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Article

Expected Years Of Life Lost Due To Alcohol Consumption In Thai Adults: A 16-Year Follow-Up Cohort Of National Health Examination Survey 2004–2019

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Abstract

Aims: Evidence of premature death attributable to alcohol, a modifiable risk factor, is crucial for guiding public health policy for alcohol control. The aim of this study was to estimate alcohol-related mortality and potential years of life lost (PYLL) in Thailand in 2004–2019.

Methods: We analysed data of the third National Health Examination Survey in 2004 linked to National Death Registry data of 2004–2019. Causes of death were based on International Classification of Diseases version 10. PYLL was calculated by cause of death, age group and sex. All analyses were weighted to take into account the probabilities for the multi-stage sampling of the 2004 Thai population aged ≥15 years.

Results: There were 10,704 deaths with a follow-up time of 507,771.7 person-years. The crude mortality rate of the initial sample was 868.6 per 100,000 population. The mortality rate attributable to alcohol was 18.6 per 100,000 population (30.7 per 100,000 population in males and 6.8 per 100,000 population in females). The top leading cause of alcohol-attributable deaths was unspecified liver diseases in both males and females (6.1 and 3.1 per 100,000 population, respectively). The total years of life lost (YLL) at baseline were 9.4 million years or 49.5 years per person on average, with significantly more years in males. Mortality rate and expected YLL were highest in ages of 30–44 years, followed by 15–29 years.

Conclusion: Males were 4-fold more likely to die from all alcohol-attributable causes compared with females. Young adults had a greater loss of life years than older adults.

INTRODUCTION

Alcohol is a well-known risk factor for premature morbidity and mortality. Alcohol use was one of the top-10 leading risk factors for disability-adjusted life years (DALY), accounting for 3.7% (95% uncertainty interval [UI]: 3.3–4.1) of global DALY and accounted for 2.07 million (95% UI: 1.79–2.37) deaths in males and 0.374 million (95% UI: 0.298–0.461) deaths in females globally in 2019 (GBD 2019 Risk Factors Collaborators, 2020). The total burden attributable to alcohol use increases with increasing level of consumption, and empirical evidence shows that the level of consumption that minimizes health loss is zero, leading to a conclusion that there is no safe level of alcohol use (Griswold *et al.*, 2018). However, this conclusion has been under a lot of debate and there remain some challenges to improve available estimates of alcohol consumption and alcohol-related burden of diseases at national levels.

Alcohol has been associated with >230 International Classification of Diseases version 10 (ICD-10) codes and has been identified as a major contributor to the burden of diseases (Rehm *et al.*, 2017a). Alcohol consumption is linked to long-term health and social consequences through the patterns of drinking and the average volume of consumption. The health consequences related to alcohol can be grouped into two categories, reflecting the nature of the conditions and the nature of the etiologic influence of alcohol on those consequences. The wholly alcohol-attributable conditions are conditions of which the attribution of alcohol-relatedness is 100%, such as alcoholic cirrhosis of liver, alcohol use disorder and mental and behavior disorder due to use of alcohol. Several chronic diseases are partially alcohol-attributable conditions with either positive or negative association with alcohol consumption; for example, breast cancer, stroke, hypertension, diabetes mellitus and coronary heart disease (Griswold *et al.*, 2018).

The potential years of life lost (PYLL), which is a measure of the number of years of life lost (YLL) due to premature deaths, is recommended as a highly impactful way of estimating alcohol's contribution to premature mortality (World Health Organization and Management of Substance Abuse Unit, 2014). An advantage of this indicator is that it allows understanding of whether high levels of drinking leads to more people dying from alcohol-attributable causes or whether some alcohol-caused conditions result in deaths at younger ages. The risk relationships of alcohol consumption are presented by estimating relative risk (RR) in comparison of non-exposure. The alcohol-attributable fractions (AAFS) for chronic conditions are generally calculated using RRs

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from published meta-analyses and the prevalence of low, medium and high average daily alcohol consumption among the general population, while for acute conditions such as unintentional and intentional injuries, AAFs are calculated from risks associated with binge drinking (Ashton et al., 2020). Mortality caused by alcohol consumption can be estimated using an AAF, which is defined as the proportion of mortality that would be prevented if the exposure to alcohol was completely eliminated from the population (Shield *et al.,* 2012).

