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Alcohol consumption and consequences in adolescents in 68 low and middle-income countries – a multi-country comparison of risks by sex

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ABSTRACT

Aims: Alcohol use is a leading risk factor for disease burden among youth. This study estimated sex differences in the prevalence of alcohol use and consequences among adolescents living in low and middle-income countries (LMIC).

Design: Multi-staged cross-sectional international standardized self-report questionnaires administered in the classroom.

Setting: The Global school-based student health survey (GSHS) comprised adolescents from 68 LMIC between 2003–2014.

Participants: 271,156 students aged 13–17 years old.

Measurements: Alcohol measures included: past month alcohol consumption, history of intoxication and alcohol-related problems. Regions were based on the World Health Organization definitions: Africa, America, Eastern Mediterranean, Europe, South-east Asia, and Western Pacific.

Findings: Overall, males had higher odds of alcohol use (OR = 2.38 [1.91–2.96]), a history of intoxication (OR = 2.64 [2.11–3.31]), and alcohol-related problems (OR = 1.72 [1.41–2.10]) than females. All regions recorded overall greater odds of alcohol use by males versus females; five regions (excluding Europe) recorded greater odds of intoxication in males; and three regions (America, South-east Asia, and Western Pacific) recorded greater odds of alcohol-related problems amongst males. However, there were country-level differences – in some countries, adolescent drinking rates and consequences were comparable by sex. Countries with the highest odds of alcohol use among males compared to females were Indonesia, Myanmar, Cambodia, Tuvalu, Morocco, Senegal, Kiribati, and Thailand.

Conclusions: Among adolescents living in LMIC, males had on average two-fold higher odds of drinking alcohol and experiencing adverse consequences. Growing affluence and improvements in sex equality in societies may increase the future prevalence of hazardous drinking in females in LMICs.

1. Introduction

In high-income countries, males generally consume more alcohol than females (Wilsnack, 2012). While some of these differences are associated with physiological difference between men and women (Holmila and Raitasalo, 2005; Schuckit et al., 2012; Schulte et al., 2009), the majority of sex-specific patterns probably arise from cultural factors (Sudhinaraset et al., 2016; Wilsnack et al., 2000). We know very little about the sex differences and associated health impact of adolescent alcohol consumption in low- and middle-income countries, where cultural differences are more diverse (Bloomfield et al., 2006; Desjarlais, 1995). This is of concern given evidence that alcohol-attributable disease burden is high in low and middle-income countries and that many of these countries lack interventions to prevent and reduce

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alcohol-related harms. Alcohol use prevention and interventions programs are maximally effective in young adolescent populations (Das et al., 2016; Skala and Walter, 2013). These issues are important to investigate because these countries account for a significant proportion of the 3.3 million alcohol-related deaths that occur worldwide each year and for significant morbidity (Connor et al., 2016; WHO, 2014). Examining sex specific patterns in adolescent alcohol use in lower income countries is therefore a global research priority.

In the United States, about half of both males and females have reported using alcohol in the past 12 months and about one in five have engaged in binge drinking (typically defined as 5+ standard units of alcohol per day) by the age of 15 (Patrick and Schulenberg, 2013). There are small differences in rate of alcohol consumption and alcohol-induced risk behavior between males and females under 15 years of age but sex differences emerge later in adolescence and young adulthood as males drink more often and in larger quantities than females (Leatherdale and Burkhalter, 2012; Livingston et al., 2018). More recently, the gap between men and women's alcohol use has begun to close, although among younger cohorts there has been less change in sex-specific patterns of alcohol consumption drinking (Livingston et al., 2018; McPherson et al., 2004). There are developmental variations in the growth of alcohol use across time for males compared to females. An Australian study found that females start off lower than males at around 10 years of age, but catch up by 14 years of age (Kelly et al., 2011).

Physiological differences contribute to sex differences in alcohol consumption. Higher sensitivity to alcohol, lower alcohol metabolism, and lower overall percentage of body water are thought to be reasons why females consume less alcohol on average than males (Ely et al., 1999; Schuckit et al., 2012; Schulte et al., 2009). The narrowing of sex differences in alcohol consumption may reflect more malleable cultural factors that have trended to reduce distinction between sex roles. Cultural variations in alcohol use in low income countries are associated with economic disadvantage, religious beliefs, pervasive sex norms, political climate, and the legal status rights of women (Bloomfield et al., 2006; Holmila and Raitasalo, 2005; Kuntsche et al., 2006; Sudhinaraset et al., 2016). Progressive political climates in high income countries have supported more cultural equality of gender roles, lower income countries have been slower to respond to these changes (Duflo, 2012).

Based on research mainly from high-income countries, adolescent males consume more alcohol that adolescent females across regions, with larger disparities in Northern than Southern Europe and less disparities in Australia, Canada and the United States. The sex differences in consumption widens as young people transition into adulthood, although the prevalence of alcohol use in high-income countries have appeared to be converging in recent years (Bratberg et al., 2016; Leatherdale and Burkhalter, 2012; Livingston et al., 2018; McPherson et al., 2004).

There is a hypothesis that females and males will converge as gender inequality diminishes. On this hypothesis, growing affluence and improvement in female status in societies would predict that an increasing proportion of females alcohol consumers in low and middle-income countries (Allen et al., 2018). This raise additional concerns because females tend to experience more negative health consequences than male per unit of alcohol consumption. Should this be the case it is likely that alcohol-attributable diseases will proportionally increase in females and more effective gender targeted policy and prevention approaches may need to be considered.

