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Gender differences in the incidence of pharynx cancer related to alcohol drinking by socioeconomic status in 2020; an ecological study

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Abstract

Introduction: Alcohol consumption is a well-established risk factor for pharyngeal cancer, yet its impact varies across populations depending on gender and socioeconomic context. Understanding these disparities is essential for guiding prevention strategies and public health policies.
Objectives: This study aimed to examine the global burden of alcohol-attributable pharyngeal cancer in 2020 by analyzing age-standardized incidence rates (ASRs) and population attributable fractions (PAFs), stratified by gender and human development index (HDI) categories, to identify patterns of inequality and highlight areas where targeted interventions may be most needed.
Materials and Methods: This ecological study analyzed population-level data from the International Agency for Research on Cancer (IARC) on pharyngeal cancer cases attributable to alcohol consumption in 2020, stratified by gender and HDI categories. The ASR and PAF were extracted to quantify incidence and risk, with PAF calculated from exposure prevalence and relative risk. Descriptive statistics summarized values and uncertainty limits, focusing on gender disparities and socioeconomic gradients, while ecological comparisons highlighted relative differences without inferential testing.
Results: The results indicated that alcohol-related pharyngeal cancer new cases in 2020 revealed a clear gender disparity, with men consistently carrying a heavier burden than women across all socioeconomic contexts. The disparity was most evident in highly developed regions, though it persisted globally and even in lower development settings where overall rates declined.
Conclusion: Alcohol-related pharyngeal cancer shows a pronounced gender imbalance, with men bearing consistently higher incidence across all socioeconomic levels, underscoring the need for male-focused, gender-sensitive prevention and public health strategies.

Introduction

Head and neck cancer comprises a significant global health burden, with more than 650,000 patients diagnosed worldwide annually, and represents the seventh most common cancer type globally (1). Males demonstrate substantially higher incidence rates of head and neck cancers compared to females, with male-to-female ratios varying widely depending on anatomical subsite (2). Alcohol consumption has been consistently identified as a major risk factor for head and neck cancers, with a powerful association observed in hypopharyngeal cancer. This link predominantly affects the oral cavity, pharynx, and larynx (3). Drinking frequency is a stronger risk factor than the daily amount of alcohol consumption. The association between alcohol and pharyngeal cancer risk demonstrates a dose-dependent relationship (4), with drinking more than three alcoholic beverages per day being associated with increased risk in both men and women (5). However, emerging evidence suggests that the relationship between these established risk factors and cancer incidence varies substantially across gender and may be modified by socioeconomic circumstances (6).

Socioeconomic status represents a

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Key point

This study's results emphasize the importance of recognizing alcohol consumption as a significant modifiable risk factor for pharyngeal cancer, particularly among men. The consistently higher incidence observed in male populations across all socioeconomic strata suggests that targeted screening, preventive counseling, and risk-reduction strategies should prioritize this group. In contrast, the minimal burden among women indicates that broad population-level interventions may need to be tailored differently by gender, with male-focused approaches likely to yield greater impact.

fundamental social determinant of health that shapes cancer incidence, stage at diagnosis, and survival outcomes across diverse populations (7). Disparities in cancer incidence and survival according to socioeconomic status have been documented worldwide, with individuals in lower socioeconomic categories experiencing a higher cancer burden (8). Health risk behaviors, including tobacco smoking and alcohol consumption, are thought to mediate inequalities in cancer outcomes across socioeconomic groups, as these behaviors vary significantly in prevalence by educational attainment, income level, and occupational status (9). The relationship between socioeconomic deprivation and cancer mortality demonstrates independent and substantial effects, with deprivation showing stronger impacts on cancer outcomes than other contextual factors (10). Furthermore, socioeconomic gradients in cancer mortality are steeper in nonmetropolitan than in metropolitan areas, suggesting that place-based inequalities interact with individual-level socioeconomic factors (11).

