Global alcohol exposure between 1990 and 2017 and forecasts until 2030: a modelling study

Jakob Manthey, Kevin D Shield, Margaret Rylett, Omer S M Hasan, Charlotte Probst, Jürgen Rehm

Summary

Background Alcohol use is a leading risk factor for global disease burden, and data on alcohol exposure are crucial to evaluate progress in achieving global non-communicable disease goals. We present estimates on the main indicators of alcohol exposure for 189 countries from 1990–2017, with forecasts up to 2030.

Methods Adult alcohol per-capita consumption (the consumption in L of pure alcohol per adult [≥15 years]) in a given year was based on country-validated data up to 2016. Forecasts up to 2030 were obtained from multivariate log-normal mixture Poisson distribution models. Using survey data from 149 countries, prevalence of lifetime abstinence and current drinking was obtained from Dirichlet regressions. The prevalence of heavy episodic drinking (30-day prevalence of at least one occasion of 60 g of pure alcohol intake among current drinkers) was estimated with fractional response regressions using survey data from 118 countries.

Findings Between 1990 and 2017, global adult per-capita consumption increased from 5·9 L (95% CI 5·8–6·1) to 6·5 L (6·0–6·9), and is forecasted to reach 7·6 L (6·5–10·2) by 2030. Globally, the prevalence of lifetime abstinence decreased from 46% (42–49) in 1990 to 43% (40–46) in 2017, albeit this was not a significant reduction, while the prevalence of current drinking increased from 45% (41–48) in 1990 to 47% (44–50) in 2017. We forecast both trends to continue, with abstinence decreasing to 40% (37–44) by 2030 (annualised 0·2% decrease) and the proportion of current drinkers increasing to 50% (46–53) by 2030 (annualised 0·2% increase). In 2017, 20% (17–24) of adults were heavy episodic drinkers (compared with 1990 when it was estimated at 18·5% [15·3–21·6%], and this prevalence is expected to increase to 23% (19–27) in 2030.

Interpretation Based on these data, global goals for reducing the harmful use of alcohol are unlikely to be achieved, and known effective and cost-effective policy measures should be implemented to reduce alcohol exposure.

Funding Centre for Addiction and Mental Health and the WHO Collaborating Center for Addiction and Mental Health at the Centre for Addiction and Mental Health.

Published **Online** May 7, 2019 http://dx.doi.org/10.1016/S0140-6736(18)32744-2

See **Online/Comment** http://dx.doi.org/10.1016/S0140-6736(18)33002-2

Institute of Clinical Psychology and Psychotherapy, TU Dresden, Dresden, Germany (J Manthey MA, Prof J Rehm PhD); **Institute for Mental Health Policy Research** (K D Shield PhD, M Rylett MA, O S M Hasan BA, C Probst PhD, Prof J Rehm), **Campbell Family Mental Health Research Institute** (Prof J Rehm), **and WHO Collaborating Centre for Addiction and Mental Health** (Prof J Rehm), **Centre for Addiction and Mental Health, Toronto, ON, Canada; and Dalla Lana School of Public Health** (K D Shield, O S M Hasan, Prof J Rehm), **Institute of Medical Science, Medical Sciences Building** (K D Shield, Prof J Rehm), **and Department of Psychiatry** (Prof J Rehm), **University of Toronto, Toronto, ON, Canada**

Correspondence to:
Mr Jakob Manthey, Institute of Clinical Psychology and Psychotherapy, TU Dresden, Chemnitzer Strasse 46, 01187 Dresden, Germany
jakob.manthey@tu-dresden.de

For more on **SDG 3.5** see https://sustainabledevelopment.un.org/sdg3

Introduction

Alcohol use is a major risk factor for burden of disease.[1–3] Alcohol is a unique risk factor because it leads to an increased risk of disability and death from a broad range of causes,[4] with mostly low population-attributable fractions for single conditions, but a high overall burden when cumulated across conditions.[1,2] Specifically, alcohol is causally related to more than 200 International Classification of Disease three-digit codes,[4] including non-communicable diseases (NCDs) and injuries.

Alcohol is the only risk factor for which more than one dimension must be considered when modelling the attributable burden of disease. These dimensions include the average level of use as well as the pattern of drinking, operationalised by heavy episodic drinking occasions.[5] Heavy episodic drinking is important to consider, because the attributable burden is affected by whether an amount of alcohol is consumed in small doses over time or in larger doses on a few occasions.[4]

Because of the attributable burden, monitoring and surveillance of alcohol use is part of several international frameworks, most prominently WHO's Global Action Plan for the Prevention and Control of NCDs 2013–2020 (with a specific target of reducing the harmful use of alcohol by 10%), the Sustainable Development Goals (SDGs; reduction of harmful use is explicitly included in SDG 3.5, and WHO's Global Strategy to Reduce the Harmful Use of Alcohol.[6] The main indicator for these targets is adult alcohol per-capita consumption, which is monitored by ongoing literature searches, with yearly reporting of alcohol exposure indicators within the SDG framework.[6]

In the past 3 decades, alcohol use has been declining in many western European countries,[7] while it has been increasing in several Asian countries—most notably in India—albeit from substantially lower levels.[2,5] For China, there has been a net increase in alcohol use since 1990, with periods of stagnation and decline for various reasons, such as alcohol policies.[8] In contrast to North African and Eastern Mediterranean countries, alcohol use in sub-Saharan Africa has been above the global average since 2005.[2,9] In South America, alcohol use has traditionally been lower than in North American countries.[5] As diverging trends in alcohol use have been

Research in context

Evidence before this study

A literature search was conducted on Global Health data exchange, UNICEF – MICS, Demographic and Health surveys, WHO Multi-Country Studies Data Archive, The Health Navigator, International Household Survey Network, and Google as well as Google Scholar using the following term list: ("alcohol" OR "health") AND "study" AND "country name" AND "year". Alcohol use is a major risk factor for burden of disease. Data on alcohol exposure are regularly updated for the Global Burden of Diseases Injuries, and Risk factors studies and for the Global Status Reports on Alcohol and Health (both provide data up to 2016 in the most recent versions). Large differences exist in the levels of alcohol consumed between countries, sexes, and age groups. The aim was to provide a complete, ie, global assessment of all relevant alcohol use indicators for all countries since 1990, in addition to providing forecasts until 2030.

Added value of this study

This study presents the most up-to-date data, based on a revised and systematic modelling approach to determine alcohol exposure globally. All data up to 2016 have been validated, by country, using WHO procedures, and show a marked increase in alcohol use from 1990 to 2017. For 2010–17, the most notable increases in alcohol per-capita consumption were recorded in countries in the WHO southeast Asian and western Pacific regions (eg, a 38% increase in India, from 4·3 to 5·9 L; and a 90% increase in Vietnam, from 4·7 to 8·9 L), while there were decreases in alcohol consumption in countries in the WHO European region (eg, an 82% decrease in Azerbaijan, from 2·9 to 0·5 L; a 22% decrease in Russia, from 15·8 to 12·3 L; and a 7·4% decrease in the UK, from 12·3 to 11·4 L) and in some countries in South America (eg, a 24% decrease in Peru, from 8·0 to 6·1 L). Overall, increases in alcohol exposure at the global level are attributable to a marked growth in alcohol use in lower-middle-income countries. Global alcohol use is expected to further increase, driven by increases in use in WHO southeast Asian and western Pacific countries.