There is an urgent need for quantitative data on harmful alcohol use and related consequences among male and female adolescents in low and middle-income countries. In this study, we estimated sex differences of alcohol use, intoxication and adverse alcohol-related adverse consequences among adolescents living in low- and middle-income countries. We hypothesised that sex differences in alcohol use and consequences will differ by country and regionals. In addition, we explored whether this relationship was moderated by age of students, by year of data collection, and by country-level gender inequality measures.

2. Methods

2.1. Setting

Data were drawn from the Global School-based Student Health Survey (GSHS). The GSHS is conducted by the World Health Organization and Centers for Disease Control and Prevention with the United Nations. The GSHS is a cross-sectional survey delivered to school students aged 13–17 years to collect data on a range of health-related factors and behaviors, including alcohol use. A standardized sampling methodology and data collection processes were used in all participating countries from 2003–2014. Participants were selected using two-stage cluster design to provide a national representative sample. All students in the selected school classes were given an anonymous self-administered questionnaire during a 40–45 min period in the classroom. Further details on GSHS methods are available online (https://www.cdc.gov/gshs/). Our paper is reported in accordance with The Guidelines for Accurate and Transparent Health Estimates Reporting (checklist presented in Supporting Materials Table S3). The GSHS study was conducted inaccordance with the World Health Organization Office of Compliance, Risk Management and Ethics guidelines, and the analysis of data for this paper was approved by The University of Queensland's Human Research Ethics Committee.

2.2. Participants

There were 274,067 students from 68 countries aged 13–17 who completed the alcohol modules in the GSHS between 2003–2004. We excluded 2911 students (1.1%) who did not report their sex (male/female), resulting in a final sample of 271,156. Sample sizes and percentage of missing data (mean = 0.82% missing) by country are presented in Supporting Materials Table S1.

2.3. Measures

Alcohol drinking measures included: alcohol use in the past 30 days, a history of intoxication, and a history of alcohol-related problems. Past 30 days alcohol use was measured by the item 'During the past 30 days, on how many days did you have at least one drink containing alcohol?'. Lifetime history of intoxication was measured using the item 'During your life, how many times did you drink so much alcohol that you were really drunk?' History of alcohol-related problems was measured by the item 'During your life, how many times have you ever had a hangover, felt sick, got into trouble with your family or friends, missed school, or got into fights, as a result of drinking alcohol?'. Participants who reported one or more times were categorized as 'yes'. Country-level Gender Inequality Index (GII) Human Development Index (HDI) closest to the year of survey were extracted from the United Nations Development Programme Database.

2.4. Statistical analysis

Prevalence of alcohol drinking, history of intoxication and alcohol-related problems were estimated for males and females in each country. Prevalence were estimated by taking into consideration the primary sampling unit, stratification clusters, and weights of the study to adjust for non-response and the varying probabilities of selection. Odds ratios and 95% confidence intervals of the alcohol measures for males versus females were estimated for each country, with higher odds indicating higher odds in males. The odds ratios and 95% confidence intervals of alcohol drinking measures in males compared to females in each country were pooled using weighted meta-analyses. Subgroup analyses were conducted by regions, then an overall pooled odds ratio was

