



Global Burden of Alcohol Use Disorder in Adolescents and Young Adults, 1990-2021: Systematic Analysis of the Global Burden of Disease Study 2021

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Abstract

Background: Alcohol Use Disorder (AUD) imposes a significant health burden on adolescents and young adults, contributing to both physical and mental health challenges. With varying impacts based on sociodemographic index (SDI) levels, this study provides a comprehensive assessment of the global and regional AUD burden, revealing critical patterns that influence public health strategies. To evaluate global trends in the burden of AUD among adolescents and young adults (aged 15-39 years) from 1990 to 2021. This study aims to assess prevalence, disability-adjusted life years (DALY), and mortality related to AUD, analyze disparities across sociodemographic categories, and identify factors associated with increased risk, focusing on the influence of socioeconomic and demographic factors on AUD.

Methods: This study is a systematic analysis based on the 2021 Global Burden of Disease (GBD) dataset, encompassing individuals aged 15-39 years across 204 countries and territories over a 30-year period (1990-2021). A range of statistical approaches, including Age-Period-Cohort (APC) analysis, decomposition, frontier analysis, and predictive modeling, was employed to assess the trends in AUD burden by SDI, age, sex, and geographic location. The primary outcomes measured were age-standardized prevalence, DALY, and mortality rates for Alcohol Use Disorder among people aged 15-39 years.

Results: Globally, age-standardized prevalence, DALY, and mortality rates for AUD among adolescents and young adults showed a declining trend from 1990 to 2021, with Average Annual Percent Changes (AAPC) of -0.97%, -1.03%, and -1.5%, respectively. Males consistently exhibited higher prevalence and DALY rates compared to females. High SDI regions demonstrated higher AUD burdens, while low and low-middle SDI countries showed slower reductions, with population growth being a significant factor in increasing AUD DALY in these regions.

Conclusions: The findings underscore the need for targeted and context-sensitive interventions to reduce AUD burden, particularly in high-SDI regions where social and lifestyle factors increase risks, as well as in low-SDI regions facing limited resources. Tailoring prevention and intervention strategies to meet the unique socioeconomic and demographic needs of various populations could enhance the effectiveness of AUD management and public health outcomes globally.

Keywords: AUD, Prevalence, Disability-adjusted life years (DALYs); Joinpoint; BAPC.

Contributions to the Literature: This systematic analysis of the Global Burden of Disease Study 2021 data revealed a decline in age-standardized prevalence, DALY, and mortality rates for AUD among adolescents and young adults globally from 1990 to 2021. However, the decline was less pronounced in low and low-middle SDI countries. Males consistently exhibited higher AUD prevalence and DALY rates than females. Significant risk factors, such as childhood sexual abuse, were identified as contributing factors to AUD, with higher impacts in specific regions and demographics. Tailored public health initiatives could effectively reduce AUD-related health outcomes by addressing regional disparities and high-risk populations.

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INTRODUCTION

Alcohol use disorder (AUD) encompasses a range of conditions characterized by harmful patterns of alcohol consumption that impair health, relationships, and the ability to function in daily life [1]. Characterized by patterns of alcohol consumption that lead to physical, psychological, and social harm, AUD includes three major categories: alcohol dependence, alcohol abuse and harmful use [2,3]. Alcohol dependence is marked by tolerance, withdrawal, and an inability to control drinking despite adverse outcomes, while harmful use leads to physical or psychological damage and social or legal problems [4,5].

According to the Global Burden of Disease (GBD) Study 2019, AUD ranked among the leading causes of disability-adjusted life years (DALY) for middle-aged adults. However, World Health Organization (WHO) and many studies have identified adolescents and young adults



as a key population for AUD prevention, as this age group, often in their most formative and productive years, is pivotal for the development of behavioral and health habits, and highly susceptible to alcohol-related problems [6,7]. This age group is particularly vulnerable due to ongoing brain development, which can be adversely affected by alcohol consumption. Previous research indicated that the earlier individuals began drinking, the higher their risk of developing AUD later in life [8]. Besides, adolescents and young adults who develop AUD are at higher risk for psychiatric disorders, including depression, anxiety, and suicide [9]. This intersection of issues highlights the need for targeted interventions that address both alcohol use and associated mental health challenges. Moreover, the impact of alcohol on liver health is becoming increasingly evident, particularly among young individuals. Previous studies have shown that harmful alcohol use affected 29.3% of individuals under 35 years, compared to 16.9% in those aged 35-64 and 5.1% in those 65 and older in US, with young females and Hispanic individuals being disproportionately affected [10]. This trend underscores the urgency of early detection and intervention strategies tailored to adolescents and young adults [11,12]. Understanding the dynamics of AUD within this demographic is essential for informing public health strategies that address the specific needs and challenges faced by young people. The implications of such research extend beyond individual health; they play a crucial role in shaping effective public health policies and interventions aimed at reducing the overall burden of AUD. Nevertheless, due to the lack of high-quality national-level data in recent years, particularly in low resources countries, the prevalence of AUD among adolescents and young adults in many countries and in vulnerable populations remains unknown.

Alcohol Use Disorder (AUD) among adolescents and young adults is not only a biomedical issue but also a deeply socioeconomically and culturally embedded phenomenon. Susceptibility to AUD is influenced by a complex interplay of individual, social, and structural determinants. At the individual level, socioeconomic status (SES) can shape exposure to chronic stressors, affect neurodevelopmental pathways linked to impulse control and reward processing, and influence coping mechanisms. Adolescents from lower socioeconomic backgrounds may experience higher levels of adversity, limited access to positive recreational alternatives, and increased exposure to environments where alcohol use is normalized, thereby elevating AUD risk.

To systematically and comprehensively understand the global and regional burden of AUD among individuals aged 15 to 39 years from 1990 to 2021. The aim of this analysis was to: (1) examine the global trends in the prevalence, DALY, and mortality of AUD by each decade since 1990, (2) identifying the year with the most significant changes in these trends, (3) stratify the global trends by age groups, sex, and sociodemographic index (SDI), and (4) report the trends at both regional and national levels.

METHODS

Data source

The data of the 2021 GBD study was used for this analysis and was extracted from the Global Health Data Exchange query tool (<http://ghdx.healthdata.org/gbd-results-tool>). The GBD database comprehensively documents the global burden of 369 diseases and injuries, including AUD. We utilized the data on age-standardized prevalence, DALY and mortality by age, sex, SDI, regions, and countries for adolescents and young adults in five age groups (15-19 years, 20-24 years, 25-29 years, 30-34 years and 35-39 years) based on data availability. The methodology and definitions of terms used in GBD 2021 have been detailed in previous studies and can be found in the Supplemental Methods [13].

Case Definition

AUD is typically diagnosed clinically using the Diagnostic and

Statistical Manual for mental Disorders, 5th edition (DSM-5), which outlines 11 diagnostic criteria in total [14]. According to the DSM-5, AUD requires at least two of these criteria to be met within a 12-month period, categorized as mild (meeting 2-3 criteria), moderate (meeting 4-6 criteria), or severe (meeting 7-11 criteria). AUD is classified under diagnosis code F-10 in the International Statistical Classification of Diseases (Tenth Revision) (ICD-10) [15]. Detailed information about DSM-5 can be found in the Supplemental Methods.