The latest Thailand's Burden of Disease and Risk Factors study in 2014 shows that the leading risk factors for the burden of disease in males included alcohol use, tobacco use and high blood pressure (accounting for 12.0, 11.7 and 7.5% of the total DALY in males, respectively). In females, overweight and obesity (11.3% of the total DALY in females) were the leading contributors. The study also illustrates that, for men, the use of tobacco and alcohol are the significant risk factors contributing to cardiovascular disease, cancer and traffic injuries, while for females, overweight and obesity, high blood pressure and high cholesterol were the major risk factors associated with non-communicable diseases, such as diabetes, cardiovascular disease and stroke (Workgroup for the Study of Burden of Diseases Attributable to Risk Factors 2014, 2018). However, the aforementioned study used population data for both level of alcohol consumption and number of deaths and it did not report the total YLL attributable to alcohol use in detail. Evidence of the contribution of different levels of alcohol consumption, which is a modifiable risk factor, to the burden of diseases and mortality by type of disease, age group and sex, is crucial for guiding public health policy.

To understand the magnitude of harmful risk of alcohol consumption and the premature loss of expected life years, this study aims to determine the number of deaths and the PYLLs attributable to alcohol in Thailand in 2004–2019. We linked individual data of a cohort of National Health Examination Survey in 2004 with death registry data in 2004–2019.

METHODS

Study design and data sources

Data of the third National Health Examination Survey (NHES-III) in 2004 were used in this study. The surveys were designed to represent the non-institutionalized Thai population by using a multistage stratified sampling method (Aekplakorn *et al.,* 2007). The NHES-III enrolled 38,275 participants aged ≥15. Data on demographics and health-risk behaviors were collected by a face-to-face interview.

Alcohol consumption measure

The alcohol consumption questionnaire was based on a beverage-specific quantity-frequency questionnaire. We used two questions to measure consumption of each type of beverage in the last year: (a) 'In the last 12 months how often did you have an alcoholic drink?' (options: every day, 5–6 days per week, 3–4 days per week, 1–2 days per week, 2–3 days a month, 1 day a month, 7–11 days a year, 4–6 days a year, 2–3 days a year, once in the past year and no drinking in the past year); and (b) 'On a day that you have drunk alcohol, how much did you usually drink (beer, wine, spirits and home-made alcohol)?' The respondents were asked to report the type, brand and beverage-specific amount of intake in a unit of container familiar to them, e.g. cup, glass, can or bottle. Pictures of common container sizes were shown to the respondents to help them reveal the most accurate amount of consumption. The amount of alcohol consumed was calculated by multiplying the total volume (in liter) of beverage consumed with the concentration of alcohol in each type of beverage and the specific gravity of alcohol (0.79). The alcohol concentration in each type of beverage was assumed to be 5% for beer, 40% for spirits and homemade alcohol and 12% for wine. The total amount consumed during a person's single drinking day was calculated by aggregating the quantities of all types of beverages consumed. The frequencies of drinking were converted to number of days per year by using the midpoint of each frequency category. For example, someone who drank 5–6 days per week would have a frequency of $5.5 \times 52 = 286$ drinking days per year. Total annual consumption was derived from the multiplication of the total amount of alcohol consumed in a drinking day with the number of drinking days. The average daily ethanol intake was calculated by dividing the annual volume by 365. Alcohol consumption was categorized into four levels: non-drinking (abstainers), <12.5 g/day (low drinking), 12.5 to ≤50 g/day (moderate drinking) and >50 g/day (heavy drinking) (Ashton, 2020). Binge drinking was asked in another question: 'In the last 12 months how many days did you indulge in binge drinking?', where binge drinking was defined as consuming >50 g per time, and the proportion of binge drinkers among current drinkers in 2004 was used in the calculation of AAFs for acute conditions.

Mortality data

Mortality data were derived from National Death Certification Registry System, which is regularly maintained by the Ministry of Public Health. The encrypted national identification number of the NHES-III respondents was used to link with the mortality data. The causes of death, ages and dates at death of all dead respondents of the NHES-III were collected from the year 2004 up to 31 December 2019. Causes of death recorded in the death registry data were based on the ICD-10.

Alcohol attribution

AAF is defined as the proportion of mortality that would be prevented if the exposure to alcohol was completely eliminated from the population (Shield *et al.,* 2012).