Implications of all the available evidence

Global targets to reduce harmful alcohol use, as outlined in the Non-Communicable Disease Framework and the Sustainable Development Goals, will not be achieved based on projected trends. Known effective and cost-effective policy measures should be implemented to reduce alcohol exposure.

seen across the globe in recent years, a summary of past trends and forecasts of alcohol use is required to assess progress towards achievement of the NCD and SDG goals on reducing the harmful use of alcohol.

We aim to present a regional and global overview of alcohol use as an exposure for burden of disease in 2017; provide past trends and forecasts of alcohol use, by sex, country, and region since 1990; and forecast alcohol use indicators by sex up to and including 2030. These forecasts cover all the relevant dimensions necessary to model the burden of disease associated with alcohol:[2,10] alcohol per-capita consumption, drinking status (ie, prevalence of current drinking and lifetime abstinence), and prevalence of heavy episodic drinking.

Methods

Data sources and statistical modelling

See Online for appendix 2

This study fully adheres to the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement (see appendix 1). We used three different statistical models (figure 1), which are comprehensively described in appendix 1. The key indicator for the average level of alcohol use in a country is alcohol per-capita consumption, defined as the consumption in L of pure alcohol per adult (≥15 years) in a given year.[11] Per-capita consumption is calculated as the sum of recorded and unrecorded consumption[12,13] and is corrected for the consumption of both inbound and outbound tourists for each country. With these data, the overall volume of alcohol consumed can be obtained and divided by the adult population size to calculate per-capita consumption.

See Online for appendix 1

Per-capita alcohol consumption data have been continuously collected by WHO for all member states since 1996 within the Global Information System on Alcohol and Health.[11] This database contains data on recorded consumption from 1960 onwards, and alcohol per-capita consumption from 1990. The largest portion of alcohol per-capita consumption globally stems from recorded consumption, which is either based on taxation records or estimated via production, import, and export.[11,14] Many countries (n=45) estimate recorded consumption as part of their routine statistics. For all other countries, data are collected regularly from published sources of industry or from UN organisations, and published in the Global Information System on Alcohol and Health.[15] For the vast majority of countries (n=176), data are available until 2015 or 2016 (appendix 2, tab 1). For all years with available per-capita consumption data, unrecorded per-capita consumption was calculated using proportions based on a recently published global modelling study,[12] and corrections due to tourist consumption were obtained from the Institute for Health Metrics and Evaluation (IHME). Within regular monitoring for international frameworks, alcohol per-capita consumption data have been validated by WHO member states up to and including 2016.

For all remaining years (primarily 2016 or 2017 to 2030), alcohol per-capita consumption data were forecasted at the country level using multivariate log-normal mixture Poisson models[16] (model A; figure 1). More specifically, both recorded and unrecorded data were modelled based on current and historical recorded and unrecorded per-capita consumption, gross domestic

product per capita at purchasing power parity (GDP-PPP), and the proportion of the population that identifies as Muslim.[17,18] Both covariates were entered as time-varying variables and comprised historical and forecasted data. When data were not well described by the model, restrictions in covariates or restrictions (or both) in the years included in the time series model were applied (appendix 1).

For better stability and comparability with WHO statistics, all presented per-capita consumption values were 3-year moving averages. Thus, the year 2017 was comprised of 2016, 2017, and 2018 (2017 and 2018 being estimates).

There are three mutually exclusive indicators for drinking status: lifetime abstention, former use (ie, lifetime alcohol use but not in the past 12 months), and current drinking (ie, any alcohol use in the past 12 months). Since the prevalence of former drinkers can be derived from the prevalence of lifetime abstainers and current drinkers, presentation of these numbers was omitted from this study. Heavy episodic drinking was defined as the 30-day prevalence of at least one occasion of 60 g of pure alcohol intake among current drinkers.[2] This definition was used because it is relevant for modelling ischaemic heart disease risk.[19]

Data on drinking status and heavy episodic drinking were collected via published survey reports, and individual-level survey datasets. From published survey reports, the study team extracted publications on nationally or regionally representative samples from 144 countries that reported drinking status, heavy episodic drinking estimates, or both. From individual-level survey datasets, data on about 630 000 individuals across 108 countries from five types of surveys were analysed (details in appendix 1). The results from both published survey reports and individual-level survey datasets were combined with the database created by Shield and colleagues[20] to produce estimates for the latest global overview of alcohol exposure. The final database featured sex-stratified and age-stratified aggregate estimates of drinking status for 149 countries and of heavy episodic drinking for 118 countries (details in appendix 2, tab 1).

Using these data as input, two separate regression models were fitted to estimate country-specific, year-specific, age-specific, and sex-specific estimates for drinking status (model B1; figure 1) and heavy episodic drinking among current drinkers (model B2; figure 1) for 1990 to 2030. In model B1, we used a Dirichlet regression[21] to estimate the prevalence of lifetime abstinence, former drinking, and current drinking. These models are suited for compositional data and impose a sum-constraint, where the proportions add up to one across all dependent variables. In model B2, the prevalence of heavy episodic drinking among current drinkers was estimated using a fractional response regression, which allows modelling for proportions similar to logistic regressions. In both models, alcohol per-capita consumption (historical data and forecasts from model A), GDP-PPP (time-varying across all years),[17] Global Burden of Disease (GBD) regions,[22] Muslim population size (time-varying across all years), and Muslim-majority countries with alcohol prohibition,[23] were entered as covariates. In model B2, the prevalence of past-year abstainers (obtained from model B1) was also used to predict the prevalence of heavy episodic drinking. A comprehensive model summary is provided in appendix 1.

Data combination and processing

All data from models A and B were combined, resulting in alcohol exposure data for 189 countries from 1990 to 2030. The prevalence of heavy episodic drinking in the adult population was derived by combining the prevalence of current drinking with that of heavy episodic drinking among current drinkers. The ratio of male-to-female drinkers was calculated by dividing the prevalence of male drinkers by the prevalence of female drinkers. Adult alcohol per-capita consumption was disaggregated by sex and age using data on drinking status (model B1) and the average alcohol intake level obtained from surveys (details in appendix 1). To

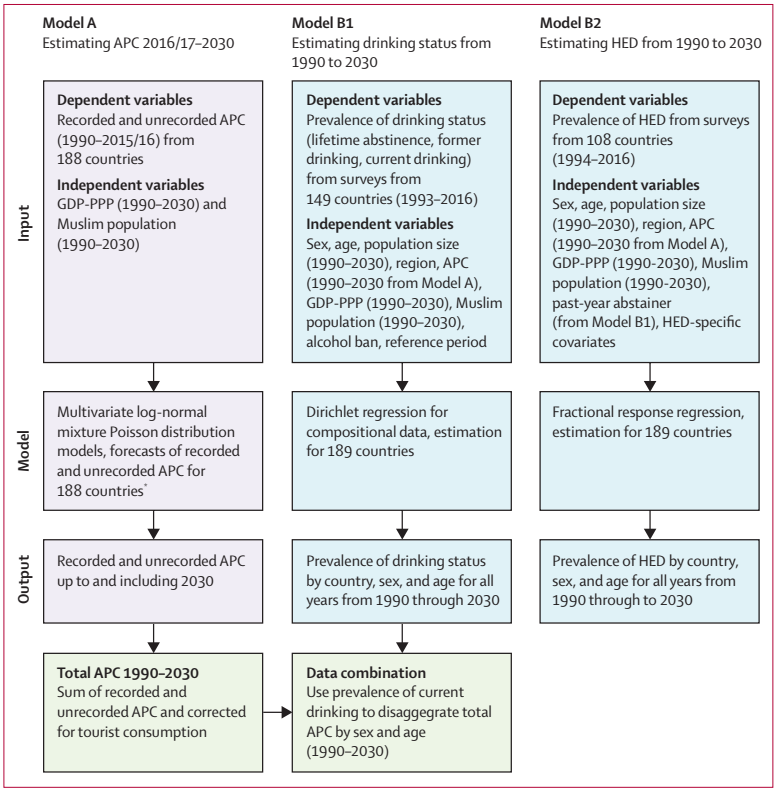

Figure 1: **Flow chart of statistical models for alcohol per-capita consumption and prevalence of drinking status and heavy episodic drinking**

GDP-PPP=gross domestic product per capita at purchasing power parity. *Sudan was not forecasted in model A but previous values carried forward (details in appendix 1).