Risk-Attributable Burden

The 2021 GBD identifies a total of 87 risk factors, of which childhood sexual abuse shows a non-zero contribution to disability-adjusted life years (DALY) for adolescents and young adults with AUD. We assessed the percentage contribution of this risk factor to adolescents and young adults AUD DALY in 2021. As the population attributable fraction by alcohol use was assumed to be 100% in the 2021 GBD Study [16], we did not include consumption of alcohol use in our final analysis. Detailed definitions of the included risk factor can be found in the Supplemental Methods.

Age-period-cohort model analysis

In this study, the APC model was employed to analyze the trends in AUD prevalence across different age groups, time periods, and birth cohorts. In APC model analysis, the age interval is typically equivalent to the period interval, requiring the use of 5-year age groups paired with 5-year periods. We utilized the data from the 2021 GBD database, which includes AUD prevalence over the past 30 years (1992-2021) for the adolescent and young adults population, along with the corresponding population data for each location. The age range of 15-39 years was divided into five age groups in the analysis: 15-19, 20-24, 25-29, 30-34 and 35-39 years. The study's timeframe, spanning from 1992 to 2021, was subsequently divided into six 5-year periods: 1992-1996, 1997-2001, 2002-2006, 2007-2011, 2012-2016 and 2017-2021. In the APC model, the age effect is represented by age-specific prevalence corresponding to the birth cohorts, while the period/cohort effect is expressed as the prevalence ratio by comparing the age-specific prevalence for each period/cohort to that of a reference period/cohort.

Statistical Analysis

Descriptive analyses were conducted to characterize the overall AUD burden in adolescents and young adults, overall and by age, sex, SDI, and location, using age-standardized rates. Average annual percent change (AAPC) along with corresponding 95% confidence intervals were calculated to assess the extent and direction of temporal trends in the prevalence, DALY and mortality related to adolescents and young adults AUD using joinpoint regression analysis. The program began with the minimum number of joinpoints (i.e., a straight line with zero joinpoint) and assessed whether additional joinpoints were statistically significant and warranted inclusion in the model. To gain better insight into the factors mediating variations in the DALY of adolescents and young adults with AUD between 1990 and 2021, decomposition analyses were performed based on age structure, population size, and changes in the epidemiology. To examine the association between sociodemographic development and the burden of AUD in adolescents and young adults, a frontier analysis was conducted using the SDI to estimate the lowest feasible rate of DALY, aiming to determine the least achievable rate. Detailed description of the decomposition analysis and frontier analysis was described in the supplementary methods. The disparity in the burden of adolescents and young adults AUD across various countries was quantified using the slope index of inequality and the health inequality concentration index, which are standard measures representing absolute and relative gradients of inequality, respectively.

All statistical analyses were executed employing GraphPad Prism (version 10.3.1), Rstudio software (version 4.3.3), and the Joinpoint



Regression Program (version 4.9.0.0). Comprehensive details regarding the statistical methodologies employed are elucidated within the Supplemental Methods.

Data Processing and Assumptions:

All rates were age-standardized using the GBD global standard population. Missing data for certain country-years were modeled using spatiotemporal Gaussian process regression as part of the GBD estimation process—a method that assumes smooth changes over time and space. While robust, this approach may underestimate uncertainty in regions with sparse data. Analyses were conducted using R (v4.3.3) and Joinpoint Regression (v4.9.0.0), with significance levels set at $p < 0.05$.

Limitations of Analytical Approaches:

Although frontier analysis helped visualize the “best achievable” DALY rates given a country’s SDI, it assumes that SDI is the primary determinant of health system performance, ignoring political will, governance, or cultural factors. Similarly, inequality indices (Slope Index of Inequality, Concentration Index) assume that socioeconomic ranking is accurately captured by SDI, which may oversimplify multidimensional poverty and inequality.

RESULTS

Global Trends

Globally, AUD age-standardized prevalence, age-standardized DALY and age-standardized mortality showed a decreased trend from 1990 to 2021 among adolescents and young adults, with AAPC of -0.97% (95%

uncertainty interval [UI], -1.02% to -0.92%; $P < 0.001$), -1.03% (-1.32% to -0.74%) and -1.5% (-2.11% to -0.89%), respectively. In 2021, the global age-standardized prevalence, age-standardized DALY, and age-standardized mortality per 100000 population were 1719.08 (95% confidence interval [CI] 1269.54 to 2269.07), 228.99 (164.16 to 320.89), and 0.95 (0.72 to 1.07), respectively (Figure 1).

The changes in the disease burden parameters were strongly associated with SDI categories. Countries with a high SDI had the highest age-standardized prevalence and age-standardized DALY (age-standardized prevalence 2769.91, 95% CI 2067.41 to 3617.04; age-standardized DALY 347.26, 246.12 to 495.31), and countries with a low SDI had the lowest age-standardized prevalence (1441.9, 1047.58 to 1937.74), age-standardized DALY (176.98, 120.37 to 256.73) and age-standardized mortality (0.55, 0.35 to 0.71). The data showed positive associations between SDI and age-standardized prevalence and age-standardized DALY were presented among adolescents and young adult. The largest reduction in the prevalence was observed in the low-middle SDI countries, with an AAPC of -1.11% (95% UI, -1.34% to -0.89%), and the high-middle SDI countries had the largest reduction in DALY and mortality, with an AAPC of -1.29% (95% UI, -2.34% to -0.23%) and -2.28% (95% UI, -3.66% to -0.88%), respectively, between 1990 and 2021. Notably, all SDI quintiles had reductions in prevalence, DALY and mortality from 1990 to 2021.

Global Trends by Sex and age group

Globally, in 2021, there were 39.64 million AUD prevalent cases in males and 12.18 million prevalent cases in females, and the age-standardized prevalence, age-standardized DALY and age-standardized