1) For chronic diseases, AAF was calculated from the RR of mortality based on a given level of alcohol consumption and the prevalence of alcohol consumption at different levels of consumption, age and sex. The RRs were derived from previous studies (Samokhvalov *et al.,* 2010; Cherpitel *et al.,* 2015; Rehm *et al.,* 2017a). In this paper, we divided the subjects into four age groups, 15–29, 30–44, 45–59 and ≥60 years. For example, from our data, the weighted prevalence of alcohol consumption level for males aged 30–44 years at baseline in 2004 was 21.0% for non-drinking, 39.0% for low-level drinking, 0.25% for moderate-level drinking and 0.15% for high-level drinking. Using liver cancer as an example, the RRs are 1.1, 1.52 and 2.4 for low-, moderate- and high-level

Table 1. Relative risk (RR) of developing a disease associated with alcohol consumption when compared to alcohol abstainers

Causes of deaths	Relative risk (RR)					
	Low[a]		Moderate[a]		Heavy[a]	
	Male	Female	Male	Female	Male	Female
Tuberculosis[b]	1.43	1.20	2.46	1.71	3.65	2.37
HIV[b]	1.54	1.54	1.54	1.54	1.54	1.54
Malignant neoplasm of oral cavity and pharynx[b]	1.61	1.28	3.12	2.30	4.83	2.99
Malignant neoplasm of lip, unspecified[b]	1.61	1.28	3.12	2.30	4.83	2.99
Malignant neoplasm of nasopharynx[b]	1.39	1.14	2.25	2.18	4.69	8.32
Malignant neoplasm of oesophagus[b]	1.39	1.14	2.25	2.18	4.69	8.32
Malignant neoplasm of colon[b]	1.13	1.60	1.37	1.21	1.57	1.35
Malignant neoplasm of liver and intrahepatic bile ducts[b]	1.09	1.02	1.52	1.16	2.40	1.47
Malignant neoplasm of larynx[b]	1.33	1.16	1.98	1.52	2.58	1.93
Malignant neoplasm of breast[c]	na	1.11	na	1.36	na	1.63
Diabetes mellitus (Type II)[b]	0.83	0.68	0.72	0.62	0.66	0.97
Epilepsy and status epilepticus[b]	1.29	1.14	1.86	1.45	2.44	1.81
Hypertensive diseases[b]	1.20	0.56	1.57	0.49	1.92	0.47
Ischemic heart diseases[b]	0.79	1.30	0.64	1.38	1.00	1.18
Hemorrhagic stroke[d]	1.15	1.16	1.41	1.55	1.64	2.20
Cardiac arrhythmias[b]	1.12	1.60	1.33	1.19	1.51	1.32
Unspecified liver diseases[b]	1.60	5.60	2.80	7.70	5.60	10.1
Acute and chronic pancreatitis[b]	0.91	0.91	0.91	0.91	0.91	0.91
Cholelithiasis[b]	0.99	0.99	0.99	0.99	0.99	0.99
Traffic accidents[e]	4.60	4.70	5.60	6.00	7.30	8.70
Fall injuries[e]	4.60	4.70	5.60	6.00	7.30	8.70
Drowning[e]	4.60	4.70	5.60	6.00	7.30	8.70
Fire injuries[e]	4.60	4.70	5.60	6.00	7.30	8.70
Intentional self-harm[e]	4.60	4.70	5.60	6.00	7.30	8.70
Assault by unspecified means[e]	4.60	4.70	5.60	6.00	7.30	8.70
Unspecified multiple injuries[e]	4.60	4.70	5.60	6.00	7.30	8.70
Fibrosis and cirrhosis of liver[b]	1.60	5.60	2.80	7.70	5.60	10.1

Reference level: alcohol abstainers where RR = 1. na, not relevant. [a]Low = <12.5 g/day, moderate = 12.5 and ≤50 g/day, heavy = >50 g/day (Ashton et al., 2020). Source of RR: [b]Rehm *et al.*, 2017a; [c]Bagnardi *et al.*, 2015; [d]Samokhavalov *et al.*, 2010; [e]Cherpitel *et al.*, 2015.

alcohol consumption levels per day when compared to non-drinking (Rehm et al., 2017a) (Table 1). The AAFs for chronic health conditions were calculated based on the following formula:

$$\mathrm{AAF} = \frac{\sum_{i=1}^{k}\left[P_e\mathrm{x}\ (\mathrm{RR}(i) - 1)\right.}{\sum_{i=0}^{k}\left[P_e\mathrm{x}\ (\mathrm{RR}(i) - 1)\right] + 1},$$

where the level of exposure to alcohol (in average grams of ethanol consumed per day) is $i = 0, 1, 2, \ldots, k = 150$ g/day, P_e is proportion of level of alcohol consumption in population and RR(i) is RR of mortality in exposed groups compared with unexposed groups.