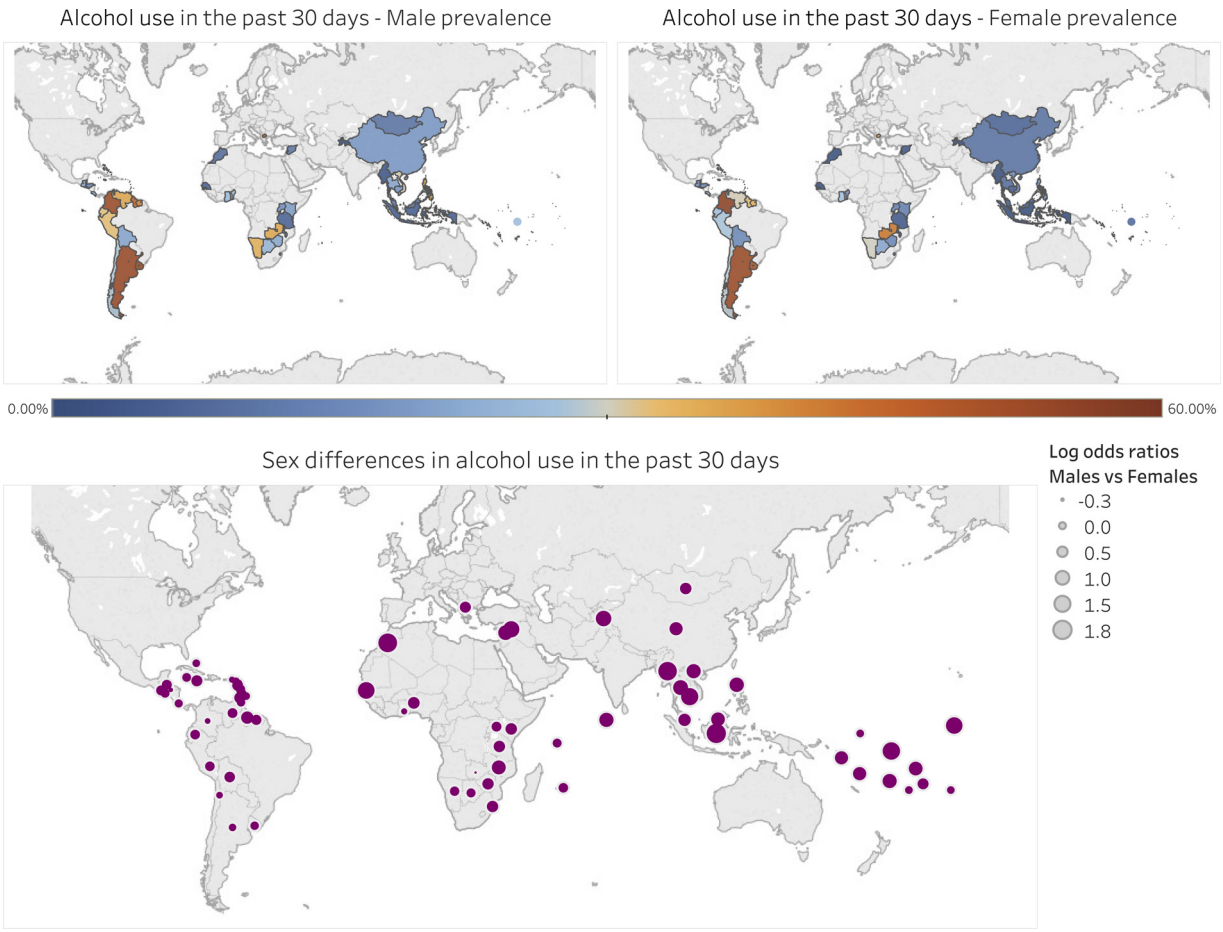

Fig. 1. Maps presenting prevalence on past 30 days alcohol use by sex among school-based adolescents in low and middle-income countries.

estimated. A diagram presenting the conceptual overview of the data analysis method is available in Supporting Materials Fig. S4. Meta-regression analyses, adjusting for prevalence of alcohol use, examined whether variations in sex differences in the alcohol measures were associated with the year of data collection, age of students, and country-level gender inequality and human development levels.

3. Results

3.1. Prevalence of alcohol drinking and consequences by sex

The weighted prevalence of past 30 days alcohol use, history of intoxication and alcohol-related problems are presented for males and females in Figs. 1–3 respectively (see Supporting Materials Table S2 for a downloadable table of results, and interactive data visualization available online as maps and individual country profiles). Calculation of crude differences in prevalences showed that 15%, 3%, and 11% of LMIC examined had alcohol use, intoxication, and alcohol-related problems rates in females, respectively, that were within 1% difference in rates in males (see Table S2).

Within the Africa region, Seychelles had the highest prevalence of past-30-day alcohol use (males = 59.74%, females = 56.15%) and intoxication (males = 55.52%, females = 46.40%), with approximately one-quarter reporting alcohol-related consequences (males = 26.51%, females = 16.09%). The lowest prevalence of alcohol use was in Senegal (males = 5.81%, females = 1.66%) and Malawi (males = 7.78%, females = 3.62%).

In the Americas, high levels of alcohol use were observed in most countries. The lowest was Honduras (males = 14.48%, females = 16.93%) and the highest in males in Saint Lucia (males = 58.80%, females = 52.29%) and in females in Colombia (males = 53.19%, females = 56.09%). A history of intoxication were also highest in Colombia (males = 45.79%, females = 37.73%). Alcohol-related problems were lowest in El Salvador (males = 5.40%, females = 6.55%) and highest in Colombia (males = 23.24%, females = 18.08%) and Uruguay (males = 21.97%, females = 19.13%).

In the Eastern Mediterranean region alcohol use was low in males and even lower in females in Morocco (males = 8.15%, females = 1.56%) and Syrian Arabic Republic (males = 10.54%, females = 3.36%). In Morocco, a history of intoxication closely followed the prevalence of alcohol use (males = 6.81%, females = 1.47%). The percentage reporting alcohol-related problems were very high in comparison to the prevalence of alcohol use (males = 16.16%, females = 12.16%). There were no data on intoxication or alcohol-related problems in Syrian Arab Republic. In Lebanon 29.31% of males reported alcohol use, while prevalence in female were half that figure (14.02%).

In the Europe region, the prevalence of alcohol use was very low in Tajikistan (males = 1.01%, females = 0.35%) and high in Macedonia (males = 47.25%, females = 37.67%). In Macedonia, reports of intoxication (males = 32.17%, females = 24.33%) and alcohol-related problems (males = 21.95%, females = 21.28%) were also common.

South-east Asia had the lowest overall prevalence of alcohol use and its adverse consequences. The lowest prevalence of alcohol use was in Myanmar (males = 2.99%, females = 0.58%), though the proportion with alcohol-related problems were comparatively high (males = 7.25%, females = 4.26%). Thailand reported the highest prevalence of alcohol use (males = 21.02%, females = 9.17%), intoxication (males = 24.40%, females = 12.43%), and alcohol-related problems (males = 14.46%, females = 4.74%).