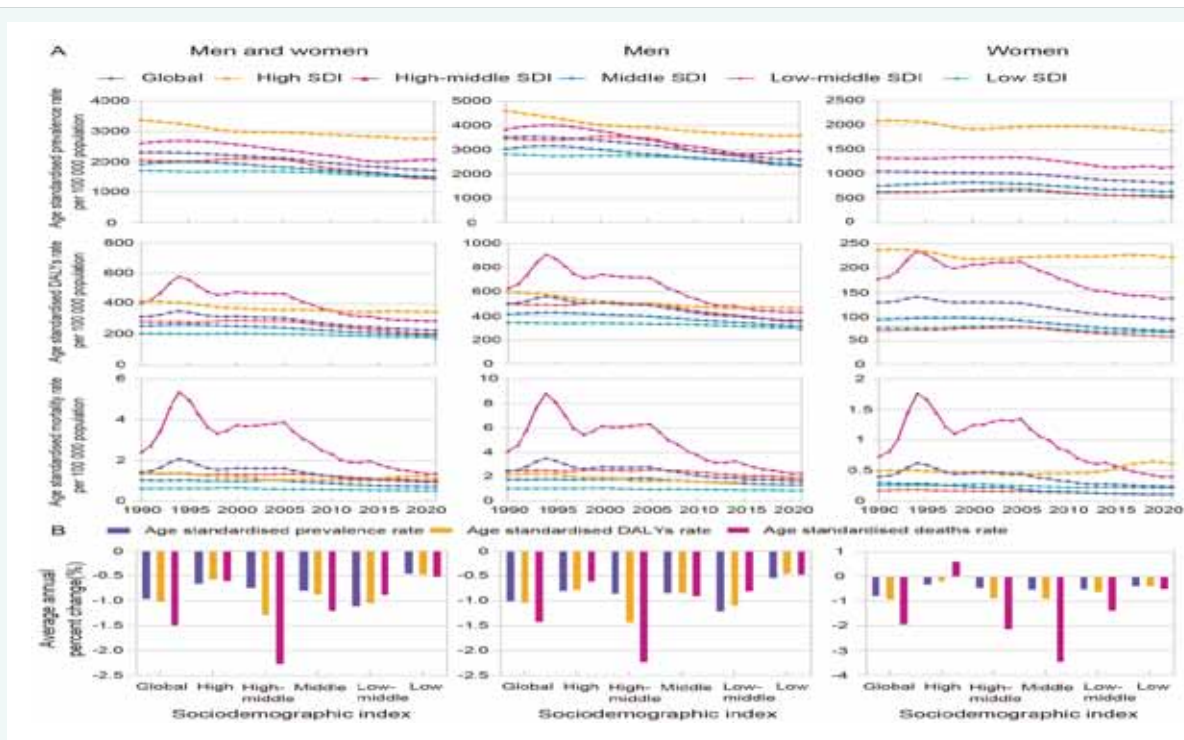


Figure 1 : This study examines the temporal trends in the age-standardized prevalence, age-standardized disability-adjusted life years (DALY), and age-standardized mortality for the burden of alcohol use disorder among adolescent and young adults, both globally and across different sociodemographic index categories (high, high-middle, middle, low-middle, and low) from 1990 to 2021. It also presents the average annual percent change for these metrics globally and by sociodemographic index category over the same period.



mortality were higher in males (2595.16, 359.33 and 1.65) than that in females ((821.63, 95.54 and 0.24) (Figure 1). There were global decreases in the AUD prevalence from 1990 to 2021 in both males and females, with an AAPC of -1.02% (95% UI, -1.11% to -0.93%) in males and -0.81% (95% UI, -0.85% to -0.77%) in females.

The highest age-standardized prevalence was observed among adolescent and young adults who were aged 35-39 years in both 1990 (4868.13 per 100 000 population) and 2021 (3772.15 per 100 000 population). Additionally, the differences in the prevalence, DALY, and mortality between males and females can be primarily attributed to the disparities in the older age groups (25-29, 30-34 and 35-39 years). However, the largest decrease in the AUD prevalence between 1990 and 2021 was observed in males aged 20-24 years old, with an AAPC of -1.12% (95% UI, -1.19% to -1.06%). Furthermore, all five age subgroups in both sexes had decreasing prevalence, DALY and mortality between 1990 and 2021; and males had higher prevalence, DALY and mortality than females (Figure 2).

Region and country Trends

At the regional level, Eastern Europe, Western Europe and Southern Latin America were the top 3 regions with the highest age-standardized prevalence of 3628.5, 3343.63 and 3273.48 per 100 000 population. Notably, between 1990 and 2021, Australasia was the region with largest

increase in age-standardized prevalence (AAPC, 0.48% [95% UI, 0.32% to 0.63%]), age-standardized DALY (AAPC, 0.41% [95% UI, 0.27% to 0.56%]) of AUD in young populations. While, High-income North America had the largest increase in age-standardized mortality due to AUD (AAPC, 1.63% [95% UI, 0.62% to 2.66%]). The observed regional age-standardized prevalence, age-standardized DALY and age-standardized mortality in relation to the SDI, compared to the expected levels for each location based on the SDI, are illustrated. Except for Eastern Europe and Central Asia, the age-standardized DALY and age-standardized mortality in most GBD regions exhibited a little change with increasing SDI values.

Nationally, the country with the highest adolescent and young adult AUD prevalence in 2021 was Greenland (5842.19 per 100 000 population). The country with the highest AUD_DALY in 2021 was Mongolia (1265.48 per 100 000 population), which was also the country with the highest mortality (11.85 per 100 000 population) (Figure 3). From 1990 to 2021, Mongolia had the largest increases in AUD age-standardized prevalence (AAPC, 2.19% [95% UI, 2.06% to 2.32%]), and age-standardized DALY (AAPC, 1.43% [95% UI, 1.02% to 1.84%]). The largest increase in AUD mortality was observed in United Kingdom (AAPC, 2.14% [95% UI, 1.52% to 2.77%]). In 2021, there were significant associations between age standardize prevalence for AUD and SDI at the national level, with some exceptions. However, both DALY and mortality showed no significant relationship with SDI.

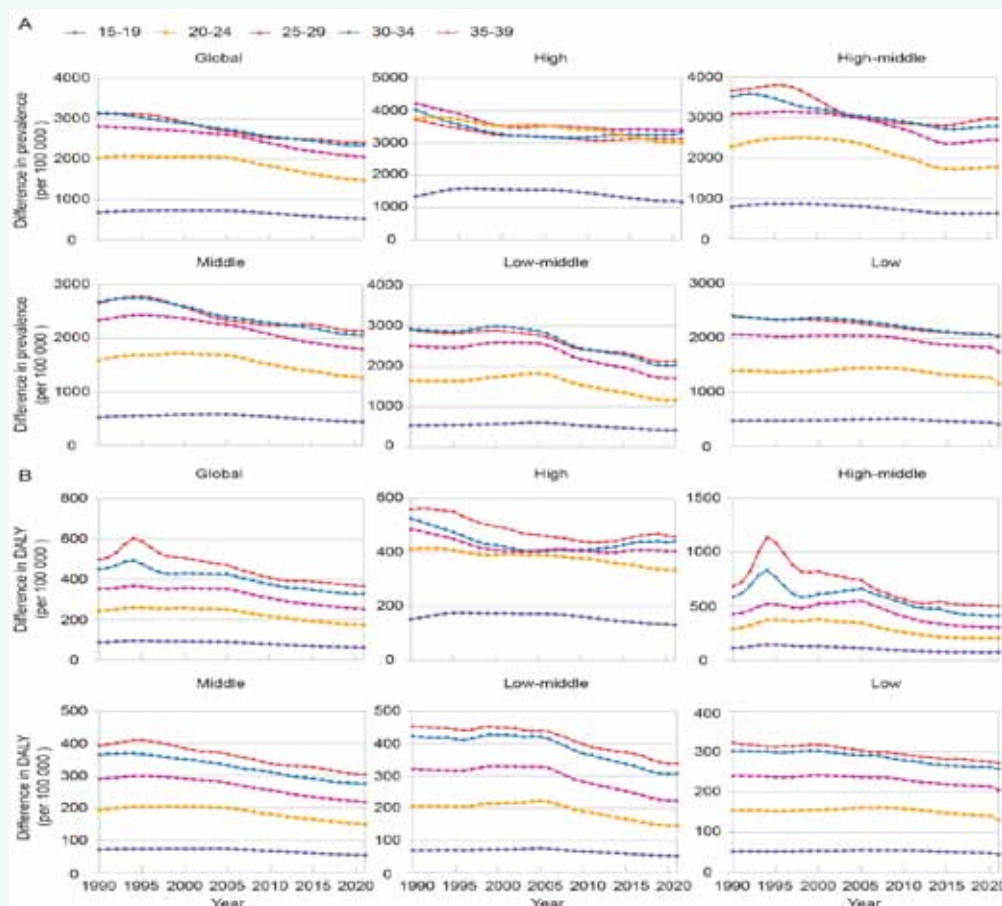


Figure 2 : Variation in age-specific prevalence and DALY of alcohol use disorder between men and women across sociodemographic index categories (high, high-middle, middle, low-middle, and low) from 1990 to 2021. DALY= disability-adjusted life years.