Therefore, from this example, the AAF for liver cancer in males aged 30–44 was calculated as

$$\frac{0.21 * (1-1) + 0.39 * (1.1–1) + 0.25 * (1.52–1) + 0.15 * (2.4-1)}{1 + [0.21 * (1-1) + 0.39 * (1.1–1) + 0.25 * (1.52–1) + 0.15 * (2.4-1)]} = 0.274.$$

Number of deaths attributable to alcohol in a given period for a given cause, age and sex group was calculated from number of deaths from that cause in that period times AAF. In this example, assuming there is no significant change in the prevalence of alcohol consumption over years, alcohol-attributable deaths from liver cancer of all male population aged 30–44 in 2004–2019 can be calculated from the extrapolated number of all deaths from liver cancer in the Thai population in this period (10,239 deaths) times 0.274 (AAF), which equals 2806 deaths (Supplementary Table S1).

The alcohol-attributable deaths from liver cancer of all four age groups were then summed to derive total alcohol-attributable deaths from liver cancer in 2004–2019. An age-adjusted alcohol-attributable mortality rate of liver cancer was then obtained from the total number of alcohol-attributable deaths of liver cancer divided by number of total NHES-III, separately for male and female subjects, and extrapolated to the average annual age-adjusted alcohol-attributable mortality rate per 100,000 population by using the average total number of Thai populations of all years from 2004 to 2019.

2) The AAFs for acute health conditions (injury) were calculated based on the following formula which assumed that all binge drinkers are given the same RR (Ashton et al., 2020):

$$\mathrm{AAF}_{\mathrm{injury}} = \frac{P_{\mathrm{abs}} + P_{\mathrm{former}} + P_{\mathrm{nonbinge}} + \left(P_{\mathrm{binge1}} * \mathrm{RR}_{\mathrm{binge1}}\right) - 1}{P_{\mathrm{abs}} + P_{\mathrm{former}} + P_{\mathrm{nonbinge}} + \left(P_{\mathrm{binge1}} * \mathrm{RR}_{\mathrm{binge1}}\right)},$$

where $\mathrm{RR}_{\mathrm{binge1}} = P_{\mathrm{dayatrisk}} * P_{\mathrm{daysatrisk}} * \left(\mathrm{RR}_{\mathrm{crude}} - 1\right) + 1$ and P_{abs} is the proportion of lifetime abstainers in the age- and gender-specific groups; P_{former} is the proportion of former drinkers in the age- and gender-specific groups; $P_{nonbinge}$ is the proportion of current drinkers who do not engage in binge drinking in the age- and gender-specific groups; P_{binge1} is the proportion of current drinkers who engage in binge drinking in the age- and gender-specific groups; RR_{binge1} is the risk ratio for binge drinkers, given a binge amount of alcohol consumed, corrected for both time at risk and number of drinking occasions; $P_{dayatrisk}$ is the proportion of a given day during which a person binge drinks and is at risk; $P_{daysatrisk}$ is the percentage of days the person undertakes binge drinking and RR_{crude} is the RR at binge drinking level *ii*, which is not adjusted for the time at risk per occasion.

Therefore, the AAF for all injuries was 0.08 in males aged 30–44 and 0.001 in females at the same age.

YLL attributable to alcohol consumption was estimated using the formula $\sum_{i}^{k}\left(\text{reference}_{\text{age}} - \text{age}_{\text{at}_{\text{death}}}\right)$, with *i*–*k* being the number of deaths attributable to alcohol consumption in people equal to or younger than the reference life expectancies at birth in Thailand in 2004–2019. The World Health Organization (WHO) standard life expectancy table was used in which life expectancy for both sexes is 86.0 years (World Health Organization and Management of Substance Abuse Unit, 2014). We first calculated YLL for each age group and disease and then the total YLL was obtained from the sum of these YLL of all age groups separately for males and females. YLL per death was then calculated from the total YLL divided by number of deaths of each disease. All analyses were weighted to take into account the probabilities in the multi-stage sampling of the 2004 Thai population aged ≥15 years, and all deaths and YLL were presented as extrapolated values, representing Thai population aged ≥15 years.