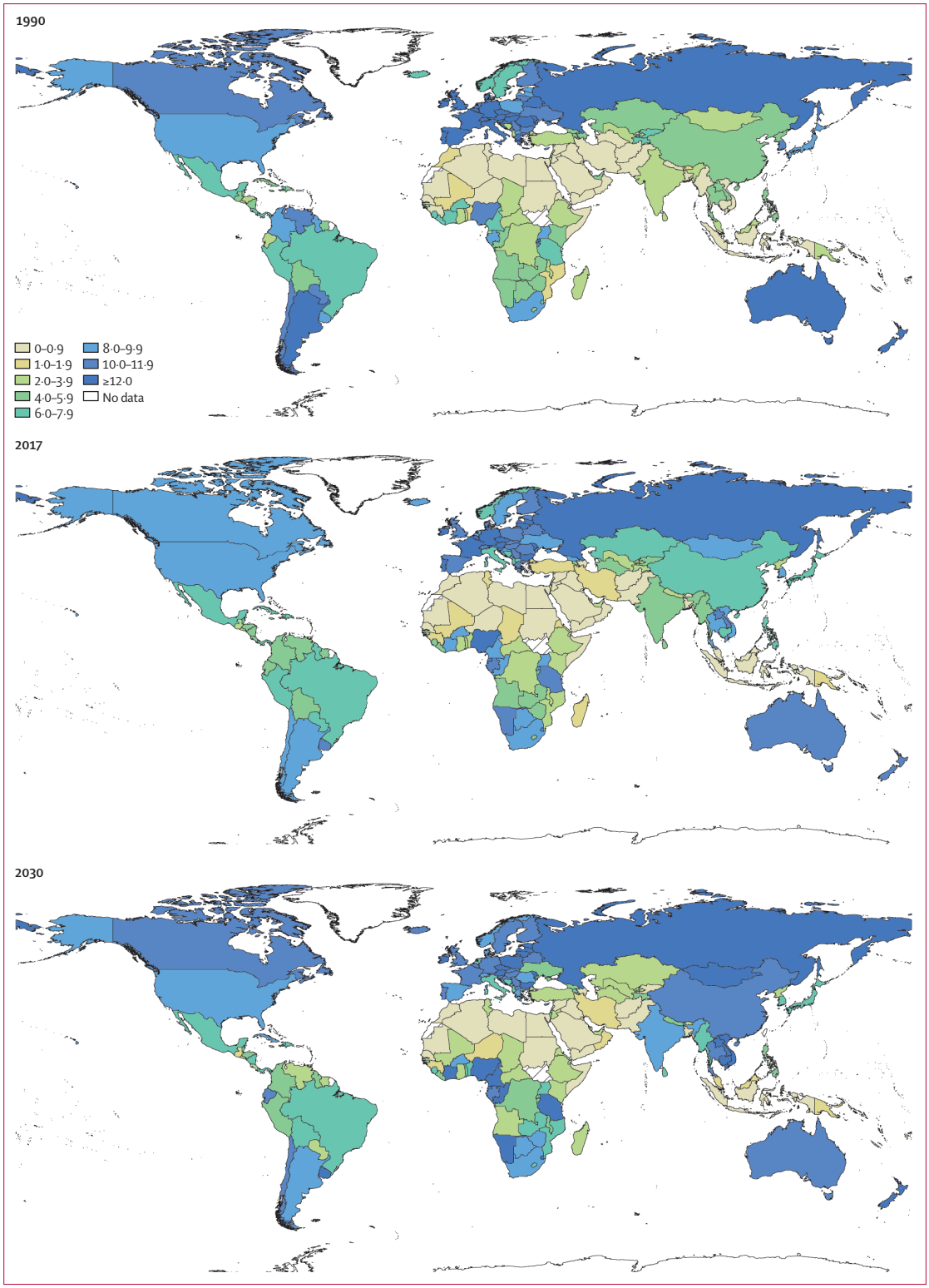

Figure 2: Adult alcohol per-capita consumption (L) in 1990, 2017, and 2030

www.thelancet.com **Published online May 7, 2019** http://dx.doi.org/10.1016/S0140-6736(18)32744-2

illustrate variations in alcohol use across geographies and time, the ratio of country-specific or region-specific per-capita consumption to global per-capita consumption (the alcohol per-capita consumption ratio) was calculated for each country or region and year. The alcohol per-capita consumption ratio is a comparative indicator giving the deviation of country or region per-capita consumption from the global mean for a given year with values greater than 1 denoting an alcohol use level in the country or region to be above the global mean. To test for significant time trends, we calculated annualised rates for the given measure (eg, alcohol per-capita consumption, prevalence of drinking status or heavy episodic drinking, and number of drinkers) from autoregressive integrated moving average (ARIMA) models by inclusion of drift terms. All results presented are significant unless otherwise stated.

All data were aggregated by WHO regions (n=6),[24] GBD regions (n=21),[22] and income classification (based on 2017)[25] using UN population data for weighting.[26] Names of regions in the text and figures always correspond to WHO regions, whereas the tables refer to GBD regions. Country-specific data on all variables of interest for 1990, 2010, 2017, and 2030 can be obtained from appendix 2, tab 2. All data were processed in R version 3.5.1.[27]

Role of the funding source

The study sponsor had no impact on study design, data collection, data analysis, interpretation of data, writing of the report, or in the decision to submit the paper for publication. The corresponding author had full access to all the data in the study and final responsibility for the decision to submit for publication.

Results

Alcohol per-capita consumption was estimated to vary markedly globally in 2017, with the lowest per-capita consumption observed in North African and Middle Eastern countries (mostly <1 L), and the highest consumption in Central and Eastern European countries (many >12 L; figure 2, table). Globally, alcohol per-capita consumption increased from 5·9 L (95% CI 5·8–6·1) in 1990 to 6·5 L (6·0–6·9) in 2017. In the following 13 years, alcohol per-capita consumption is expected to grow by 17%, reaching 7·6 L (6·5–10·2) in 2030.