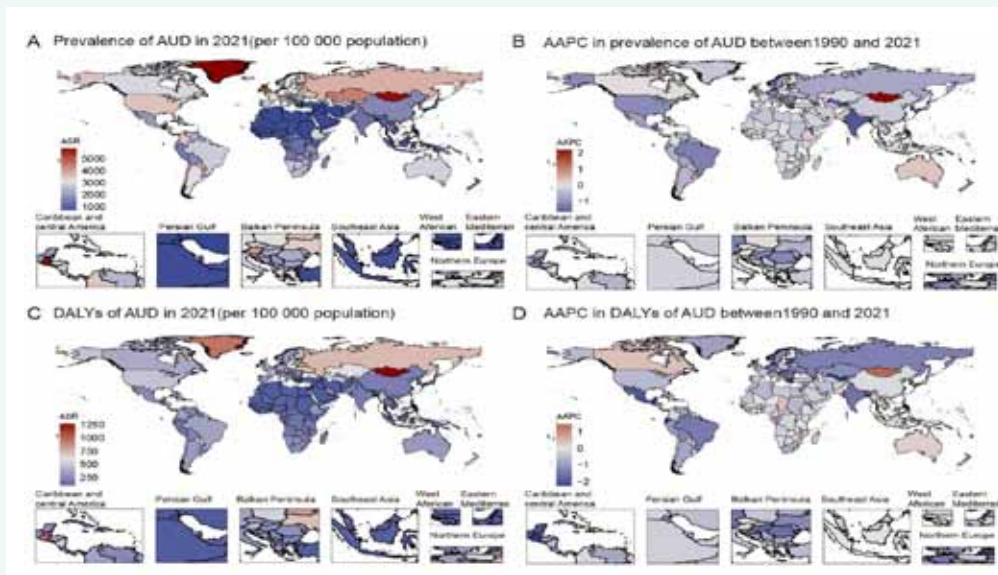


Figure 3 : World map of 2021 prevalence (A) and DALY (C) and average annual percentage changes in prevalence (B) and DALY (D).

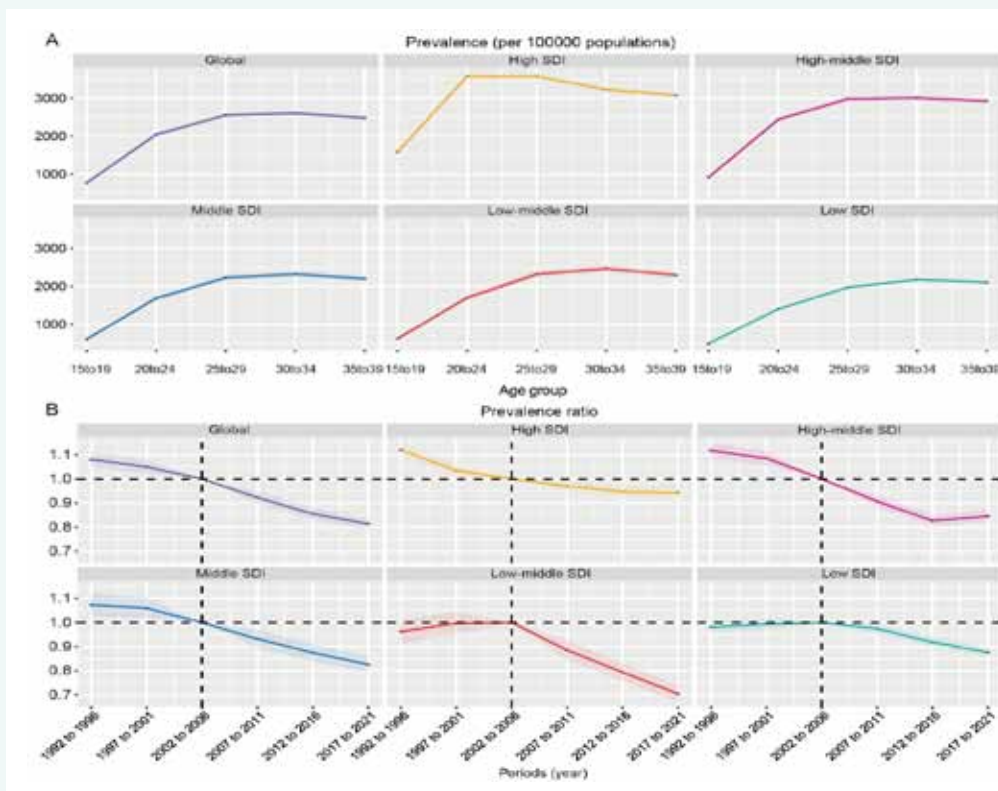


Figure 4 : APC models for age, period and birth cohort effects on AUD prevalence in adolescent and young adults. (A) The age effect is illustrated through age-specific longitudinal rates, which are adjusted for variations across different birth cohorts and account for period-specific deviations. (B) Period effects are demonstrated by the relative risk of AUD prevalence across different time periods, calculated as the ratio of age-specific rates from 1992-1996 to 2017-2021, with 2002-2006 set as the baseline period. AUD= alcohol use disorder.



The observed high AUD burden in Eastern Europe can be attributed to a combination of historically high per-capita alcohol consumption, culturally entrenched drinking norms, relatively affordable alcohol, and periods of socioeconomic transition that increased psychosocial stress. In Southern Latin America, similar patterns are evident, with social drinking deeply integrated into daily life and festivities, alongside variable enforcement of alcohol control policies.

Conversely, the increase in AUD prevalence in Australasia may reflect both better detection and reporting and rising binge-drinking cultures among youth, despite strong public health campaigns. In High-income North America, the rising mortality trend could be linked to the co-occurrence of AUD with other substance use (e.g., opioids), mental health crises, and unequal healthcare access despite high overall SDI.

Age, period and birth cohort effects on the prevalence of AUD in adolescent and young adult

Figure 4 illustrate the age, period, and birth cohort effects of AUD, as derived from the APC model. Overall, the age effect exhibited a comparable pattern across various SDI regions. The least risk was evident among adolescents aged 15 to 19 years, followed by a subsequent rise in risk with an increase of age. Besides, compared to other SDI regions, the high SDI region showed a relatively higher prevalence across all age groups, with the disparity between different age groups within these regions being relatively small (Figure 4A).

Globally, the period effect indicated a consistent downward trend in the age-standardized prevalence, a pattern also observed across middle SDI regions. Throughout the study duration, regions with low and low-middle SDI generally demonstrated favorable period risks. Compared with individuals in the reference 2002-2006 period, the relative period risk for individuals in the 2007-2011, 2012-2016, 2017-2021 period was 0.9748 (95% CI: 0.9540 to 0.9961), 0.9193 (95% CI: 0.8996 to 0.9395) and 0.8768 (95% CI: 0.8579 to 0.8961) in low SDI regions, and was 0.8854 (95% CI: 0.8498 to 0.9225), 0.7945 (95% CI: 0.7616 to 0.8288) and 0.7046 (95% CI: 0.6749 to 0.7357) in low-middle SDI regions (Figure 4B).