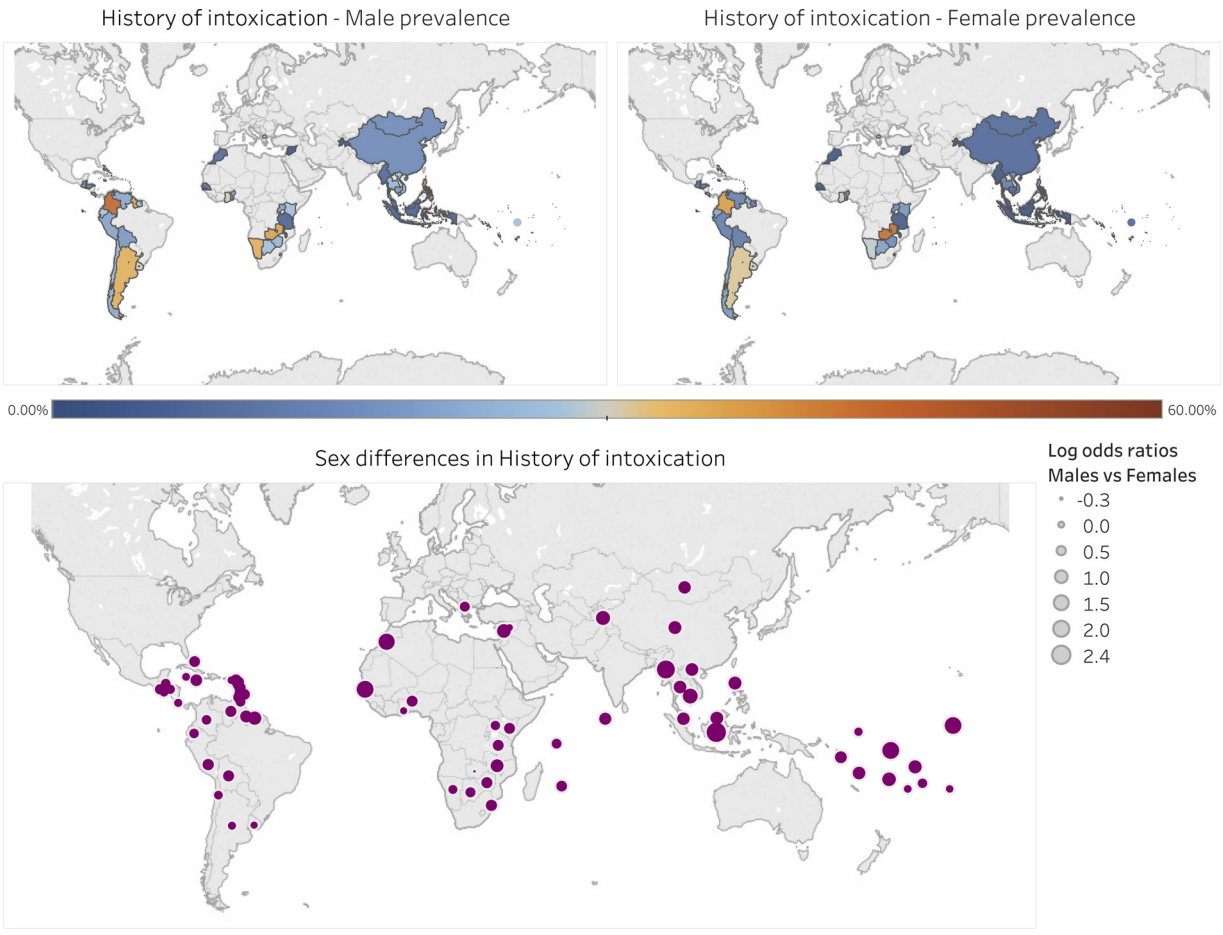

Fig. 2. Maps presenting prevalence on history of intoxication by sex among school-based adolescents in low and middle-income countries.

In the Western Pacific region, the lowest prevalence of alcohol use was observed in Brunei (males = 5.72%, females = 2.71%), as were a history of intoxication (males = 5.21%, females = 2.27%) and alcohol-related problems (males = 2.24%, females = 0.97%). The highest prevalence of alcohol use was in Kiribati (males = 46.85%, females = 19.86%) and Samoa (males = 45.29%, females = 27.56%). Samoa also had the highest rate of intoxication in males (males = 48.21%, females = 27.22%) and alcohol-related problems in both sexes (males = 41.90%, females = 27.43%). History of intoxication were highest among females in Cook Islands (males = 31.76%, females = 30.23%).

3.2. Sex differences in alcohol use

Overall, males had over two times higher odds of reporting past-30-day alcohol use than females, OR = 2.38 (1.91–2.96), see Table 1. Sex differences were largest in the Eastern Mediterranean region, OR = 4.03 (2.55–6.39) followed by the South-east Asia region, OR = 3.41 (2.03–5.73), and smallest in the America region, OR = 1.13 (1.01–1.27). Among the LMIC examined, 87% showed higher odds in males, 3% showed higher odds in females, and 10% showed no sex differences in alcohol use (forest plot of meta-analysis on alcohol use is available in Supplementary material S5).

Within the Africa region, the largest sex difference was in Senegal, where males had over three times higher odds of alcohol use than females, OR = 3.66 (2.31–5.78). The second largest sex difference was in Malawi, OR = 2.25 (1.54–3.29). In Zambia, males had lower odds of alcohol use than females, OR = 0.75 (0.63–0.90). Within the America region, there were no statistically significant sex differences or small magnitude differences in alcohol drinking across countries, ranging from OR = 0.83 (0.64–1.08) in Honduras to OR = 1.77 (1.54–2.03) in Guyana. Within the Eastern Mediterranean region, males were at much higher odds of alcohol use than females across countries, ranging from OR = 2.54 (2.26–2.86) in Lebanon to OR = 5.58 (3.45–9.02) in Morocco.

Within the Europe region, sex differences in the odds of alcohol use varied from 1.48 (1.24–1.77) in the former Yugoslav Republic of Macedonia to 2.95 (1.69–5.16) in Tajikistan. Within the South-east Asia region, males had over five times higher odds of alcohol use than females in Indonesia, OR = 6.29 (3.48–11.35), and Myanmar, OR = 5.32 (2.50–11.33). Within the Western Pacific region, the largest sex difference in alcohol drinking were found in Tuvalu at OR = 4.24 (2.83–6.35), Cambodia at OR = 4.05 (3.21–5.12), and Kiribati at OR = 3.56 (2.85–4.45). No significant differences by sex were observed in Cook Islands OR = 1.03 (0.82–1.29), Nauru OR = 1.03 (0.70–1.52), and, Tonga OR = 1.04 (0.83–1.30).