Ecological study designs provide a complementary epidemiological approach to examine population-level associations between contextual factors and disease outcomes, particularly when investigating how macro-level social and economic variables influence disease patterns across geographic regions or time periods (12). In 2020, the global burden of nasopharyngeal cancer and related pharyngeal malignancies continued to demonstrate marked geographic variation, with East Asia accounting for 49.39% of global nasopharyngeal cancer cases (13). To our knowledge, no previous ecological study has simultaneously examined the intersecting relationships among gender, alcohol drinking patterns, socioeconomic status, and pharyngeal cancer incidence at the population level in 2020. This ecological analysis aims to characterize the distribution of pharyngeal cancer incidence by gender across different socioeconomic status categories globally, and to evaluate the association between population-level alcohol consumption and pharyngeal cancer incidence, stratified by gender and socioeconomic context in 2020.

Objectives

This study aimed to evaluate gender differences in the incidence of pharyngeal cancer attributable to alcohol consumption across varying levels of socioeconomic development in 2020, using an ecological approach, to identify patterns of disparity and inform targeted prevention and public health strategies. This study helps clinicians in risk stratification, patient education, and the development of gender-sensitive preventive strategies in the management of alcohol-related cancers.

Materials and Methods

Study design

This study employed an ecological design, utilizing population-level data on the incidence of pharyngeal cancer attributable to alcohol consumption in 2020, stratified by gender (male/female) and socioeconomic status as defined by the human development index (HDI). Age-standardized rates (ASRs) and population attributable fraction (PAF) were extracted from International Agency for Research on Cancer (IARC) estimates, allowing for comparisons across very high, high, medium, low, and missing HDI categories, as well as worldwide aggregates. By analyzing aggregated data rather than individual-level information, the study aimed to identify broad patterns of gender disparity across socioeconomic variation in alcohol-related pharyngeal cancer incidence.

PAF definition

The PAF is a measure used in epidemiology to quantify the impact of risk factors (such as alcohol) on cancer incidence and mortality. This scale is defined as the proportion of disease incidence or mortality in a population that would not have occurred if exposure to a particular risk factor had been absent. Mathematically, it combines the prevalence of exposure with the relative risk of disease due to that exposure, thereby quantifying the public health impact of modifiable risk factors, and is calculated as follows (14):

$$\mathrm{PAF} = \frac{\mathrm{Pe}\ (RR - 1)}{\mathrm{Pe}\ (\mathrm{RR} - 1) + 1}$$

Pe = Prevalence of exposure in the population
RR = Relative risk of cancer associated with the exposure

ASR definition

The ASR is defined as the weighted average of age-specific rates, calculated using the direct method and the world standard population, where the weights are derived from a standard population age distribution (commonly the World Standard Population). By adjusting for differences in age structure, ASR provides a summary measure that enables valid comparisons of cancer incidence or mortality between countries or over time. The ASR is expressed per 100,000 person-years (15).

Data collection

This study utilized secondary data extracted from the Global Cancer Observatory (GCO) of the IARC, specifically

the "Causes of Cancer- Alcohol" database (https://gco.iarc.fr/causes/alcohol). Estimates of pharyngeal cancer cases attributable to alcohol consumption in 2020 were obtained in the form of PAF and ASR (world) per 100,000 population. Data were stratified by gender and socioeconomic status, categorized according to the HDI levels (very high, high, medium, low, and missing). The collection process involved compiling aggregated, population-level statistics rather than individual patient records, ensuring comparability across regions and enabling global and regional analyses of gender disparities. All values were derived from standardized modeling approaches used by IARC, which integrate cancer incidence data, alcohol exposure prevalence, and relative risk estimates to generate attributable fractions and incidence rates.

Measurement outcome

The primary outcomes of this study were the PAF and the ASR (per 100,000 population) of pharyngeal cancer cases linked to alcohol consumption in 2020, analyzed by gender and stratified across socioeconomic levels defined by HDI categories.