Regarding the birth cohort effect, globally, there was a noticeable pattern of prevalence risk initially a decelerating downward trend, followed by an accelerating downward trend across consecutive birth cohorts. Notably, with the exception of high SDI regions, other SDI regions exhibited a progressive improvement in the prevalence across successive

birth cohorts. Compared to the 1972-1981 birth cohort, individuals born before this cohort had a higher prevalence of AUD, whereas those born after this cohort had a relatively lower prevalence. However, in high SDI regions, the prevalence of AUD for individuals born before the 1972-1981 cohort gradually decreased, while the prevalence in those born after 1982-1991 cohort decreased significantly.

Decomposition analysis

Figure 5 present the results of decomposition analyses by population growth, aging, and epidemiological changes across the global, SDI quintiles and regional levels. Globally, DALY of AUD among adolescent and young adult increased slightly from 2019 to 2021. However, it was most pronounced among the Low-middle SDI and Low SDI quintile, where the DALY increase was the largest. A significant amount of the decrease in adolescent and young adult AUD DALY came from epidemiological change in countries with a High-SDI quintile (127.24%) and High-middle SDI quintile (129.38%). However, population growth was a main contributor to the increase in adolescent and young adult AUD DALY in Low-middle SDI quintile (195.47%) and Low-SDI quintile (124.40%). In most regions, population growth was the largest contributor, especially in the South Asia regions (222.92%). In central, eastern, southern and western sub-Saharan Africa, population growth accounted for more than a 100% increase in DALY for adolescent and young adult AUD.

Frontier analysis for the relationship between DALY of AUD and status of the country's development

Based on Frontier analysis, data about age-standardized DALY and SDI in 2021 were utilized to examine the relationship between the DALY of adolescent and young adult AUD and a country's development status. The frontier lines indicated the areas with the lowest DALY, representing optimal performers based on their SDI. A country's effective distance from the frontier is defined as the gap between its observed and potentially achievable DALY. This gap can be reduced or eliminated depending on the sociodemographic resources available in each country or territory. In 2021, SDI and DALY were used to calculate the effective difference between each country and territory. As the SDI increased, the effective difference tended to be bigger and more variable. There were five countries exhibiting the lowest effective difference from the frontier (effective difference range: 18.57 to 1.60): Mauritania, Afghanistan, Yemen, Niger and Somalia (Figure 6).

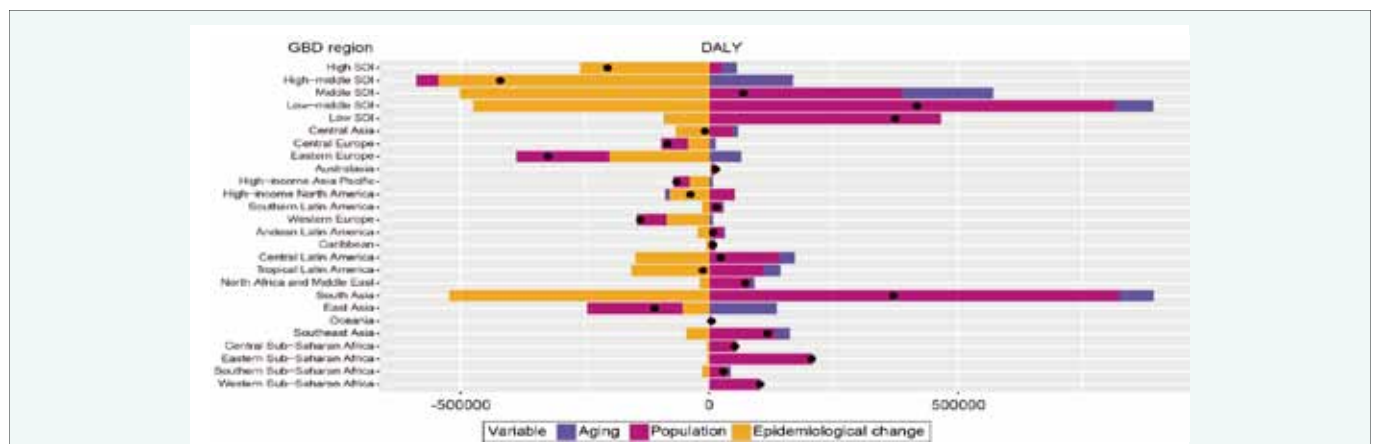


Figure 5 : Changes in DALY of AUD based on population-level determinants of growth, aging, and epidemiological shifts from 1990 to 2021, both by SDI quintile and GBD regions. The black dot represents the overall change contributed by all three components combined. For each component, the magnitude of a positive value indicates an increase in AUD DALY attributed to that factor, while the magnitude of a negative value reflects a decrease in AUD DALY related to the component. AUD= alcohol use disorder. DALY= disability-adjusted life years

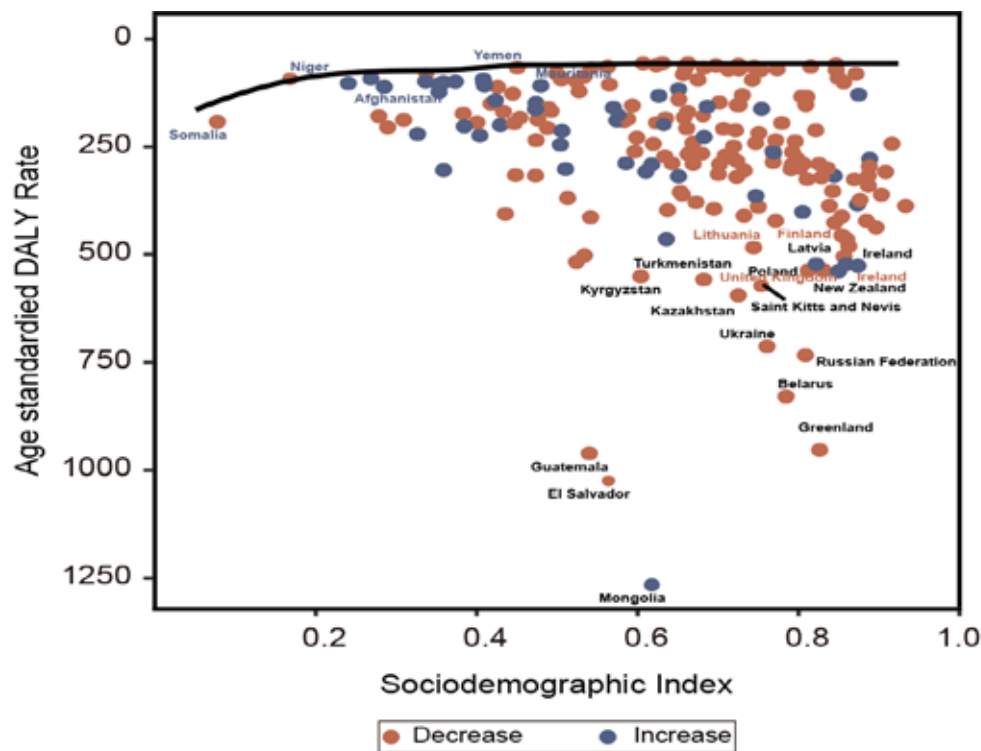


Figure 6 : Frontier analysis based on SDI and age-standardized AUD DALY rate in 2021. The frontier is delineated in solid black; countries and territories are depicted as dots. Countries with the largest effective difference are labeled in black. Countries and territories with a low SDI and a low effective difference for their level of development are labeled in blue. Countries and territories with a high SDI and a relatively high effective difference for their level of development are labeled in red. Red dots indicate an increase in age-standardized AUD DALY rate from 1990 to 2021, while blue dots indicate a decrease. AUD= alcohol use disorder. DALY= disability-adjusted life years.