3.3. Sex differences in history of intoxication

Overall, males had two times higher odds of lifetime history of intoxication than females (OR = 2.64 [2.11–3.31]; see Table 1). As with the differences in alcohol drinking, sex differences were largest in the Eastern Mediterranean region (OR = 4.42 [2.22–8.82]) and South-east Asia region (OR = 3.35 [1.39–8.05]), and lowest in the America region (OR = 1.47 [1.26–1.71]). Among the LMIC examined, 81% showed higher odds in males, 1% showed higher odds in females, and 18% showed no sex differences in history of intoxication (forest plot of meta-analysis on alcohol use is available in Supplementary material S6).

Within the Africa region, the largest sex difference in a history of intoxication was found in Senegal (OR = 5.69 [3.61–8.96]). The sex

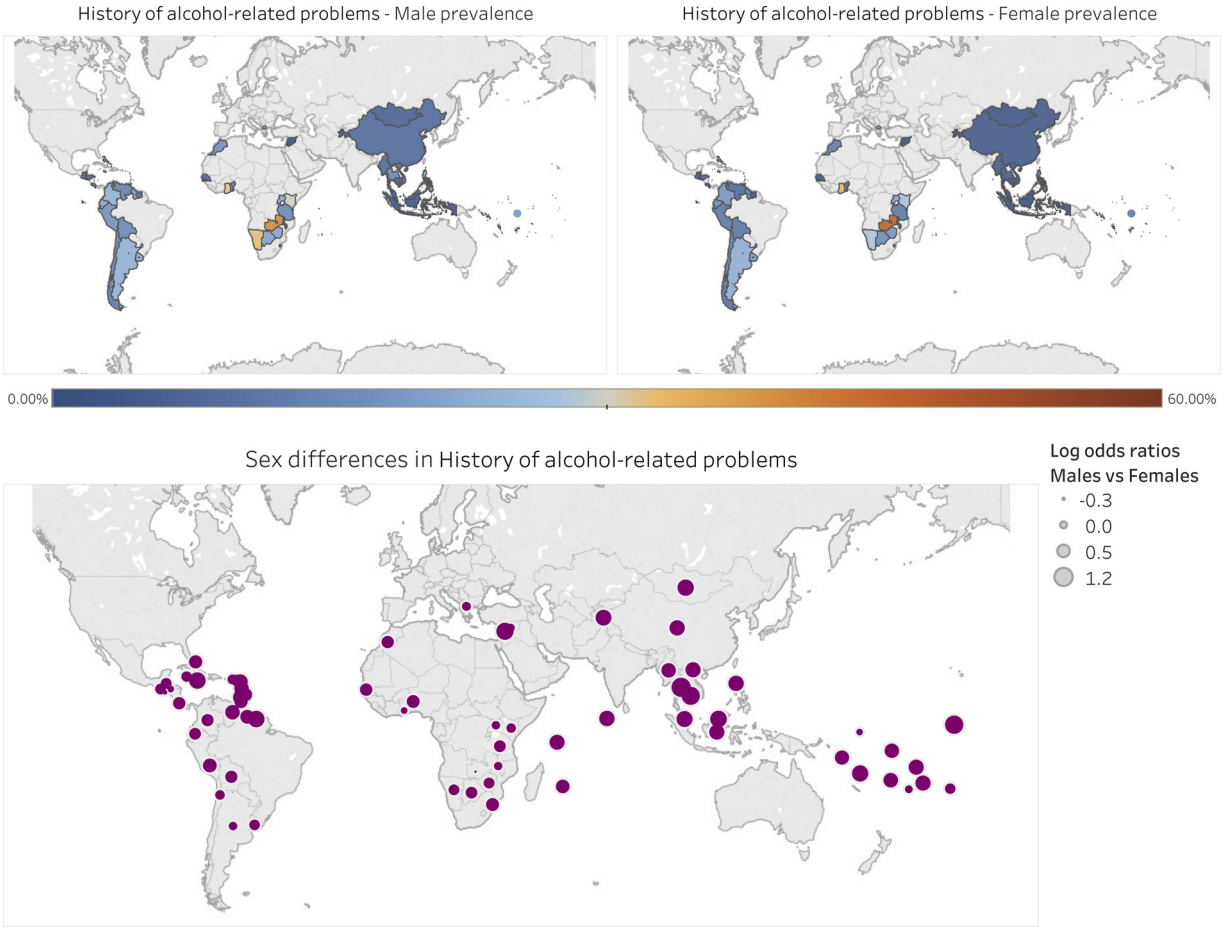

Fig. 3. Maps presenting prevalence on history of alcohol-related problems by sex among school-based adolescents in low and middle-income countries.

Table 1
Pooled regional and overall sex differences in alcohol drinking and consequences presented as odds ratios in male compared to female school-based adolescents in low and middle-income countries.

