multivariable analysis.

Abbreviations: AAF, alcohol-attributable fraction; BMI, body mass index; CI, confidence interval; HBV, hepatitis B virus; HCV, hepatitis C virus; IHDI, Inequality-Adjusted Human Development Index; NI, not included; RC, regression coefficient.