Cross-Country Social Inequality Analysis

Significant absolute and relative inequalities related to the SDI were observed in the distribution of adolescent and young adult AUD burdens across 204 countries, with High SDI countries bearing disproportionately higher burdens. As indicated by the slope index of inequality, the differences in DALY between the highest and lowest SDI countries were 252.40 (95% CI: 144.23 to 340.94) in 1990 and 170.00 (95% CI: 83.70 to 228.55) in 2021, respectively. Furthermore, the concentration index showed a significant decrease from 0.17 (95% CI: 0.12 to 0.22) in 1990 to 0.13 (95% CI: 0.09 to 0.18) in 2021.

Global disease burden prediction for AUD to 2030

We applied Bayesian Age-Period-Cohort (BAPC) model to forecast the future trends of age-standardized prevalence and the number of cases due to AUD among young populations from 2022 to 2030. Key assumptions of the model include:

Continuity of Trends

Past trends in age, period, and cohort effects will continue linearly into the future. This assumes no major disruptions such as pandemics, wars, or sudden policy changes after 2021.

Stable Population Structure

Future population projections (from the UN) are accurate and shifts in age distribution will follow current patterns.

Constant Reporting and Diagnosis Practices

Case identification and health reporting systems remain consistent across countries over time.

It was projected that the total number of AUD cases worldwide will slightly decreased from 2021 to 2030, reaching an estimated 48,764,101 (95% UI: 39629172 to 57899030) by 2030. Meanwhile, the age-standardized prevalence was expected to exhibit a mild downward trend, peaking at 1690.76 (95% UI: 1637.72 to 1743.81) (Figure 7A).

Figure 7B explicitly demonstrates the projections for China and India, two countries with large population bases. The model predicted a continued decline in AUD age-standardized prevalence in India. However, China was expected to see a mild increase, which may corresponding with its declining population. The number of AUD cases in both countries was similar to the global pattern. Relevant forecasts for additional GBD regions, providing comprehensive insights into the diverse trajectories expected worldwide.

Risk Factors

Figure 8 contains the contribution of childhood sexual abuse to age-standardized DALY due to AUD aged 15 to 39 years in 2021. At the global level, along with age, the attributable proportion of childhood sexual abuse for AUD showed a U-shaped curve, peaking at the ages of 15-19 years (Figure 8A). Besides, at the regional level, Western Sub-Saharan Africa (13.59%) had the highest attributable proportion (Figure 8B). Females with AUD were more likely to be affected by childhood sexual

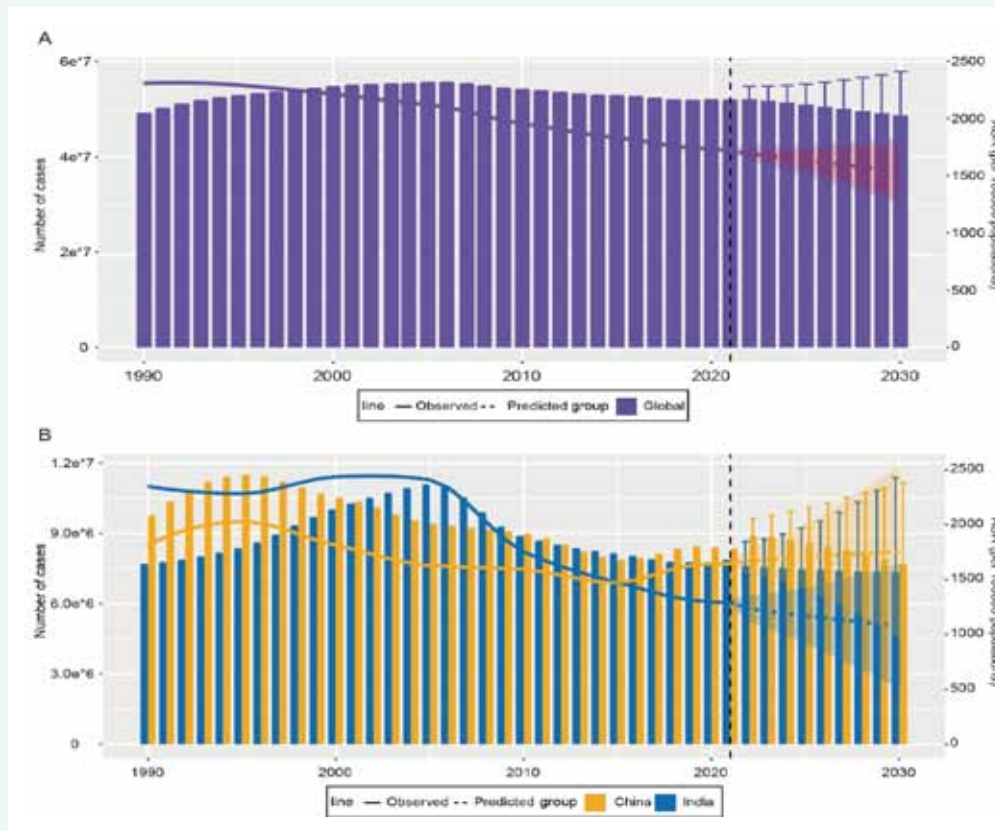


Figure 7 : Projects the age-standardized incidence and numbers of AUD in adolescent and young adults for global(A), China and India(B). AUD= alcohol use disorder.

abuse risk factor, especially in High-income North America, Eastern Europe and Australasia, compared with males (Figure 8C-D).

DISCUSSION

Principal Findings

Based on the data from the 2021 GBD Study, this is the first study to report on the prevalence, DALY and mortality of change of AUD among adolescents and young adults aged 15-39 years, across 204 countries, from 1990 to 2021, at the global, regional, and national levels. Our analysis found a steady decrease in the global age-standardized prevalence, DALY, and mortality for AUD over the past three decades, suggesting some progress in reducing the overall burden of AUD among adolescents and young adults. However, we observed that countries with low and low-middle SDI experienced less pronounced declines compared to high and high-middle SDI countries. This disparity underscores how socioeconomic factors play a pivotal role in determining the accessibility and effectiveness of AUD prevention and treatment resources, indicating that many low-resource countries still face significant challenges in addressing AUD. Moreover, males consistently showed higher prevalence and DALY than females across all age groups, which may be attributed to both biological susceptibilities and societal norms around alcohol consumption.

Our study identified several key trends and factors influencing the burden of AUD among adolescents and young adults over the past three decades. Firstly, the age, period, and APC model analysis revealed that AUD prevalence was most prevalent among older adolescents and young adults, particularly those aged 30-34. We also observed that in other

SDI regions except high SDI regions, younger birth cohorts—specifically those born after 1972-1981 exhibited a favorable downward trend in AUD prevalence. The decline may be due to increased awareness and preventive efforts targeted at younger age groups. This model emphasized the necessity for ongoing prevention strategies that are adapted to the unique characteristics and vulnerabilities of specific age cohorts.