Data analysis

Descriptive statistics were used to summarize PAF and ASR values, along with their uncertainty limits, across HDI strata and globally. Comparative analysis focused on identifying gender disparities and socioeconomic gradients in alcohol-attributable pharyngeal cancer incidence. Patterns were interpreted by contrasting male and female rates within each HDI category, as well as examining overall global trends. No inferential statistical tests were applied, as the study relied on modeled estimates provided by IARC; instead, emphasis was placed on ecological comparisons and the interpretation of relative differences across populations.

Results

In 2020, the estimated proportion of pharyngeal cancer cases attributable to alcohol consumption, expressed as the PAF, demonstrated a consistent gender disparity across all levels of socioeconomic development. Among males, the fraction of cases linked to alcohol was markedly higher than among females, regardless of HDI category. This difference was most pronounced in populations with very high and high HDI, where men carried a substantially greater burden of alcohol-related pharyngeal cancer compared to women. Even in medium and low HDI settings, the relative contribution of alcohol remained more significant among males, though the gap narrowed somewhat. At the global level, the same pattern persisted, with men showing a considerably larger proportion of pharyngeal cancer cases attributable to alcohol than women (Table 1 and Figure 1).

The results indicated that the incidence of pharyngeal cancer attributable to alcohol consumption in 2020 demonstrates a marked gender disparity across all levels of socioeconomic development. Men consistently exhibit higher age-standardized rates compared to women, regardless of HDI category. This difference is most pronounced in populations with very high HDI, where male incidence is substantially elevated relative to female incidence, while in lower HDI settings the rates for both

Table 1. Estimated new pharyngeal cancer cases in 2020 attributable to alcohol consumption, expressed as the PAF based on socioeconomic status and gender (https://gco.iarc.fr/causes/alcohol)

Gender	Population	Pharynx cancer related to alcohol drinking incidence		
		PAF (%)	Uncertainty limits	
			Lower	Upper
Male	Very high HDI	34.6	14.2	53.00
	High HDI	27.1	10.7	43.7
	Medium HDI	14.6	5.1	38.9
	Low HDI	17.1	6.6	34.00
	Missing HDI	20.3	7.6	33.4
	World	25	10.4	43.4
Female	Very high HDI	12.4	4.8	20.8
	High HDI	6.1	2.4	10.8
	Medium HDI	2.9	0.8	8.6
	Low HDI	5.1	1.8	10.5
	Missing HDI	3.3	1.2	5.9
	World	7.4	2.8	13.4
Both sexes	Very high HDI	30.5	12.5	47.00
	High HDI	23.5	9.3	38.1
	Medium HDI	12.4	4.3	33.1
	Low HDI	13.4	5.1	26.8
	Missing HDI	18.6	7.00	30.7
	World	22	9.00	37.8

HDI: Human development index, PAF: Population attributable fraction.