Disaggregating the global trend by WHO regions showed decreases in per-capita consumption in the European region, but increases in South-East Asia and Western Pacific regions: between 1990 and 2017, adult alcohol per-capita consumption increased by 104% (58–150%) in the WHO southeast Asia region and by 54% (30–81%) in the western Pacific region, but

	Alcohol per-capita consumption*			Alcohol per-capita consumption ratio†		
	Women	Men	Both sexes	Women	Men	Both sexes
Andean Latin America	2·6 (2·0–3·2)	8·3 (6·4–10·4)	5·6 (4·3–7·0)	0·96 (0·74–1·21)	0·82 (0·63–1·03)	0·87 (0·67–1·09)
Australasia	5·2 (4·3–6·2)	16·2 (13·1–19·2)	10·7 (8·7–12·7)	1·95 (1·58–2·31)	1·61 (1·31–1·91)	1·66 (1·35–1·97)
Caribbean	2·6 (2·3–2·9)	9·8 (8·6–11·1)	6·2 (5·5–7·1)	0·95 (0·84–1·08)	0·97 (0·86–1·10)	0·97 (0·86–1·10)
Central Asia	1·6 (1·4–1·8)	6·7 (5·8–7·7)	4·1 (3·6–4·7)	0·58 (0·50–0·67)	0·66 (0·58–0·77)	0·63 (0·55–0·73)
Central Europe	5·3 (4·8–5·7)	17·8 (16·4–19·4)	11·5 (10·6–12·5)	1·96 (1·80–2·13)	1·78 (1·64–1·93)	1·79 (1·65–1·94)
Central Latin America	2·4 (2·1–2·7)	9·1 (8·0–10·2)	5·8 (5·1–6·5)	0·90 (0·79–1·01)	0·91 (0·80–1·02)	0·90 (0·80–1·02)
Central sub-Saharan Africa	1·7 (1·0–2·8)	6·4 (3·8–10·3)	4·1 (2·4–6·6)	0·65 (0·39–1·04)	0·63 (0·38–1·02)	0·64 (0·38–1·03)
East Asia	3·1 (1·9–4·3)	11·1 (6·9–15·6)	7·3 (4·5–10·2)	1·15 (0·71–1·61)	1·11 (0·68–1·55)	1·14 (0·70–1·59)
Eastern Europe	4·8 (3·5–6·2)	19·4 (14·1–25·0)	11·6 (8·5–14·9)	1·80 (1·32–2·31)	1·93 (1·41–2·49)	1·80 (1·32–2·32)
Eastern sub-Saharan Africa	1·8 (1·6–2·0)	7·7 (6·8–8·8)	4·7 (4·2–5·4)	0·67 (0·59–0·76)	0·77 (0·68–0·87)	0·74 (0·65–0·83)
High-income Asia Pacific	3·8 (3·2–4·5)	12 (10·1–14·1)	8·2 (6·9–9·6)	1·43 (1·20–1·68)	1·20 (1·00–1·40)	1·28 (1·07–1·50)
High-income North America	4·5 (3·5–5·5)	14·9 (11·8–18·1)	9·7 (7·7–11·8)	1·67 (1·32–2·03)	1·48 (1·17–1·80)	1·51 (1·19–1·83)
North Africa and Middle East	0·2 (0·2–0·3)	1·5 (1·2–1·9)	0·9 (0·7–1·1)	0·08 (0·07–0·11)	0·15 (0·12–0·19)	0·13 (0·11–0·17)
Oceania	0·6 (0·4–0·7)	2·7 (2·1–3·4)	1·7 (1·3–2·1)	0·21 (0·16–0·27)	0·27 (0·21–0·34)	0·26 (0·20–0·32)
South Asia	1·6 (1·1–2·2)	7·7 (5·1–10·3)	4·7 (3·1–6·3)	0·60 (0·40–0·80)	0·76 (0·50–1·02)	0·73 (0·48–0·98)
Southeast Asia	1·7 (1·5–2·0)	7·2 (6·3–8·1)	4·5 (3·9–5·1)	0·65 (0·57–0·74)	0·71 (0·63–0·81)	0·69 (0·61–0·79)
Southern Latin America	4·6 (3·6–5·6)	14·5 (11·5–17·7)	9·6 (7·6–11·7)	1·71 (1·35–2·08)	1·45 (1·14–1·76)	1·50 (1·18–1·82)
Southern sub-Saharan Africa	3·1 (2·4–3·9)	13·9 (10·8–17·3)	8·4 (6·6–10·4)	1·16 (0·90–1·44)	1·39 (1·08–1·72)	1·31 (1·02–1·62)
Tropical Latin America	3·1 (2·2–4·2)	11·3 (7·8–15·0)	7·4 (5·1–9·8)	1·17 (0·81–1·55)	1·13 (0·78–1·49)	1·15 (0·79–1·52)
Western Europe	5·0 (4·8–5·3)	16·8 (16·2–17·5)	10·8 (10·4–11·3)	1·88 (1·80–1·96)	1·68 (1·61–1·75)	1·69 (1·62–1·76)
Western sub-Saharan Africa	3·4 (2·9–3·9)	13·6 (11·7–15·6)	8·5 (7·3–9·7)	1·26 (1·09–1·45)	1·35 (1·16–1·55)	1·32 (1·14–1·51)
Global	2·7 (2·5–2·9)	9·8 (9·2–10·5)	6·5 (6·0–6·9)	1	1	1

Figures in brackets denote the 95% confidence interval and regions are defined as in the Global Burden of Disease study. *Per-capita consumption of pure alcohol (L). †Ratio of region-specific per-capita consumption to global per-capita consumption. Values >1 denote alcohol use to be above the global average in this region. Conversely, values <1 denote alcohol use to be below the global average in this region.

Table: **Regional and global adult alcohol per-capita consumption in 2017**

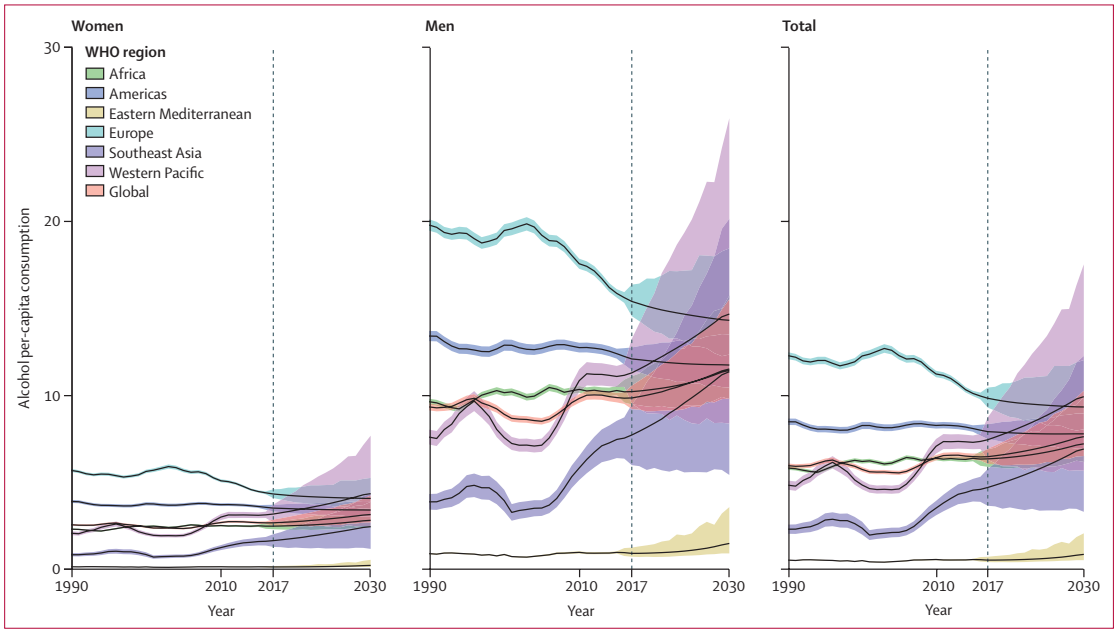

Figure 3: **Alcohol per-capita consumption time trends between 1990 and 2030 for WHO regions and globally**
Given alcohol per-capita consumption and global population growth, the total volume of alcohol consumed has increased by 70% (95% CI 59–82) from 1990 (20 999 million L) up to and including 2017 (35 676 million L). In high-income countries, the total volume of alcohol consumed has remained stable, while it has grown in lower-middle-income and upper-middle-income countries. Conversely, high-income countries' contribution to global alcohol use will have halved by 2030 (from 42% in 1990, to 26% in 2017 and 19% in 2030).