RESULTS

Sample characteristics

Of 38,275 respondents, the means age in 2004 was 39.8 (standard deviation (SD) = 16.6) years. Almost equal percentage of males and females was seen (48.9 vs. 51.1%). Most respondents attained primary (58.9%) and secondary (28.6%) school education, with only 6.2% being university graduates. Over two-thirds (72.4%) of the respondents had monthly income of <5000 Baht (~167 USD). The prevalence rates of diabetes mellitus (fasting plasma glucose > 126 mg/dl), hypertension (blood pressure > 140/90 mmHg) and hypercholesterolemia (total cholesterol level > 240 mg/dl) were 6.6, 22.1 and 15.6%, respectively. Of all, 25.3% were current tobacco smokers, while 7.2% were former smokers who had stopped smoking for 15.4 years on average and 67.5% were non-smokers (Table 2).

Prevalence of alcohol consumption by sex and age group among Thai population in 2004

The initial sample included 47.9% of abstainers, 33.2% of low drinkers (1–<12.5 g/day), 12.0% of moderate drinkers (12.5–≤50 g/day) and 7.0% of heavy drinkers (>50 g/day). Among current drinkers, 44.2% were binge drinking (57.1% in males and 18.6% in females). Different levels of alcohol consumption were seen by age group, where highest prevalence of abstainers was seen among the oldest age group (>60 years) and the highest prevalence of heavy drinking was in the youngest age group (15–29 years) for both males and females (Table 3).

Alcohol-attributable mortality and PYLLs, 2004–2019

Of all initial subjects, 10,704 had died between 2004 and 2019, making a crude mortality rate of 868.6 per 100,000 population for a 16-year follow-up cohort. Of these, 7257 were non-drinkers in 2004.

Using extrapolation, a total of 190,186 alcohol-attributable deaths (154,884 in males and 35,302 in females) occurred in Thailand in 2004–2019, making an average of 11,887 deaths annually. The average annual death rate was 30.7 per 100,000 population in males and 6.8 per 100,000 population in females. Total number of deaths attributed to alcohol consumption varied by age group and sex. Highest numbers of alcohol-attributable deaths occurred in both males and females aged 30–44 years (Table 4).

Among males, unspecified liver diseases accounted for the highest annual death rate, representing 6.1 deaths/year per 100,000 population and was highest in those aged 30–44 years (~943 deaths per year). Malignant neoplasm of liver and intrahepatic bile ducts accounted for the second highest annual death rate (5.0 per year per 100,000 population), with highest number similarly occurring among those aged 45–59 years. Among males aged 45–59 years, cardiac arrhythmias were the leading chronic cause of alcohol-attributable deaths and accounted for 10,287 deaths (~643 deaths per year) (Table 4A).

Among females, the three topmost alcohol-attributable deaths were caused by unspecified liver diseases (999 deaths per year), cardiac arrhythmia (823 deaths per year) and ischemic heart diseases (413 deaths per year), making them totally 18.6% of all deaths. The highest number of deaths from unspecified liver diseases was among those aged 45–59 years, while those from cardiac arrhythmia and ischemic heart disease were among aged ≥60 years (Table 4B).

Among males, a total of 7.86 million potential life years lost were attributable to alcohol, with an estimate of 50.8 years per one death. The PYLL was highest among males aged 30–44 years (3,082,688 years, 39.2% of all PYLL in males). Consistent with number of deaths, the highest PYLL among male population was caused by unspecified liver diseases, malignant neoplasm of liver and intrahepatic bile ducts and cardiac arrhythmias (altogether, 45.6% of all PYLL in males). However, the PYLL per death was highest for intentional self-harm/event of undetermined intention (67.4 years per one death), followed by assault by unspecified means (66.9 years per one death) and epilepsy and status epilepticus (64.2 years per one death; Table 4A).

Among females, 1.56 million PYLL were attributable to alcohol, 92.9% of which were caused by unspecified liver diseases, cardiac arrhythmia and ischemic heart disease. In terms of PYLL per death, a death from human immunodeficiency virus (HIV) made the highest life years lost (61.6 years), whereas malignant of larynx caused the smallest (20.4 years; Table 4B).