	Past 30 days alcohol use OR (95%CI)	History of intoxication OR (95%CI)	History of alcohol-related problems OR (95%CI)
Africa region	1.48 (1.21–1.81)	1.65 (1.31–2.08)	1.08 (0.89–1.30)
America region	1.13 (1.01–1.27)	1.47 (1.26–1.71)	1.27 (1.08–1.48)
Eastern Mediterranean region	4.03 (2.55–6.39)	4.42 (2.22–8.82)	1.51 (0.74–3.08)
Europe region	1.57 (0.70–3.52)	1.67 (0.75–3.74)	1.29 (0.62–2.66)
South-east Asia region	3.41 (2.03–5.73)	3.35 (1.39–8.05)	2.50 (1.66–3.76)
Western Pacific region	2.39 (1.51–3.77)	2.40 (1.50–3.83)	1.99 (1.34–2.94)
Overall	**2.38** **(1.91–2.96)**	**2.64** **(2.11–3.31)**	**1.72** **(1.41–2.10)**

Note. Forrest plots with country-level ORs are available in Supporting Materials S5-S7.

difference was reversed in Zambia where males had *lower* odds of history of intoxication than females, OR = 0.74 (0.62-0.88). Within the America region, sex differences ranged from OR = 1.04 (0.94–1.15) in Uruguay to OR = 2.59 (2.00–3.36) in Suriname. Within the Eastern Mediterranean region, males had over two times higher odds of intoxication in Lebanon, OR = 2.83 (2.47–3.23), and over four times higher odds in Morocco, OR = 4.90 (2.97–8.08). Within the Europe region, sex differences in intoxication were larger in Tajikistan, OR = 3.00 (2.03–4.43) than the former Yugoslav Republic of Macedonia, OR = 1.48 (1.22–1.79). Within the South-east Asia region, we found an over 10-fold sex difference in Indonesia, OR = 10.96 (5.02–23.95), although the confidence intervals were wide because of the very low prevalence reported among females. This was followed by Myanmar, where an over 7-fold sex difference was found, OR = 7.55 (4.11–13.88). Within the Western Pacific region, no significant sex differences were found in Cook Islands, OR = 1.07 (0.85–1.36), Nauru, OR = 1.18 (0.80–1.73), Niue, OR = 1.37 (0.63–2.96), and Tonga, OR = 1.10 (0.87–1.40). The highest sex differences in reporting history of intoxication was found in Tuvalu, OR = 5.71 (3.66–8.92) and Kiribati OR = 5.52 (4.24–7.18).

3.4. Sex differences in history of alcohol-related problems

Overall, males had higher odds of reporting alcohol-related problems than females (OR = 1.72 [1.41–2.10]; see Table 1). On a regional-level, sex differences were largest in South-east Asia (OR = 2.50 [1.66–3.76]), followed by Western Pacific (OR = 1.99 [1.34–2.94]). The smallest sex differences were observed in the Africa region (OR = 1.08 [0.89–1.30]) and Europe region (OR = 1.29 [0.62–2.66]), where confidence intervals included 1.00. Among the LMIC examined, 70% showed higher odds in males, 1% showed higher odds in females, and 28% showed no sex differences in reporting alcohol-related problems (forest plot of meta-analysis on alcohol use is available in Supplementary material S5).

Within the Africa region, sex differences in history of alcohol-

related problems were the highest in the Seychelles, OR = 1.88 (1.45–2.44). Within the America region, sex differences were highest in Jamaica, OR = 2.27 (1.71–3.01), Suriname, OR = 2.27 (1.47–3.50), Venezuela, OR = 1.79 (1.46–2.19), and Antigua and Barbuda, OR = 1.79 (1.25–2.55). Within the Eastern Mediterranean region, sex differences were larger in Lebanon, OR = 2.49 (2.16–2.87), than Morocco, OR = 1.39 (1.12–1.74). Within the Europe region, males had two times higher odds of reporting alcohol-related problems in Tajikistan, OR = 2.09 (1.56–2.80), while no statistically significant sex differences were found in the former Yugoslav Republic of Macedonia, OR = 1.04 (0.84–1.28). Within the South-east Asia region, sex differences were comparatively high, with the largest sex difference observed in Thailand, OR = 3.40 (2.54–4.54). Within the Western Pacific region, the largest sex differences were found in Kiribati, OR = 2.95 (2.27–3.85) and Cambodia, OR = 2.88 (1.89–4.38), while no statistically significant sex differences were found in Nauru, OR = 0.90 (0.59–1.37), Tonga, OR = 0.96 (0.75–1.24), and Cook Islands, OR = 1.17 (0.89–1.54).

3.5. Meta-regression results

Meta-regression results of sex differences in alcohol measures by age of students, year of survey, and gender inequality and development of the countries are presented in Table 2. Age was a significant moderator on sex differences in alcohol use (B = 0.26, SE = 0.08, p = 0.002), that is, the sex differences were stronger among older students. As countries were surveyed at different years, we examined if variations in sex differences was associated with year of data collection. Year of survey did not have a significant association with sex differences in past 30 days alcohol use (B = 0.01, SE = 0.02, p = 0.637), history of intoxication (B = 0.01, SE = 0.02, p = 0.496), and alcohol-related problems (B = 0.02, SE = 0.01, p = 0.118). We did not find significant effects from Gender Inequality Index nor Human Development Index.

4. Discussion

This is the first known quantitative study of sex differences in alcohol drinking and associated consequences using a large multi-country sample of adolescents from low and middle-income countries. Overall, we found that males had over two-fold increased odds of past-30-day alcohol use and history of intoxication than females, and almost two times higher odds of reporting alcohol-related problems than females. While on an overall level, consumption in males were consistently higher on average, on a country-level, this was less the case.

Table 2
Meta-regression results on sex differences in alcohol drinking by age, year of survey, and country-level Gender Inequality Index (GII) and Human Development Index (HDI).