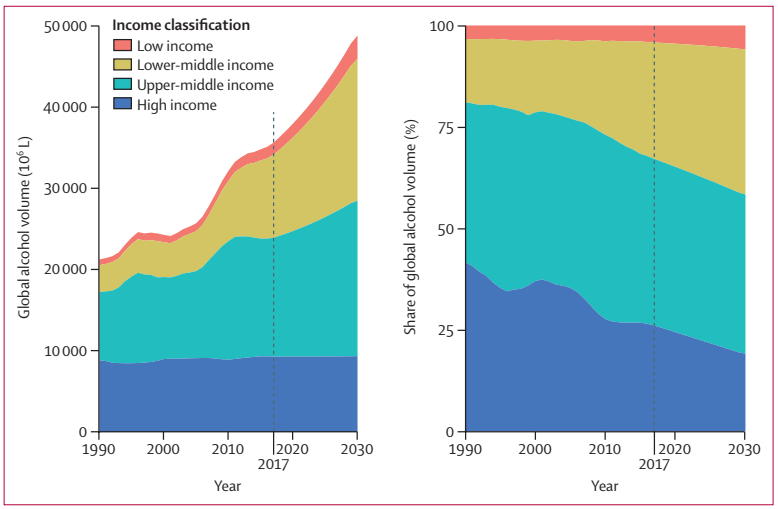

Figure 4: **Absolute and relative share of global volume of pure alcohol consumed over time and by income classification**

decreased by 20% (–15 to –24%) in the European region. Relatively stable time trends were observed in the African, American, and Eastern Mediterranean regions (figures 2, 3). Between 2010 and 2017, per-capita consumption increased by 34% (95% CI 4–64) in the southeast Asian region from 3·5 L (3·1–3·9) to 4·7 L (3·6–5·8), with increases in countries such as India, Vietnam, and Myanmar (the region definition was taken from WHO) and southeast Asia includes the following countries (see also appendix 1): Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand, Timor-Leste. In the WHO European region, alcohol per-capita consumption decreased by 12% (7–17) between 2010 and 2017, from 11·2 L (11·0–11·4) to 9·8 L (9·3–10·4), with decreases mainly in former Soviet Republics such as Azerbaijan, Kyrgyzstan, Ukraine, Belarus, and Russia. Data for country-level relative change, as well as data for 1990, 2017, and 2030 by GBD and WHO regions are shown in appendix 1.

The estimated volume of alcohol consumed globally is illustrated in figure 4. Given APC and global population growth, the total volume of alcohol consumed has increased by 70% (95% CI 59–82%) from 1990 (20 999 million L) up to and including 2017 (35 676 million L). In high-income countries, the total volume of alcohol consumed has remained stable, while it has grown in lower and upper middle-income countries. Conversely, high-income countries' contribution to global alcohol use will have halved by 2030 (1990: 42%; 2017: 26%; 2030: 19%).

In 2017 43% (95% CI 40–46) of adults globally were estimated to be lifetime abstainers and 47% (44–50) were current drinkers (appendix 1). For current drinkers, prevalence has increased since 1990 from 45% (41–48) to 47% (44–50, annualised rate: +0·1%). For lifetime abstainers, prevalence has decreased from 46% (42–49) to

For more on **WHO region definitions** see https://www.who.int/choice/demography/by_country/en/

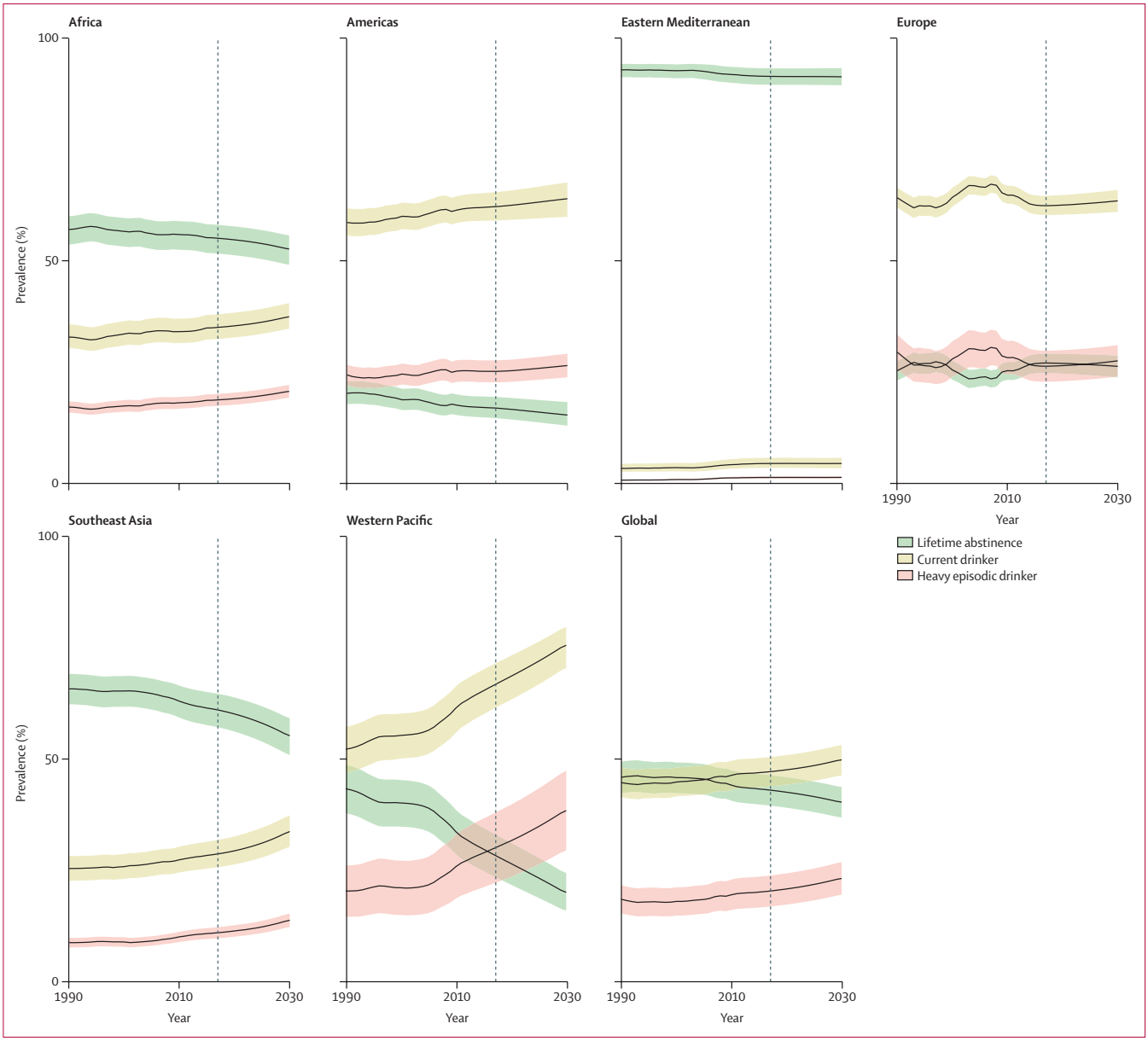

Figure 5: **Prevalence of drinking status (lifetime abstinence, current drinking) and heavy episodic drinking, by WHO region and globally over time**

43% (40–46), albeit this was not a significant reduction. Up to 2030, the global prevalence of lifetime abstinence is forecasted to decrease (to 40% [37–44] in 2030; annualised 0·2% decrease). Conversely, the proportion of current drinkers is projected to increase during the same period (to 50% [46–53] in 2030; annualised 0·2% increase).