Among all alcohol-attributable deaths, 4272 (35.9%) involved adults aged 30–44 years, 3394 (28.6%) involved adults aged 45–60 years and 2589 (21.8%) involved young adults aged 15–29 years. The overall number of alcohol-attributable deaths among males was ~4-fold compared with

Table 2. Sample characteristics of the National Health Examination Survey respondents by gender at baseline, 2004

	Male ($n = 18,385$)	Female ($n = 19,890$)	Total ($n = 38,275$)
Gender	48.9 (48.4, 49.3)	51.1 (50.7, 51.6)	
Age groups			
15–29 years	32.9 (31.4, 34.5)	30.7 (29.3, 32.1)	31.8 (30.6, 33.0)
30–44 years	33.8 (32.6, 35.1)	33.2 (32.3, 34.1)	33.5 (32.7, 34.3)
45–59 years	20.7 (19.8, 21.6)	21.2 (20.4, 22.1)	21.0 (20.2, 21.7)
≥60 years	12.6 (12.3, 12.8)	14.9 (14.7, 15.2)	13.8 (13.6, 14.0)
Mean age (SD)	39.1 (16.1)	40.5 (17.1)	39.8 (16.6)
Highest education			
No formal	2.9 (2.4, 3.5)	7.1 (6.3, 7.9)	5.0 (4.5, 5.7)
Primary	57.1 (55.4, 58.8)	60.6 (59.1, 62.2)	58.9 (57.6, 60.3)
Secondary	32.6 (31.1, 34.1)	24.8 (23.5, 26.2)	28.6 (27.4, 29.8)
University	6.1 (5.4, 7.0)	6.2 (5.4, 7.2)	6.2 (5.5, 7.0)
Others	1.2 (0.7, 2.1)	1.3 (0.8, 2.0)	1.3 (0.8, 1.9)
Income (Baht per month)			
<3000	19.7 (18.1, 21.3)	33.7 (31.8, 35.7)	26.8 (25.3, 28.4)
3000–4999	45.6 (43.4, 47.8)	45.6 (43.6, 47.5)	45.6 (43.8, 47.4)
5000–9999	22.6 (21.2, 24.1)	14.0 (12.8, 15.4)	18.2 (17.1, 19.5)
10,000–24,999	10.1 (9.0, 11.2)	5.8 (5.1, 6.5)	7.9 (7.1, 8.7)
>25,000	2.1 (1.7, 2.6)	0.9 (0.8, 1.2)	1.5 (1.2, 1.8)
Diabetes (FPG >126 mg/dl)	5.9 (5.1, 6.8)	7.3 (6.5, 8.1)	6.6 (5.8, 7.4)
Hypertension (>140/90 mmHg)	23.3 (21.2, 25.4)	21.0 (19.6, 22.4)	22.2 (20.6, 23.7)
High cholesterol (TC > 240 mg/dl)	13.9 (12.5, 15.3)	17.2 (15.7, 18.8)	15.6 (14.3, 16.9)
Smoking			
Non-smoker	39.7 (37.7, 41.7)	96.2 (95.7, 96.7)	68.6 (67.5, 69.6)
Current smoker	47.1 (45.4, 48.8)	2.5 (2.1, 2.9)	24.3 (23.4, 25.2)
Former smoker	13.3 (12. 2, 14.4)	1.3 (1.1, 1.6)	7.2 (6.6, 7.7)

Note: Values presented in the table are unweighted percentage and 95% confidence interval (CI). Abbreviations: FPG, fasting plasma glucose; TC, total cholesterol.

Table 3. Weighted prevalence of alcohol consumption by sex and age group in NHES cohort 2004