	Coef	SE	z	(95%CI)	p
Sex differences in alcohol use in the past 30 days					
Age	0.26	(0.08)	3.22	(0.10,0.42)	0.002
Year of survey	0.01	(0.01)	0.70	(−0.02,0.03)	0.484
Gender Inequality Index (GII)	−0.40	(0.41)	−0.96	(−1.22,0.42)	0.340
Human Development Index (HDI)	−0.87	(0.45)	−1.94	(−1.77,0.02)	0.054
Sex differences in history of intoxication					
Age	0.14	(0.09)	1.52	(−0.04,0.31)	0.131
Year of survey	0.01	(0.01)	1.04	(−0.01,0.04)	0.299
Gender Inequality Index (GII)	−0.65	(0.39)	−1.66	(−1.42,0.13)	0.100
Human Development Index (HDI)	−0.32	(0.42)	−0.76	(−1.16,0.52)	0.448
Sex differences in history of alcohol-related problems					
Age	0.14	(0.09)	1.52	(−0.04,0.31)	0.131
Year of survey	0.01	(0.01)	1.04	(−0.01,0.04)	0.299
Gender Inequality Index (GII)	−0.65	(0.39)	−1.66	(−1.42,0.13)	0.100
Human Development Index (HDI)	−0.32	(0.42)	−0.76	(−1.16,0.52)	0.448

The highest sex differences in past-30-day alcohol use was reported in East Mediterranean countries, followed by South East Asia and Western Pacific countries. The prevalence of past-30-day alcohol use aligns with history of intoxication in most countries. Africa had the highest proportion of countries where history of intoxication was more common than past-30-day alcohol use: Ghana, Kenya, Swaziland, Uganda, Zambia and Zimbabwe. Males were more likely to have been intoxicated than females in all African countries except in Zambia where rates were higher in female, and in Ghana were there was no significant sex differences. Looking at a narrow measure of absolute differences, an important new finding is that within LMIC countries, 15% reported comparable rates of male and female drinking, based on less than 1% variation in self-reported consumption (data available in Supplementary material S2). For drinking consequences, 3% and 11% of countries reported comparable rates of intoxication and alcohol-related problems.

In contrast, high-income countries generally have the highest alcohol consumption, but there were not associated elevations in high-risk drinking (Patrick and Schulenberg, 2013). In our study, the similar rate in past 30-day alcohol use and intoxication suggests that although teenagers in low- and middle-income countries have less access to alcohol, intoxication is more common when alcohol was consumed. The reasons underlying this differential are unclear. It is possible that supply and demand reduction policies are less effective in low-middle income countries (such as regulations/practices around alcohol advertising, liquor sales and density). Prevention programs might be oriented towards heavy alcohol use, and perhaps be targeted to high risk groups, in addition to universal prevention (Masterman and Kelly, 2003). Adolescents who consume alcohol heavily commonly have allied problems, and systemic approaches to these more complex groups may be important (Kelly et al., 2019). Of course, systemic approaches are often more intensive (and expensive), but recent innovations in multi-level approaches, including community-based approaches, have the benefit of high sustainability, a greater sense of community ownership, and the imparting of skills to community stakeholders (Rowland et al., 2018). High income countries have a valuable role to play in co-creating and enhancing the approaches of lower income countries to adolescent alcohol use and heavy alcohol use, particularly as the cost per capita of addressing health risk behaviors in LMIC is typically low for high income countries (Patton et al., 2009).

A cross-national school-based study among high-income countries have reported that sex differences in heavy drinking and intoxication has been converging (sex difference was found in 20 countries in 2002 vs 14 countries in 2010) (WHO, 2018). As research suggests female are more vulnerable to health and social problems associated with alcohol even at a lower level of consumption than male, the potential converging trends in alcohol use and intoxication in low- and middle-income countries may require special attention. Our study did not find an overall significant effect of gender inequality or human development on the country-level prevalence of alcohol use and related consequences in adolescents. A potential explanation of this finding could be that all students in this study were from LMICs, therefore limiting the variations in those country-level index. Future surveys with standardized measurements of alcohol use across low and middle to high income countries would provide a better data source to compare the effects of country-level factors associated with variations in adolescent risky alcohol use across the globe.

The percentage of teens who reported alcohol-related problems because of their drinking was rarer than intoxication in all regions. However, Fiji (Western Pacific), Myanmar (South East Asia), Tajikistan (Europe) and Morocco (East Mediterranean) also reported a higher rate of alcohol-related problems than intoxication. This may reflect the stronger social disapproval of any alcohol use in these locations, where

any level of drinking may get the adolescent into trouble. Future research on cultural differences in what lead adolescents to get into trouble from their alcohol use may shed light on this finding.

In most countries, the percentage of males who had experienced trouble because of their drinking surpassed that in females. Later maturation in brain structure and cognitive function among males compared to females may also cause misjudgement of risks related to alcohol use and consequences (Schulte et al., 2009). Sex differences in personality, specifically higher novelty/sensation seeking in males, also play a potential role (Boson et al., 2019; Cloninger et al., 1988). Previous literature suggests peer influence is a major driver of drinking among adolescents (Schuckit et al., 2012). The persistence of gender inequalities in low- and middle-income countries put men in resources and financial control in a household (Zhou and Li, 2017). Trouble related to alcohol use (e.g. missing schools, criminal offences) among male adolescents may have long-term negative impact on education attainment, future occupation and earning abilities, intensifying poverty among the poor.