In addition, our decomposition analysis demonstrated that population growth had significantly contributed to the increase in DALY related to AUD, particularly in low and low-middle SDI regions, including South Asia and Eastern Sub-Saharan Africa. Meanwhile, high- and high-middle SDI regions had benefited from positive epidemiological changes that counterbalance the effects of population growth, underscoring the importance of healthcare advances and effective public health interventions in these regions. The findings suggested that while population growth remains a substantial driver of AUD burden in lower-SDI countries, ongoing improvement in healthcare infrastructure may effectively mitigate the negative impact.

Our frontier analysis revealed an interesting pattern regarding the association between DALY of AUD and socioeconomic development. Contrary to what might be expected, low-SDI countries generally exhibited lower AUD burden compared to high-SDI regions, where certain segments of the population showed particularly high AUD-related DALY. This discrepancy might reflect varying cultural attitudes toward alcohol consumption and the differences in alcohol availability and affordability, which were more restricted in low-SDI regions. Conversely, high-SDI countries faced greater challenges due to lifestyle factors associated with higher disposable income, such as increased access to alcohol and societal norms. This finding underscored the need for targeted AUD interventions

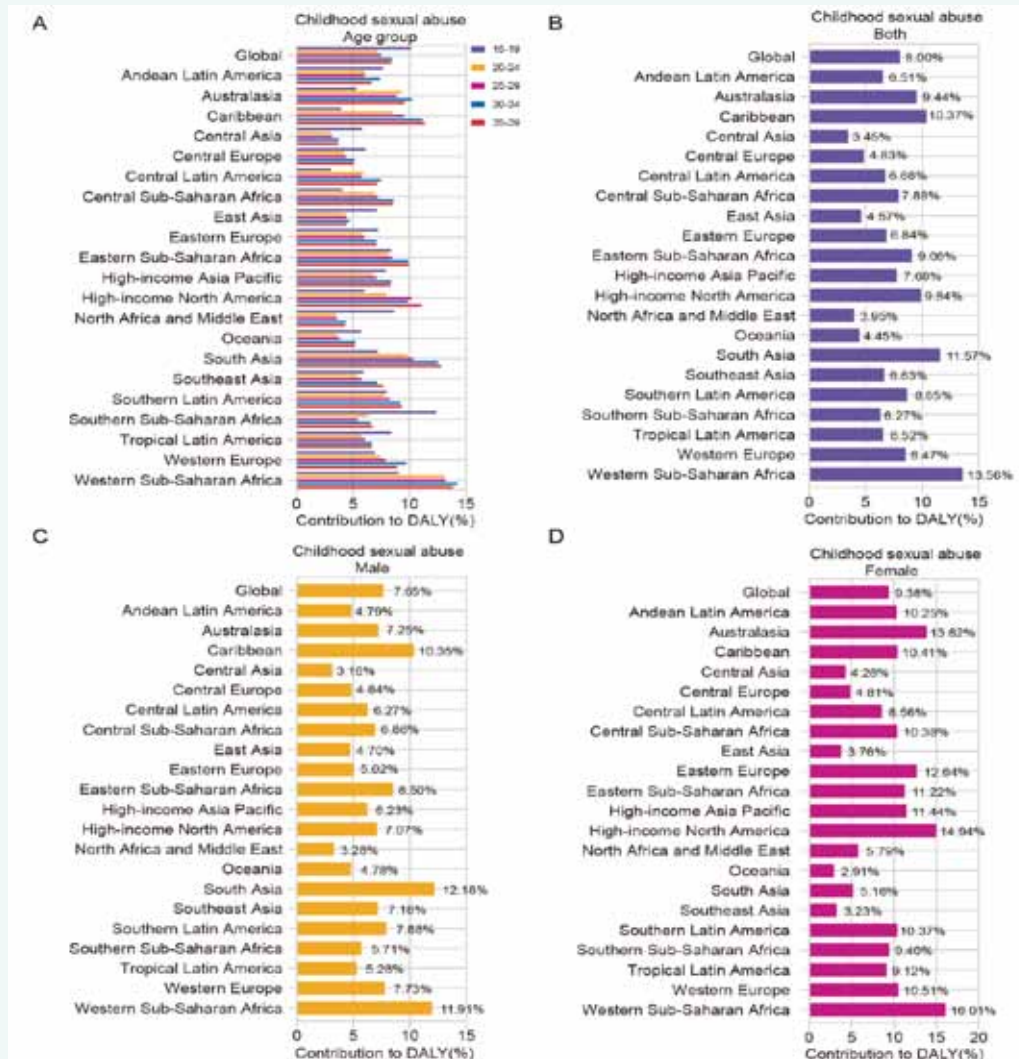


Figure 8 : Percentage contribution of risk factors to DALY of AUD among adolescents and young adults aged 15 to 39 in 2021 for globally and by regions. AUD= alcohol use disorder. DALY= disability-adjusted life years.

in high-income regions where the burden remains high, particularly interventions aimed at addressing the cultural factors and lifestyle behaviors that contribute to AUD in these settings.

Our social inequality analysis highlighted the notable disparities in the burden of AUD among adolescents and young adults, with high SDI countries bearing a disproportionately higher share of DALY. This pattern suggested that while high-income countries may have more resources for AUD prevention and treatment, they also faced unique challenges related to lifestyle and cultural acceptance of alcohol use. By contrast, low-SDI countries have seen relatively smaller reductions in AUD burden over time, further emphasizing the need for resource-appropriate interventions that could effectively address the prevalent risk factors prevalent in these regions. Predictive modeling suggested a continued decline in both the number and age-standardized AUD prevalence among adolescent and young adults by 2030, suggesting that the global burden of AUD in this demographic presented a positive signal to the 2030 WHO goals. We also observed that the patterns of attributable risk factors for AUD among adolescent and young adults across different regions. The results showed that individuals who had experienced childhood sexual abuse are at

a notably higher risk of developing AUD than others, underscoring the profound and lasting impact of early adverse experiences on mental and behavioral health. This finding is closely aligned with existing literature, which linked traumatic childhood events to an increased likelihood of substance abuse in later life due to the enduring effects on psychological well-being [17]. Addressing such risk factors through targeted prevention and intervention strategies, including mental health support and trauma-informed care, was essential for reducing the risk of AUD and mitigating its long-term health effects. These findings laid the basis for understanding the epidemic nature of AUD among adolescent and young adults and emphasized the urgent need for global action to address this issue.

Comparison with other studies

Our findings may be explained by public health initiatives and policy changes, including educational campaigns, stricter regulations on alcohol marketing, and increased taxation on alcoholic beverages, in some high-income regions. For instance, North America and Australia have implemented relevant policies and campaigns aiming to reduce alcohol consumption among young people. Studies in the United States



have reported downward trends in hospitalizations due to alcohol use disorder from 1998 to 2016, indicating a growing awareness and possibly improved interventions for managing AUD among youth [18]. This trend was significant as it reflected broader changes in substance use behaviors among youth and attributed to enhanced awareness campaigns and stricter regulations on underage substance sales. For instance, the prevalence of marijuana use disorders among adolescents has shown a decline from 2002 to 2013, with a notable 24% reduction attributed to decreasing rates of conduct problems [19]. Similar patterns may be observed in alcohol use as well. This comprehensive understanding of substance use trends is crucial for developing effective public health strategies aiming at further reducing AUD prevalence and promoting healthier lifestyles among adolescents in the United States. Moreover, in Australia, the introduction of random breath testing programs has been associated with a reduction in alcohol consumption and related harms, particularly among younger populations [20]. Similarly, the WHO has emphasized the need for comprehensive alcohol policies that include age restrictions and marketing regulations to protect youth from the harmful effects of alcohol [21]. Overall, the integration of public health approaches and policy changes is crucial in mitigating the risks of alcohol consumption among youth, ultimately contributing to better health outcomes and reduced alcohol-related harms in society [22].