	15–29 years ($N = 3874$)		30–44 years ($N = 7704$)		45–60 years ($N = 7797$)		≥60 years ($N = 18,900$)	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Non-drinkers[a]								
Male	22.27	19.6, 25.2	20.95	18.5, 23.7	30.21	27.8, 32.8	59.18	57.1, 61.3
Female	65.96	61.9, 69.8	58.69	55.6, 61.8	67.36	64.9, 69.7	85.84	84.3, 87.3
Low[a]								
Male	35.2	32.3, 38.2	38.7	36.1, 41.3	40.3	38.0, 42.7	29.1	27.1, 31.1
Female	30.7	27.2, 34.5	37.4	34.5, 40.4	29.0	26.7, 31.4	12.6	11.3,14.1
Moderate[a]								
Male	24.8	22.1, 27.8	25.3	23.1, 27.6	19.6	17.8, 21.5	9.1	8.2, 9.9
Female	1.8	1.2, 3.0	3.3	2.4, 4.4	2.9	2.3, 3.6	1.3	1.0, 1.6
Heavy[a]								
Male	17.7	15.4, 20.3	15.1	13.4, 17.0	9.9	8.7, 11.2	2.7	2.3, 3.2
Female	1.5	0.9, 2.5	0.6	0.4, 1.0	0.8	0.5, 1.1	0.3	0.2, 0.4

[a]Non-drinking = 0 g/day, low = <12.5 g/day, moderate = 12.5 and ≤50 g/day, heavy = >50 g/day.

females (Fig. 1). Regarding alcohol-attributable PYLL, an average annual number of 0.59 million years was lost, with 39.4, 30.2 and 23.9% being attributed to adults aged 30–44 years, 15–29 years and 45–60 years, respectively. Alcohol-attributable PYLLs in males were ~5-fold compared with females (Fig. 2).

DISCUSSION

This study reports a very high number of deaths and life years prematurely lost attributable to alcohol consumption in a Thai cohort with 16 years of follow-up. It confirms the great effect of alcohol consumption on leading causes of death. Our estimate of an average of 11,887 alcohol-attributable deaths per year in Thai population is lower than the estimates from a previous Thai Burden of Disease (BOD) Study in 2014 (21,843 deaths) (Workgroup for the Study of Burden of Diseases Attributable to Risk Factors 2014, 2018). Our study improves on estimation of mortality attributable to alcohol by using updated RRs for different levels of alcohol consumption from the latest meta-analysis available as well as by including more disease categories, such as tuberculosis, HIV, pancreatitis and epilepsy. Furthermore, using individually linked data over 16 years indeed increases the validity of the results on the contribution of alcohol on deaths and YLL.

Males were 4-fold more likely to die from all alcohol-attributable causes than females (30.7 vs. 6.8 deaths per year per 100,000 population) and had about five times higher PYLL (7.87 vs. 1.56 million years in 2004–2019), with highest number of deaths and PYLL occurring among those aged 30–44 years. This is consistent with other studies (Taylor *et al.*, 2009; Holmes *et al.*, 2016) and reflects higher levels

Table 4. Alcohol-attributable deaths (extrapolated number), age-adjusted average annual deaths per 100,000 population and alcohol-attributable PYLL, PYLL per death by disease and sex in Thailand, 2004–2019