These global trends are largely reflected at the regional level (figure 5, appendix 1): the strongest decreases in lifetime abstinence are expected to be seen in the countries of the Western Pacific region (from 28% [23–32] in 2018 to 20% [16–24] in 2030; annualised 0·6% decrease) and South-East Asia (from 61% [57–64] in 2018 to 55% [51–59] in 2030; annualised 0·4% decrease). Thus, the forecasted global increase in alcohol use can be attributed to increases in economic wealth in low-income and middle-income countries, which was one of the predictors of our model (appendix 1).

Since 1990, an almost constant ratio of male to female drinkers has been observed (1·42 in 1990; 1·40 in 2017). This ratio decreased only in the Western Pacific region (1·46 in 1990; 1·34 in 2017). By 2030, the gap between males and females is forecasted to slowly decrease globally

(1·37 in 2030; annualised decrease of 0·003), in Western Pacific (1·33 in 2018, 1·24 in 2030; annualised decrease of 0·008), and in Eastern Mediterranean countries (2·64 in 2018, 2·57 in 2030; annualised decrease of 0·006).

Heavy episodic drinking in the adult population was estimated to vary largely across the globe, with the highest prevalence in 2017 in the Western Pacific region (30% [95% CI 22–38]) and the lowest in the Eastern Mediterranean region (1·3% [1·0–1·5]; appendix 1). The prevalence of HED has increased from 18% (15–22) to 20% (17–24), albeit this was not a significant increase. Globally, the trends of current and heavy episodic drinkers in the adult population are largely similar (figure 5), with the prevalence of heavy episodic drinkers being forecasted to increase from 20% (17–24) in 2018 to 23% (19–27) in 2030 (annualised 0·2% increase; figure 5, appendix 1). This upward trend is most pronounced in Western Pacific (31% [23–38] in 2018 to 38% [29–47] in 2030; annualised 0·6% increase), and South-East Asian countries (11% [10–12] in 2018; 14% [12–15] in 2030; annualised 0·2% increase).

Discussion

This study provides a comprehensive overview of the changing landscape in global alcohol exposure. Before 1990, most alcohol was consumed in high-income countries, with the highest use levels recorded in Europe.[5] However, this pattern has changed substantially since 1990. Alcohol use has decreased in most European countries, with the largest reductions achieved recently in Eastern Europe. At the same time, alcohol use has increased substantially in several lower-middle-income and upper-middle-income countries, such as China, India, and Vietnam, with use levels higher than in some European countries in 2017. The forecasts up to and including 2030 suggest a continuation of this trend, and the WHO European region is predicted to no longer have the highest level of alcohol use. Moreover, the gap between male and female drinkers is forecasted to decrease by 2030, in part related to an increase of female participation in remunerated work.

Many factors affect the level of alcohol use, but three stand out as the most important: economic wealth, religion, and the implementation of alcohol policies.[28] Economic wealth is strongly associated with alcohol per-capita consumption up to a certain amount of wealth, after which no further increases in consumption are observed.[29] In low-income countries, most people simply do not have sufficient income to buy alcohol, and consequently levels of lifetime abstention are high,[30] with alcohol use mainly restricted to the more affluent members of the population.[28] This changes when the population has more disposable income, as is the case in middle-income countries.

However, although economic factors play a large part, government policies on alcohol use can alter the age of initiation as well as the level of drinking. Thus, in countries like Saudi Arabia or Brunei, alcohol use is relatively low, despite high GDP-PPP, due to the presence of religion-based alcohol policies. Alcohol policies can also have an impact without a religious basis. A prime example would be Russia, where WHO's so-called best buys (recommended interventions such as taxation, availability restrictions, and a ban on marketing) and minimum pricing were implemented, and resulted in marked changes in both alcohol use and the alcohol-attributable burden of disease.[31,32] Other factors such as war or political unrest impact alcohol use, but are more difficult to predict and are very country specific.

Globally, and in most regions, the volume of alcohol consumed grows faster (eg, a 17·8% increase from 2018 to 2030) than the number of drinkers (eg, a 5% increase in the same timeframe). Hence, the average alcohol intake per drinker is forecasted to increase, with expected negative implications for public health. Increased alcohol intake per drinker not only results in a growing proportion of heavy episodic drinkers, but also inevitably leads to an increased alcohol-attributable disease burden.

Based on our data, the aim of cutting the harmful use of alcohol by 10% by 2025 (as per WHO's Global Action Plan for the Prevention and Control of NCDs 2013–2020) will not be reached. However, there are differences between regions. Although successful efforts to reduce the level of alcohol use in Eastern and other European countries have already resulted in achieving this goal for the European region, trends in all other regions are either stable or indicate increasing levels of alcohol use. From 1990 to 2016, alcohol use has climbed up the global ranking of risk factors and is now the seventh-leading risk factor for the burden of disease,[1] and our predictions suggest that this trend will not be reversed anytime soon. Additionally, many of the diseases and causes of death (partly) attributable to alcohol, such as mental disorders and liver cirrhosis, seem to be increasing.[33] The USA is a good example of this trend—a high-income country where current increases in mortality rates and decreases in life expectancies are primarily due to alcohol-related causes of death.[34]

Alcohol use is a risk factor for burden of disease that provides us with the highest quality of data available. Since alcohol is taxed in almost all countries,[2] routine statistics on recorded consumption are readily available from government agencies, in addition to industry sources.[15] However, more uncertainty exists around estimates of unrecorded consumption. For unrecorded consumption, data are scarcer, with estimates based on surveys and expert judgments.[12] Data for drinking status are collected entirely from surveys, with the known biases of individual under-reporting,[35] and only a few sampling frames cover particular groups with high alcohol use (eg, military and homeless populations).[36]

WHO monitoring systems for alcohol exposure require validation at the country level by government or associated organisations.[11] Although such validation

can improve data quality (eg, by identifying new local data sources), it also poses a risk because some countries have answered surveys based on ideological reasoning rather than fact (eg, denial of any alcohol use in some countries with alcohol prohibition, where empirical evidence has clearly established otherwise). Forecasting models used were based on economic and religious indicators, not on alcohol policies, and thus the potential impact of any such future policies was not explicitly considered. Moreover, the uncertainty of forecasts grows with the length of the forecasting interval, which should be considered in interpreting point estimates. Lastly, because the models of drinking status and heavy episodic drinking did not account for the growing uncertainty of alcohol per-capita consumption forecasts, the 95% CIs of estimates for years with forecasted input data may not capture the full extent of the error margins.

In conclusion, alcohol use is prevalent globally, but with clear regional differences. These differences can largely be attributed to religion, implementation of alcohol policies,[2] and economic growth.[30] Economic growth seems to explain the global increase in alcohol use over the past few decades: the economic transitions and increases in economic wealth of several countries—in particular, the transition of China from a low-income to an upper-middle-income country, and the transition of India from a low-income to a lower-middle-income country—were accompanied by an increase in alcohol use. The growing alcohol market in lower-middle-income and upper-middle-income countries is estimated to more than outweigh the declining use in high-income countries, resulting in a net increase. Consequently, based on our data, WHO's aim of reducing the harmful use of alcohol by 10% by 2025 will not be reached globally. Instead, alcohol use will remain one of the leading risk factors for the burden of disease for the foreseeable future, and its impact will probably increase relative to other risk factors. Implementation of effective alcohol policies is warranted, especially in rapidly developing countries with growing rates of alcohol use.