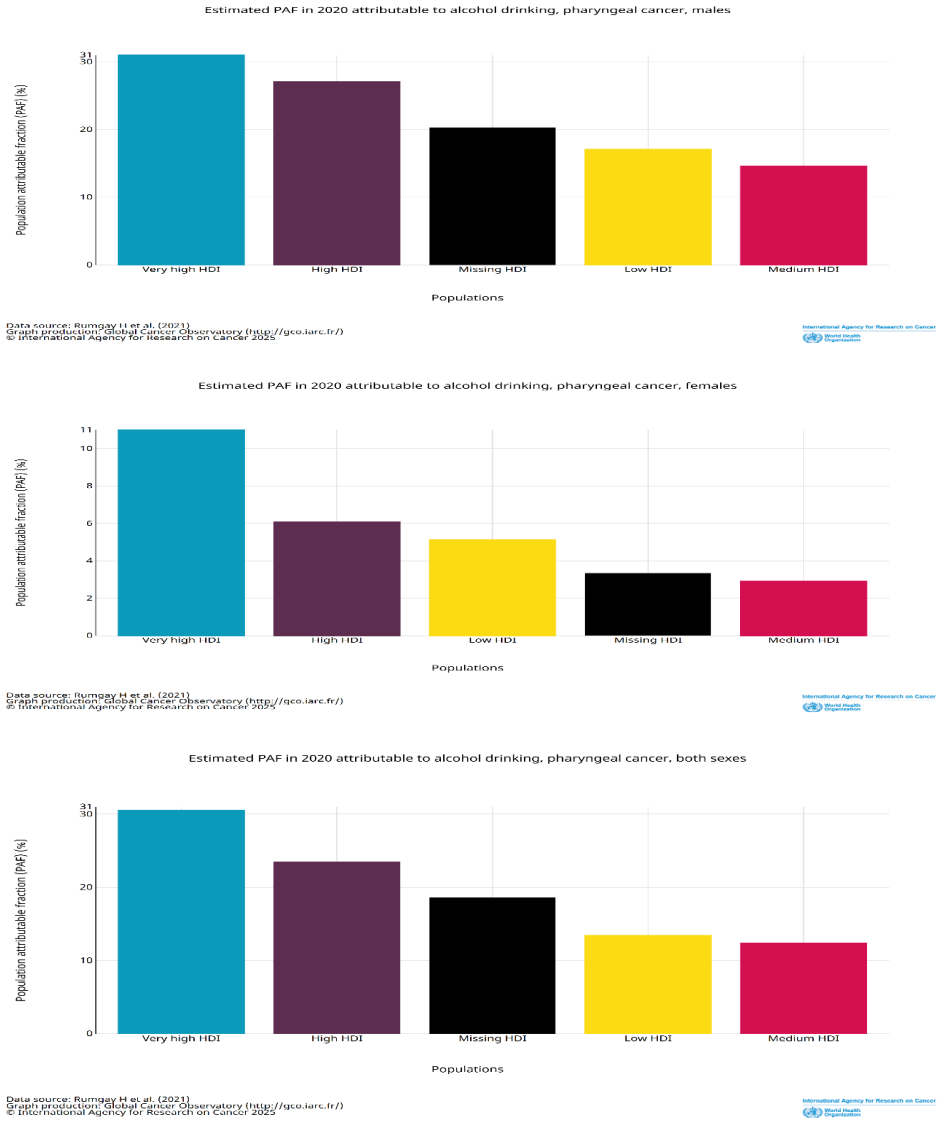

Figure 1. Estimated pharyngeal cancer new cases PAF in 2020 attributable to alcohol drinking based on socioeconomic status and gender. Note: Reproduced with permission from International Agency for Research on Cancer (IARC). 2025. Available at https://gco.iarc.fr/causes/alcohol.

genders decline, though the male burden remains greater. Even at the global level, the pattern persists, with men showing a considerably higher incidence than women (Table 2 and Figure 2).

Discussion

In this study, alcohol-attributable pharyngeal cancer incidence demonstrated a consistent global gender disparity, with men bearing a markedly higher burden than women across all HDI levels, most pronounced in very high and high HDI populations and persisting worldwide despite narrower gaps in medium and low HDI settings. Our study's finding of a persistent and pronounced global gender disparity in alcohol-attributable pharyngeal cancer incidence, with men bearing a substantially higher burden than women across all HDI levels, is corroborated by a broad body of prior research. Multiple large-scale epidemiological studies have consistently demonstrated that the incidence and mortality rates of pharyngeal and broader head and neck cancers are significantly higher in men than in women, with male-to-female ratios ranging from approximately 2:1 to 7:1 depending on anatomical subsite and region (16,17). The recent global analysis reported that the ASR incidence for hypopharyngeal cancer in 2020 was 1.60 per 100,000 in men and 0.29 per 100,000 in women, with similar disparities observed for other pharyngeal subsites. This male predominance persists across all HDI strata, though the magnitude of the disparity is most pronounced in very high and high HDI populations, where both absolute incidence and PAFs for alcohol-related pharyngeal cancers are highest among men (18,19). The gap narrows but does not disappear in medium and low HDI settings, as confirmed by recent Global Burden of Disease (GBD) analyses and registry-based studies, which show that while the male-to-female ratio decreases, men still experience higher incidence