In contrast, the findings of this study diverged from the trends observed in certain low- and middle-income countries, where AUD prevalence has remained stable or even increased [23]. Regions in Eastern Europe and parts of Latin America have seen persistently high prevalence of AUD, and a recent study has reported that there has been poor progress in reducing alcohol consumption in Europe [24]. This trend might be related to the mental health impact of the COVID-19 pandemic, which has exacerbated existing issues related to substance use disorders [25]. A systematic review indicated that mental health symptoms, such as anxiety and depression, were prevalent across various regions, including Eastern Europe and Latin America, suggesting a potential increase in substance use as a coping mechanism [26]. Addressing AUD in these regions requires a multifaceted approach that considers the unique socio-economic and healthcare challenges they face. Effective public health strategies, including education, access to treatment, and community support, are essential to mitigate the impact of AUD and improve the overall health outcomes in Eastern Europe and Latin America. Unlike Eastern Europe and parts of Latin America, the sustained high prevalence and DALY of AUD among young population in Mongolia was correlated with high alcohol consumption among young people which remained significantly high. Despite the attempts to introduce regulatory measures in Mongolia, and the cultural normalization of drinking may partially account for this sustained burden. This trend is disturbing, especially when considering the strict context of alcohol consumption patterns observed in some high-SDI countries in Asia, such as Japan and South Korea. In contrast to the high-SDI countries, these regions have shown slower progress in reducing AUD-related DALY, emphasizing the need for culturally adapted interventions and enhanced healthcare access.

Our study revealed a decline in AUD prevalence and DALY in several low income regions. This decrease in AUD burden may reflect a combination of socioeconomic factors, such as economic instability, political unrest, and conflict, which can significantly limit alcohol availability and consumption. In countries like Syria and Yemen, which have been affected by sustained conflict, the infrastructure for alcohol production and distribution has been disrupted, contributing to a lower overall AUD burden and young people face daily challenges related to survival, displacement, and trauma, which may have lowered the likelihood of engaging in alcohol consumption. The ongoing conflicts in these areas have not only led to humanitarian crises but have also severely impacted the health and well-being of vulnerable populations, particularly females, children, adolescents and young adults. For instance,

armed conflict has been shown to have disproportionately affected the morbidity and mortality rates among these groups, as highlighted in a study that assessed health interventions in ten conflict-affected countries, including Afghanistan, Syria, and South Sudan [27]. Furthermore, certain low-SDI countries have cultural and religious norms that discourage or even prohibit alcohol use. In regions where alcohol is not culturally prevalent or where religious restrictions are strictly enforced, such as in parts of the Middle East and North Africa, AUD rates among young people may naturally be lower, further reinforcing the decline observed in our study. This phenomenon is often rooted in deeply ingrained beliefs and practices that shape societal attitudes toward alcohol consumption. For instance, in many Islamic countries, the prohibition of alcohol is a significant aspect of religious doctrine, influencing not only individual behavior but also community standards and laws [28]. Similarly, in various Indigenous communities, alcohol restrictions are implemented as a means to address historical trauma and promote public health, reflecting a broader cultural commitment to well-being and social cohesion [29].

With regard to sex differences, this study revealed that while AUD age-standardize prevalence, DALY and mortality had generally declined for both young males and females, the trend among young males was characterized by more significant fluctuations. This greater variability in AUD decline among males compared to females may be attributed to several social and economic factors that may differentially influence the alcohol consumption behaviors of males and females. Firstly, social expectations regarding alcohol use differ substantially for males and females, often encouraging more variable drinking behaviors among young males. In Nigeria, young males often engage in competitive heavy drinking rituals to assert their masculinity, while females may either conform to traditional norms that discourage drinking or engage in secretive drinking practices to navigate societal expectations [30]. However, as cultural attitudes shift often influenced by social media and popular culture, young males may rapidly adjust their drinking habits in response. This phenomenon have been observed in various studies that highlighted the role of social media in shaping health behaviors and perceptions. The influence of social media on dietary behaviors among young adults implies that online platforms can significantly impact lifestyle choices, including alcohol consumption [31,32]. Economic factors may also play a role in these fluctuations. As young male's alcohol consumption patterns are often more sensitive to economic changes, such as job stability, disposable income, and overall financial security, they may reduce their alcohol intake during economic downturns or periods of job insecurity due to financial constraints. A previous study has demonstrated that the relationship between income and food insecurity highlights how financial stress can shift attention away from discretionary spending, such as alcohol, towards more immediate needs like food [33]. In this light, young males facing job insecurity may prioritize essential expenditures over alcohol consumption, reflecting a broader trend observed in middle-income countries where increased alcohol consumption correlates with rising economic challenges [34].

Strengths and limitations of this study

This study has several notable strengths. First, it provided a comprehensive and longitudinal analysis of AUD among adolescents and young adults across multiple regions over three decades. By utilizing data from the GBD study, we were able to explore the trends in prevalence, DALY and mortality across a diverse set of countries and socioeconomic contexts. This approach enabled us to examine the disparities in AUD burden by SDI, offering valuable insights into how socioeconomic status may have influenced the AUD trends. Additionally, the use of decomposition, frontier, and APC analyses provided a multifaceted perspective on the factors driving the AUD burden. By identifying childhood sexual abuse as a significant risk factor, our study underscored the importance of early intervention and mental health support in addressing AUD among young populations.



Despite its strengths, this study also had limitations. The reliance on GBD data may introduce potential biases due to variations in data quality across countries, particularly in low-income and low-middle SDI regions where healthcare infrastructure and reporting systems may be limited. Additionally, although the APC model provided valuable insights into temporal trends, it may not fully capture the complexities of environmental and cultural factors that influence the AUD prevalence in different regions. Future research should focus on integrating more detailed data from low- and middle-income countries to explore additional risk factors, such as genetic predispositions and broader social determinants, and to develop region-specific prevention and intervention strategies to reduce the AUD burden effectively.

CONCLUSIONS

In conclusion, this study highlights the need for continued global efforts to reduce the burden of AUD among young people, with a particular focus on high-risk regions and populations. By tailoring prevention and intervention strategies to the unique needs of different SDI categories and demographic groups, public health organizations can more effectively address the complex and multifaceted challenges posed by alcohol use disorder.

DECLARATIONS

Availability of data and materials

All data will be made available on request to the corresponding author. Proposals will be reviewed and approved by the sponsor, investigator, and collaborators on the basis of scientific merit. After approval of a proposal, data will be shared through a secure online platform after the signing of a data access agreement.

Author's Contributions:

Professor CS had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

CZ; PY; YY participated in Acquisition, analysis, or interpretation of data.

JW; ST participated in Critical review of the manuscript for important content.

CZ drafting of the manuscript.

JW; PY participated in supervision. All authors read and approved the final manuscript.

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