A highlight of our study is that within LMIC countries, 87% reported higher odds of drinking in males, but 10% of countries had comparable rates by sex, and 3% of countries had higher odds in females. For intoxication, males had higher odds in 81% of the countries, but there were no sex differences in 18% of the countries. This is important information that can inform international and country level policy. Despite well-recognized variations in gender in consumption and alcohol problems, gender differences are poorly reported in population-level interventions aimed at reducing alcohol-related harm (Fitzgerald et al., 2016). The most effective policies to reduce alcohol-related harm involve increasing price and decreasing availability (Connor and Hall, 2015; Connor et al., 2016). Of the countries participating in the International Alcohol Control Study, Parry et al. (Parry et al., 2018) found highest policy support for reducing alcohol from low-middle-income countries. Females reported up to 52% greater support 11 of the 12 proposed alcohol policy changes, with the exception of increasing alcohol taxes to pay for alcohol treatment (Parry et al., 2018). Given the majority of gender difference by country occur as a result of cultural factors (Sudhinaraset et al., 2016; Wilsnack et al., 2000), it is likely culturally sensitive prevention programs that take into account important intra-country gender practices will be effective. Culturally focused alcohol interventions are available but require more rigorous evaluation before they can be recommended with confidence (Foxcroft et al., 2003; Wang-Schweig et al., 2014). Some examples of culturally targeted programs involve increasing cultural pride, increasing personal efficacy and integrity, and engaging adolescents to family and community (Durand et al., 2016; Liddell and Burnette, 2017).

5. Limitations

Our findings are limited in several respects. While data were collected in more recent years in some countries, a major limitation of our findings is the age of the data in some countries. For example, the data were collected 16 years ago with no newer data available in Kenya, Uganda, Venezuela and Philippines. Without more recent data in those countries, it is unknown whether the trends by sex have changed over time. Although our additional analysis on available data showed no significant association between year of data collection and sex differences in alcohol use, more data across different times in the same country would be more informative. Future repeated surveys in countries where no recent data are available would enable the establishment of trends in the prevalence of alcohol use by sex, forming an evidence-base for the planning of harm prevention interventions for young people.

Alcohol consumption or its consequences can be affected by biological and psycho-social aspects of sex and gender differences. We are limited by the available data in our ability to compare these in the studied populations. This study focuses on sex difference in alcohol consumption in LMICs. There is only one item assessing participants' sex: "What is your sex?". We have used the term "sex differences" in this paper to be consistent with the wording of how the data was collected. The survey data does not allow us to disentangle gender-specific and sex-specific differences.

Another limitation is that the data were collected via self-reported questionnaires, which are vulnerable to perceptual and reporting bias. The self-report information is also susceptible to social desirability bias, which may lead to under-reporting if school children are worried about getting into trouble for reporting drinking, or drinking and risk-taking may be over-reported to gain peer acceptance (Schulte et al., 2009). Traditional perception of sex roles in some countries could amplify these biases. The first page of the survey has emphasized that the survey was anonymous, and all answers were kept private and fully deidentified. Specifically, the following was included in the first page, "DO NOT write your name on this survey or the answer sheet. The answers you give will be kept private. No one will know how you answer. Answer the questions based on what you really know or do. There are no right or wrong answers." This was designed to increase the students' perception of confidentiality of the survey.

The measure for history of alcohol-related problems have not been formally validated. However, the survey was designed by expert groups in the World Health Organization and Centers for Disease Control and Prevention. The measure has strong face validity and based on our investigation has strong convergent validity and discriminant validity. We found that the measure of alcohol-related problem was strongly and exclusively associated with frequency of alcohol use (see Supporting Materials 8). It was also associated with tobacco use, but the effect size for alcohol use was much stronger. A history of alcohol-related problems was not associated with other dietary measures, and it was associated with all measure of alcohol use. Future studies that collects data from the adolescent as well as another source (e.g. parents) will confirm the validity of this measure across different populations.

The magnitude of regional sex differences in drinking and related consequences should be interpreted with caution in regions that had a small number of participating countries. For example, no data were available from India, which would have made a significant impact to the regional and total estimates due to its large population size.

We also do not have data on adolescents who were not attending school, as this was a school-based survey. Higher risks of substance use are associated with being absent from school or having dropped-out of school, therefore our prevalence estimates cannot be generalized onto these high-risk sub-populations of young people (Bovet et al., 2006; Townsend et al., 2007). This was a first study that examined alcohol use by sex, we had not examined the comorbidity with mental health problems or co-use with tobacco and other substances, which is outside the scope of our study, but warrants future research as they are other top causes of disease burden in adolescents. Lastly, our measure of alcohol-related problem included a range of problems, and we did not have data on the specific type or severity of problems the adolescents had experienced as a result of drinking alcohol.

6. Conclusions

Sex differences in alcohol use exists in low and middle-income countries surveyed from the early 2000s. Among adolescents in general, males are approximately two times more likely than females to engage in in past-30-day alcohol use, have a lifetime history of intoxication and alcohol-related problems. However, in some countries, both males and females are likely to consume alcohol, while in others abstinence rates are high among females. The prevalence of alcohol use, intoxication and alcohol-related problems in females were closely aligned with males in several countries where alcohol consumption was common. Improved economic and social status for females in society is likely to reduce the greater stigma surrounding female than male drinking and alcohol-induced consequences. In LMIC where we have limited

population health data, support and encouragement to conduct repeated surveys to collect data regularly are warranted to better monitor trends in alcohol use over time and quantify sex differences in alcohol-related harms.

Contributors

JL and GC contributed to the conception and design of the work. JL, GC, and VC contributed to the acquisition and analysis of the data. JL and VC contributed to the first draft. JL, VC, GC, WH, JC, AP, and AK made substantial contributions to the interpretation of data for the work, contributed to the drafting of subsequent versions, and revising it critically for important intellectual content. All authors provided final approval of the version to be published and agree to be accountable for all aspects of the work.

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Declaration of Competing Interest

All authors have no conflicts to declare.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.06.022.

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