Table 2. Estimated the incidence of pharyngeal cancer (ASR [world] per 100000) in 2020 attributable to alcohol drinking, according to socioeconomic status and gender (https://gco.iarc.fr/causes/alcohol)

Gender	Population	Pharynx cancer related to alcohol drinking incidence		
		ASR (world) per 100,000	Uncertainty limits	
			Lower	Upper
Male	Very high HDI	1.7	0.7	2.6
	High HDI	0.4	0.2	0.7
	Medium HDI	0.9	0.3	2.4
	Low HDI	0.1	<0.1	0.3
	Missing HDI	0.4	0.1	0.6
	World	1.8	0.7	3.1
Female	Very high HDI	0.1	<0.1	0.2
	High HDI	<0.1	<0.1	<0.1
	Medium HDI	<0.1	<0.1	0.1
	Low HDI	<0.1	<0.1	<0.1
	Missing HDI	<0.1	<0.1	<0.1
	World	0.11	<0.1	0.2
Both sexes	Very high HDI	0.9	0.4	1.4
	High HDI	0.2	<0.1	0.4
	Medium HDI	0.5	0.1	1.2
	Low HDI	<0.1	<0.1	0.2
	Missing HDI	0.2	<0.1	0.3
	World	0.46	0.4	1.6

HDI: Human development index, ASR: Age-standardized rate

and mortality rates (16,17). These patterns are further supported by meta-analyses demonstrating that the relative risk (RR) of pharyngeal cancer associated with alcohol consumption is similar or slightly higher in men, but the population-level impact is greater due to higher prevalence and intensity of alcohol use among males (13,20,21). Additionally, studies adjusting for tobacco use and other confounders confirm that the gender disparity in alcohol-attributable pharyngeal cancer is not solely explained by differences in smoking, as men remain at elevated risk even after controlling for these factors (22). Importantly, recent Mendelian randomization studies and pooled analyses have validated a causal relationship between alcohol consumption and pharyngeal cancer risk, independent of smoking, with no evidence of a safe threshold for either sex (13,20,23). Furthermore, the interaction between alcohol and tobacco is synergistic, amplifying risk particularly among men, who are more likely to be dual users, especially in high and very high HDI countries (22,24,25). Regional analyses reveal that the highest male burdens are observed in Central and Eastern Europe, East Asia, and parts of Latin America, mirroring patterns of heavy alcohol consumption and limited regulatory controls in these settings (16,19). In summary, our findings are in strong agreement with the prevailing literature, which documents a robust, persistent, and globally consistent male predominance in alcohol-attributable pharyngeal cancer incidence across all levels of socioeconomic development.

The implications of these persistent gender disparities are multifaceted and underscore the need for targeted prevention, policy, and clinical strategies. The higher burden among men is largely attributable to greater prevalence and intensity of alcohol consumption, as well as higher rates of concurrent tobacco use, both of which are established risk factors for pharyngeal and other head and neck cancers (16,17,24). Behavioral studies and national surveys consistently report that men are more likely to engage in heavy and hazardous drinking, with the gap being widest in high and very high HDI countries, though recent trends indicate a narrowing of sex differences in some younger cohorts and regions due to rising alcohol use among women (26-28). Biological mechanisms may also contribute, as sex hormones, genetic polymorphisms, and differences in alcohol metabolism can modulate susceptibility to alcohol-induced carcinogenesis, with some evidence suggesting that estrogen may confer partial protection in women (27,29,30). The synergistic effect of alcohol and tobacco is particularly relevant for men, who are more likely to be dual users, resulting in multiplicative increases in pharyngeal cancer risk (22,24,25). Moreover, the persistence of the gender gap across HDI levels highlights the influence of social, cultural, and economic factors, including gender norms, access to healthcare, and public health infrastructure (17). In low and medium HDI settings, limited access to early diagnosis and advanced treatment exacerbates outcomes for both sexes, but men remain disproportionately affected due to higher exposure to risk factors and delayed health-seeking behaviors (17,31). Importantly, the narrowing of the gender gap in some regions is driven more by increasing incidence among women than by declining rates in men, raising concerns about future trends and the need for gender-sensitive interventions (18,26,32). Policy implications