Contributors

JM had full access to all the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis. JM and JR were responsible for the study concept and design. OSMH and MR collected the data. JM and KDS did the statistical analysis. JM and JR interpreted the data and drafted the manuscript. JM and CP were responsible for data visualisation. All authors critically revised the manuscript for important intellectual content and approved the final version. JR supervised the study.

Declaration of interests

All authors declare no competing interests.

Acknowledgments

This contribution is based on validated data for alcohol exposure up to and including 2016, as carried out by the WHO Headquarters and the WHO regional offices, and was financially supported by the Centre for Addiction and Mental Health, Toronto, ON, Canada, as part of their continuous support of the WHO Collaborating Centre for Addiction and Mental Health.

References

1 GBD 2016 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; **390:** 1345–422.

2 WHO. Global status report on alcohol and health 2018. Geneva: World Health Organization, 2018.

3 Rehm J, Imtiaz S. A narrative review of alcohol consumption as a risk factor for global burden of disease. *Subst Abuse Treat Prevent Policy* 2016; **11:** 37.

4 Rehm J, Gmel GE Sr, Gmel G, et al. The relationship between different dimensions of alcohol use and the burden of disease—an update. *Addiction* 2017; **112:** 968–1001.

5 Rehm J, Room R, Monteiro M, et al. Alcohol use. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, eds. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. Geneva: World Health Organization, 2004: 959–1108.

6 WHO. Global strategy to reduce the harmful use of alcohol. Geneva: World Health Organization. 2010. https://www.who.int/substance_abuse/activities/gsrhua/en/ (accessed Sept 12, 2018).

7 Shield KD, Rylett M, Rehm J. Public health successes and missed opportunities. Trends in alcohol consumption and attributable mortality in the WHO European Region, 1990–2014. Copenhagen: WHO Regional Office for Europe, 2016.

8 Tang YL, Xiang XJ, Wang XY, Cubells JF, Babor TF, Hao W. Alcohol and alcohol-related harm in China: policy changes needed. *Bull World Health Organ* 2013; **91:** 270–76.

9 Ferreira-Borges C, Rehm J, Dias S, Babor T, Parry CD. The impact of alcohol consumption on African people in 2012: an analysis of burden of disease. *Trop Med Int Health* 2016; **21:** 52–60.

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

11 Poznyak V, Fleischmann A, Rekve D, Rylett M, Rehm J, Gmel G. The World Health Organization's global monitoring system on alcohol and health. *Alcohol Res* 2013; **35:** 244–49.

12 Probst C, Manthey J, Merey A, Rylett M, Rehm J. Unrecorded alcohol use: a global modelling study based on nominal group assessments and survey data. *Addiction* 2018; **113:** 1231–41.

13 Rehm J, Kailasapillai S, Larsen E, et al. A systematic review of the epidemiology of unrecorded alcohol consumption and the chemical composition of unrecorded alcohol. *Addiction* 2014; **109:** 880–93.

14 Rehm J, Klotsche J, Patra J. Comparative quantification of alcohol exposure as risk factor for global burden of disease. *Int J Methods Psychiatr Res* 2007; **16:** 66–76.

15 WHO. Global Information System on Alcohol and Health (GISAH). Geneva: World Health Organization, 2018. http://www.who.int/gho/alcohol/en/ (accessed Sept 13, 2018).

16 Durbin J, Koopman SJ. Time series analysis by state space methods, 2nd edn. New York: Oxford University Press, 2012.

17 World Bank. World Bank Open Data 2017. http://data.worldbank.org/ (accessed March 13, 2018).

18 Grim B, Karim M. The future of the global Muslim population: projections for 2010–2030. In: Stencel S, Rosen A, Yoo D, Miller T, Ramp H, eds. The future of the global Muslim population: projections for 2010–2030. Washington DC: Pew Research Center, 2011: 158–63.

19 Rehm J, Shield KD, Roerecke M, Gmel G. Modelling the impact of alcohol consumption on cardiovascular disease mortality for comparative risk assessments: an overview. *BMC Public Health* 2016; **16:** 363.

20 Shield KD, Rylett M, Gmel G, Gmel G, Kehoe-Chan TA, Rehm J. Global alcohol exposure estimates by country, territory and region for 2005—a contribution to the Comparative Risk Assessment for the 2010 Global Burden of Disease Study. *Addiction* 2013; **108:** 912–22.

21 Maier MJ. DirichletReg: Dirichlet regression for compositional data in R. Vienna: WU Vienna University of Economics and Business, 2014. http://epub.wu.ac.at/4077/ (accessed Sept 12, 2018).

22 Institute for Health Metrics and Evaluation. GBD 2015 geographies. Seattle: University of Washington, 2015. http://www.healthdata.org/sites/default/files/files/Projects/GBD/GBDRegions_countries.pdf (accessed Sept 15, 2018).

23 Al-Ansari B, Thow AM, Day CA, Conigrave KM. Extent of alcohol prohibition in civil policy in Muslim majority countries: the impact of globalization. *Addiction* 2016; **111:** 1703–13.

24 WHO. Alphabetical list of WHO member states. Geneva: World Health Organization, 2018. http://www.who.int/choice/demography/by_country/en/ (accessed Sept 15, 2018).

25 World Bank. New country classifications by income level: 2016–2017. World Bank, 2017. http://blogs.worldbank.org/opendata/trade/new-country-classifications-2016 (accessed Sept 25, 2017).

26 Population Division of the Department of Economic and Social Affairs of the UN Secretariat. World population prospects, 2015 revision: key findings and advance tables. New York, United Nations, 2015.

27 R Core Team. R: a language and environment for statistical computing. Vienna: R Foundation for Statistical Computing, 2017.

28 Room R, Jernigan D, Carlini BH, et al. El alcohol y los países en desarrollo: una perspectiva de salud pública. Mexico: Organización Panamericana de la Salud & Fondo de Cultura Económica, 2013 (in Spanish).

29 Schmidt LA, Mäkelä P, Rehm J, Room R. Alcohol: equity and social determinants. In: Blas E, Kurup AS, eds. Equity, social determinants and public health programmes. Geneva: World Health Organization, 2010: 11–29.

30 Probst C, Manthey J, Rehm J. Understanding the prevalence of lifetime abstinence from alcohol: an ecological study. *Drug Alcohol Depend* 2017; **178:** 126–29.

31 Neufeld M, Rehm J. Alcohol consumption and mortality in Russia since 2000: are there any changes following the alcohol policy changes starting in 2006? *Alcohol Alcohol* 2013; **48:** 222–30.

32 Rehm J, Ferreira-Borges C. Risk factor policies, morbidity, and mortality in Russia. *Lancet* 2018; **392:** 1094–95.

33 GBD 2016 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; **390:** 1260–344.

34 Rehm J, Probst C. Decreases of life expectancy despite decreases in non-communicable disease mortality: the role of substance use and socioeconomic status. *Eur Addict Res* 2018; **24:** 53–59.

35 Midanik LT. The validity of self-reported alcohol consumption and alcohol problems: a literature review. *Br J Addict* 1982; **77:** 357–82.

36 Shield KD, Rehm J. Difficulties with telephone-based surveys on alcohol in high-income countries: the Canadian example. *Int J Methods Psychiatr Res* 2012; **21:** 17–28.

Increases in alcohol consumption in middle-income countries will lead to increased harms

Published Online
May 7, 2019
http://dx.doi.org/10.1016/S0140-6736(18)33002-2
See Online/Articles
http://dx.doi.org/10.1016/S0140-6736(18)32744-2

The WHO Global Monitoring Framework for Non-Communicable Diseases includes an ambitious global target of a 10% reduction in the harmful use of alcohol by 2025.[1] A modelling study by Jakob Manthey and colleagues[2] in *The Lancet* indicates that this goal will not be met, with a plateau in consumption in high-income countries offset by marked projected increases in middle-income countries.