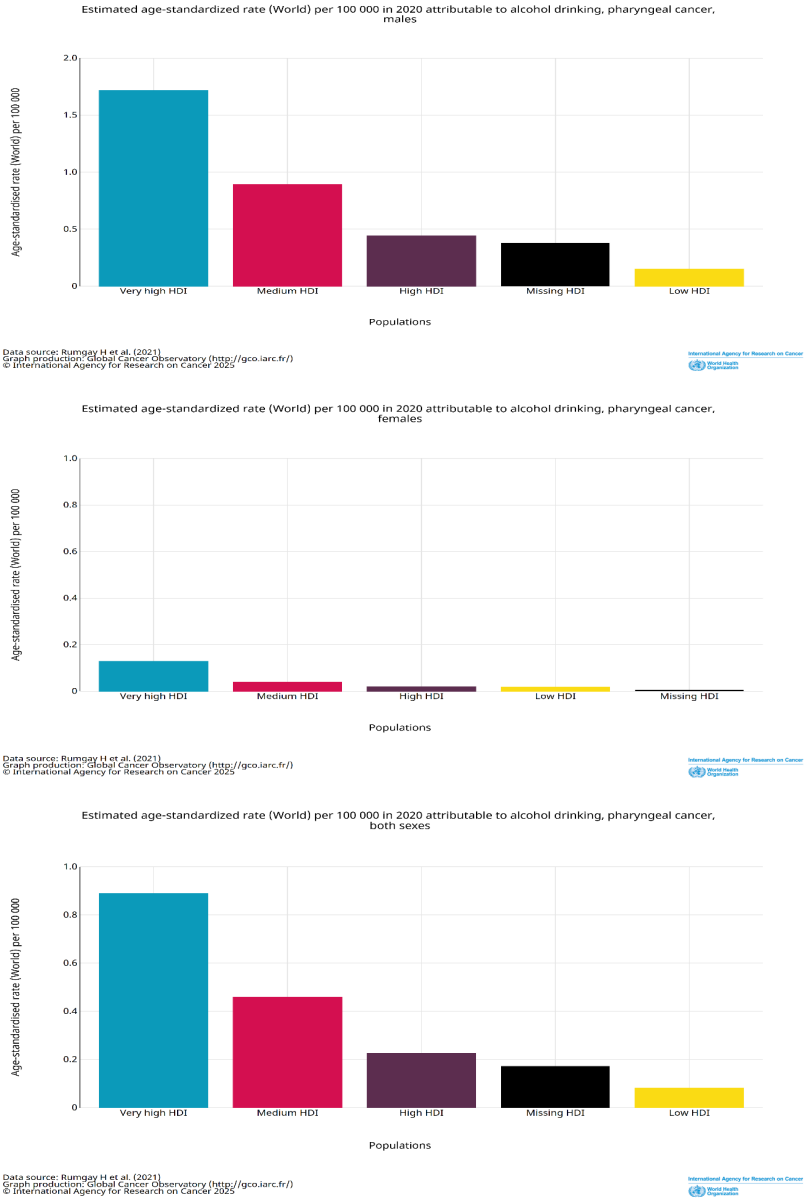

Figure 2. Estimated the pharyngeal cancer incidence (ASR [world] per 100,000) in 2020 attributable to alcohol drinking, according to socioeconomic status and gender. Note: Reproduced with permission from International Agency for Research on Cancer (IARC). 2025. Available at https://gco.iarc.fr/causes/alcohol.

include the prioritization of population-level alcohol control measures, such as taxation, marketing restrictions, and reduced availability, which have been shown to reduce alcohol-attributable cancer burden, particularly among high-risk male populations (19). Clinical implications involve the development of sex-specific screening and early detection strategies, as well as tailored risk communication that addresses gendered patterns of alcohol use and associated stigma (33,34). Finally, ongoing surveillance and research are needed to monitor temporal trends, evaluate the effectiveness of interventions, and elucidate the complex interplay of biological, behavioral, and social determinants underlying persistent gender disparities in alcohol-attributable pharyngeal cancer.

Overall, our study confirms and extends the robust evidence from prior research that alcohol-attributable pharyngeal cancer incidence is consistently and substantially higher in men than in women worldwide, with the disparity being most pronounced in very high and high HDI populations but persisting across all levels of socioeconomic development (17,19). This enduring gender gap reflects a confluence of behavioral, biological, and social factors, including higher prevalence and intensity of alcohol and tobacco use among men, sex-specific metabolic and hormonal influences, and differential access to prevention and care (27,29,30). While the gap narrows in some medium and low HDI settings, it remains a global phenomenon, underscoring the need for comprehensive, gender-sensitive public health strategies that address both upstream determinants and downstream

clinical management (17). Effective interventions must combine population-level alcohol control policies with targeted education, screening, and support services, particularly for high-risk male populations, while also anticipating and addressing rising risks among women in transitional societies (18,26). Future research should prioritize the integration of sex and gender analyses in cancer epidemiology, prevention, and treatment, as well as the evaluation of policy and clinical interventions across diverse settings (27,29,30).

Conclusion

In conclusion, the findings underscore a clear gender imbalance in the burden of pharyngeal cancer attributable to alcohol consumption, with men consistently experiencing higher incidence rates than women across all levels of socioeconomic development. This disparity is most evident in populations with very high human development, but it remains observable even in lower HDI settings and at the global level. The persistently minimal incidence among women suggests that alcohol-related pharyngeal cancer is predominantly a male-associated health issue, highlighting the need for gender-sensitive prevention strategies and targeted public health interventions that address alcohol use as a major risk factor in male populations.

Limitations of the study

This study has several limitations that should be acknowledged. First, as an ecological analysis, the findings are based on population-level data and cannot be directly applied to individual risk, which may introduce ecological fallacy. Second, the reliance on global estimates of alcohol-attributable cancer incidence may be affected by variations in data quality, reporting accuracy, and completeness across countries, particularly in low- and middle-income settings. Third, the use of HDI categories provides a broad measure of socioeconomic status but may not capture more nuanced determinants such as cultural drinking patterns, healthcare access, or genetic susceptibility.

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Authors' contribution

Conceptualization: Sina Salem Ahim and Shiva Badri.
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Validation: Zahed Karimi and Sara Teihou Jorshari.
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Writing–original draft: All authors.
Writing–review and editing: All authors.

Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilized AI tools (Perplexity, Copilot, and Grammarly) to refine grammatical points and language style in their writing. Subsequently, the authors thoroughly reviewed and edited the content as necessary, assuming full responsibility for the accuracy and content of the publication.

Ethical issues

This study has been compiled based on data from the IARC website (https://gco.iarc.who.int/). Ethical considerations related to data extraction were formally addressed through email communications with IARC officials to ensure compliance with established ethical standards. Also, the study protocol was registered on the Research Registry (unique identifying number [UIN]: researchregistry11656) website. Besides, the authors have observed ethical issues (including plagiarism, data fabrication, and double publication).

Conflicts of interest

The authors declare that they have no competing interests.

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