Manthey and colleagues[2] have compiled an impressive amount of data, facilitating the estimation of key alcohol measures for 189 countries up to 2030. Their projections mainly rely on recent trends (from 1990 onwards), together with forecasts of two key drivers of drinking rates: gross domestic product based on purchasing power parity, and the proportion of the population identifying as Muslim. Manthey and colleagues estimate that global adult alcohol per-capita consumption increased from 5·9 L (95% CI 5·8–6·1) in 1990 to 6·5 L (6·0–6·9) in 2017, and forecast that it will reach 7·6 L (6·5–10·2) by 2030. They project small decreases in consumption in the Americas (decreasing by 1·2%) and Europe (decreasing by 5·1%) between 2017 and 2030, which are in sharp contrast to large forecasted increases in most other regions—notably, a 46·8% increase in the WHO southeast Asia region and a 33·7% increase in the western Pacific region. These trends have important implications for alcohol-related harm and global health inequalities, suggesting not just an increase in per-capita alcohol consumption worldwide but also—as demonstrated in the Article[2]—a sharp increase in the proportion of consumption in lower-middle-income countries.

This shift in consumption across income groups could lead to disproportionate increases in harm—the harm per L from alcohol is substantially higher in low-income and middle-income countries than in high-income countries.[3] For example, in WHO's *Global Status Report on Alcohol and Health 2018*,[4] European per-capita alcohol consumption is estimated to be more than 1·5 times higher than Africa's (also predicted to increase by 14·2% by 2030), but more lives and disability-adjusted life-years (DALYs) are lost per capita in Africa. This discrepancy in harm and consumption is often attributed to drinking patterns; in low-income and lower-middle-income countries, the proportion of drinkers who participate in heavy episodic drinking is higher than in high-income and upper-middle-income countries.[4] However, due to a higher abstention rate in low-income and lower-middle-income countries, heavy episodic drinking is more prevalent at the population level in high-income and upper-middle-income countries.[4] Nevertheless, alcohol-attributable deaths and DALYs are higher in low-income and lower-middle-income countries than they are in upper-middle-income and high-income countries.[4] The projected increases in alcohol per-capita consumption in southeast Asia and the western Pacific shown by Manthey and colleagues[2] suggest that the relative contribution of alcohol to death and disability will increase in these regions in the coming years, although the net effect is difficult to predict because the increase in alcohol consumption could be offset by decreasing mortality due to increases in wealth. There is a precedent for this increase in alcohol-related harms—the 2015 Global Burden of Disease Study highlighted increased DALYs attributable to alcohol since 1995 despite reductions in exposure, at least partly because of increases in consumption in lower-income countries.[5]

Although comprehensive, the projections presented by Manthey and colleagues[2] rely on a fairly simple set

Linh Pham/Getty Images

of assumptions about the factors that drive per-capita alcohol consumption. For example, it is unlikely that the projected decreases of 17% for the UK and 10% for Australia would have been estimated in 2004.[6,7] These shifts have been driven by sharp declines in drinking among young people (aged 15–25 years) and seem largely unrelated to trends in economic conditions or population religion.[8,9] Further, the models rely partly on economic projections, which are themselves uncertain, especially for low-income and middle-income countries.[10] Thus, Manthey and colleagues' projections[2] should be treated with some caution.

Despite this uncertainty, policy shifts to reduce harms from these forecasted increases are crucial, particularly in low-income and middle-income countries. An increasingly robust evidence base supports use of key alcohol policy levers such as increasing price and restricting availability to curtail growing alcohol consumption beyond Europe and North America.[11] However, this evidence comes largely from high-income countries, and the potential efficacy of such policies in lower-middle-income countries, where more than half of alcohol consumption is unrecorded,[12] is likely to be limited without substantial reductions in unrecorded alcohol consumption—although previous studies show that unrecorded consumption tends to decline with economic development.[13] Thus, although price or availability-based policies are important, strict restrictions on advertising and other promotional activities are crucial to slow the growing demand for alcohol in these countries. Similarly, rigorous drink-driving countermeasures are necessary so that increasing consumption does not lead to increases in road traffic injury. Supporting evidence-based policies outside high-income countries, despite anticipated strong industry resistance, will be a key task for public health advocates in the coming decades.

*Sarah Callinan, Michael Livingston
Centre for Alcohol Policy Research, School of Psychology and Public Health, La Trobe University, Melbourne, VIC 3086, Australia (SC, ML); and Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden (ML)
s.callinan@latrobe.edu.au

SC reports a grant from the Australian Research Council and ML a grant from National Health and Medical Research Council, both outside the area of work commented on here. SC is supported by an Australian Research Council Discovery Early Career Research Award (DE180100016). ML is supported by a National Health and Medical Research Council Career Development Fellowship (GNT1123840).

1 WHO. Global NCD Target: reducing harmful use of alcohol. Geneva: World Health Organization, 2018.
2 Manthey J, Shield KD, Rylett M, Hasan OSM, Probst C, Rehm J. Global alcohol exposure between 1990 and 2017 and forecasts until 2030: a modelling study. *Lancet* 2019; published online May 7. http://dx.doi.org/10.1016/S0140-6736(18)32744-2.
3 Schmidt L, Mäkelä P, Rehm J, Room R. Alcohol: equity and social determinants. In: Blas E, Sivasankara Kurup A, eds. Equity, social determinants and public health programmes. Geneva: World Health Organization, 2010.
4 WHO. Global status report on alcohol and health 2018. Geneva: World Health Organization, 2018.
5 GBD 2015 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; 388: 1659–724.
6 Australian Bureau of Statistics. 4307.0.55.001—Apparent consumption of alcohol, Australia, 2016–17. Canberra: Australia Bureau of Statistics, 2018. http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4307.0.55.0012016-17?OpenDocument (accessed Oct 30, 2018).
7 British Beer and Pub Association. Trends in alcohol: a compilation of drinks industry statistics. London: Brewing Publications, 2018.
8 Livingston M, Raninen J, Slade T, Swift W, Lloyd B, Dietze P. Understanding trends in Australian alcohol consumption—an age-period-cohort model. *Addiction* 2016; **111:** 1590–98.
9 Meng Y, Holmes J, Hill-McManus D, Brennan A, Meier P. Trend analysis and modelling of gender-specific age, period and birth cohort effects on alcohol abstention and consumption level for drinkers in Great Britain using the General Lifestyle Survey 1984–2009. *Addiction* 2013; **109:** 206–15.
10 Artis MJ. How accurate are the IMF's short-term forecasts? Another examination of the world economic outlook. IMF Working Paper No 96/89. Feb 15, 2006. https://ssrn.com/abstract=882985 (accessed Oct 30, 2018).
11 Chisholm D, Moro D, Bertram M, et al. Are the "best buys" for alcohol control still valid? An update on the comparative cost-effectiveness of alcohol control strategies at the global level. *J Stud Alcohol Drugs* 2018; **79:** 514–22.
12 Probst C, Manthey J, Merey A, Rylett M, Rehm J. Unrecorded alcohol use: a global modelling study based on nominal group assessments and survey data. *Addiction* 2018; **113:** 1231–41.
13 Shield KD, Rehm M, Patra J, Sornpaisarn B, Rehm J. Global and country specific adult per capita consumption of alcohol, 2008. *Sucht* 2011; **57:** 99–117.