A. Male population

	Alcohol-attributable deaths					Age-adjusted Annual deaths/10^5 pop.	Alcohol-attributable PYLL					PYLL per death
	15–29 years	30–44 years	45–59 years	≥60 years	Total		15–29 years	30–44 years	45–60 years	>60 years	Total	
Tuberculosis	2703	8909	3766	4325	19,702	3.91	202,837	478,824	146,856	101,401	929,917	47.2
HIV	3222	2111	439	140	5912	1.17	210,667	112,439	17,726	3136	343,968	58.2
Malignant neoplasm of oral cavity and pharynx	0	429	1154	1268	2851	0.57	0	23,695	42,976	31,327	97,997	34.4
Malignant neoplasm of lip, unspecified	0	506	403	700	1609	0.32	0	25,426	16,274	14,154	55,854	34.7
Malignant neoplasm of nasopharynx	0	0	0	124	124	0.02	0	0	0	2846	2846	23.0
Malignant neoplasm of esophagus	0	805	4427	508	5740	1.14	0	42,738	184,460	12,852	240,050	41.8
Malignant neoplasm of colon	0	1116	1508	619	3243	0.64	0	59,563	60,296	15,122	134,982	41.6
Malignant neoplasm of liver and intrahepatic bile ducts	899	7497	12,073	4747	25,215	5.00	58,491	412,661	467,713	123,154	1,062,019	42.1
Malignant neoplasm of larynx	1208	0	2092	500	3800	0.75	78,661	0	89,076	12,740	180,476	47.5
Diabetes mellitus (Type II)	(505)	(1628)	(5016)	(2077)	(9225)	(1.83)	(37,909)	(81,753)	(190,772)	(49,576)	(360,010)	39.0
Epilepsy and status epilepticus	1523	355	0	0	1878	0.37	99,148	21,316	0	0	120,464	64.2
Hypertensive diseases	0	725	2278	3095	6098	1.21	0	36,401	87,986	66,192	190,579	31.3
Ischemic heart diseases	(440)	(4081)	(8358)	(6827)	(19,706)	(3.91)	(28,647)	(226,382)	(334,136)	(158,108)	(747,273)	37.9
Hemorrhagic stroke	654	1490	1483	1971	5598	1.11	42,557	84,173	59,639	38,351	224,720	40.1
Cardiac arrhythmias	1036	7406	10,287	4988	23,717	4.70	75,680	395,369	419,671	115,519	1,006,239	42.4
Unspecified liver diseases	3402	15,093	9788	2338	30,621	6.07	221,466	815,834	414,492	61,110	1,512,902	49.4
Acute and chronic pancreatitis	1262	0	2241	133	3636	0.72	91,936	0	96,525	3790	192,251	52.9
Traffic accidents	7594	2271	696	23	10,584	2.10	524,952	120,112	28,371	588	674,023	63.7
Fall injuries	971	1645	32	6	2655	0.53	63,223	87,848	1432	151	152,654	57.5
Drowning	702	1350	98	2	2152	0.43	52,652	72,927	3794	54	129,426	60.2
Fire injuries	0	0	21	2	23	0.00	0	0	947	44	992	43.1
Intentional self-harm	4459	642	355	6	5463	1.08	319,326	34,671	14,169	152	368,318	67.4
Assault by unspecified means	1048	645	91	1	1786	0.35	76,706	38,780	3895	27	119,408	66.9
Unspecified multiple injuries	3814	1665	539	21	6039	1.20	267,797	89,063	22,517	507	379,884	62.9
Mental and behavioral disorders due to use of alcohol	2972	7520	2287	436	13,215	2.62	193,463	424,647	103,584	10,387	732,081	55.4
Fibrosis and cirrhosis of liver	765	260	1035	95	2155	0.43	53,572	14,337	46,905	2933	117,747	54.6
Total	**37,289**	**56,729**	**43,721**	**17,145**	**154,884**	**30.71**	**2,566,578**	**3,082,688**	**1,804,396**	**408,852**	**7,862,514**	**50.8**

(Continued)

Table 4. Continued

B. Female population

	Alcohol-attributable deaths					Age-adjusted Annual deaths/ 10^5 pop.	Alcohol-attributable PYLL					PYLL per death
	15–29 years	30–44 years	45–60 years	>60 years	Total		15–29 years	30–44 years	45–60 years	>60 years	Total	
	15–29	**30–44**	**45–60**	**>60**	**Total**		**15–29**	**30–44**	**45–60**	**>60**	**Total**	
Tuberculosis	218	288	313	390	1209	0.23	15,265	17,324	11,633	9574	53,795	44.5
HIV	832	739	0	25	1595	0.31	56,607	41,021	0	647	98,275	61.6
Malignant neoplasm of oral cavity and pharynx	0	839	194	221	1254	0.24	0	42,120	7063	5236	54,418	43.4
Malignant neoplasm of nasopharynx	0	0	129	6	135	0.03	0	0	4600	176	4776	35.3
Malignant neoplasm of esophagus	0	0	279	18	297	0.06	0	0	11,667	478	12,145	40.8
Malignant neoplasm of colon	0	309	1645	759	2712	0.52	0	15,518	64,040	17,820	97,379	35.9
Malignant neoplasm of liver and intrahepatic bile ducts	38	150	331	141	660	0.13	2502	7681	13,744	3456	27,383	41.5
Malignant neoplasm of larynx	0	0	0	24	24	0.00	0	0	0	482	482	20.4
Malignant neoplasm of breast	0	1233	517	70	1820	0.35	0	67,186	20,658	1851	89,694	49.3
Diabetes mellitus (Type II)	0	(64)	(4108)	(1893)	(6065)	(1.17)	0	(3523)	(161,990)	(48,205)	(213,718)	35.2
Epilepsy and Status epilepticus	0	117	0	3	119	0.02	0	6428	0	85	6513	54.6
Hypertensive diseases	0	(355)	(3648)	(2031)	(6035)	1.16	0	(17,834)	(138,051)	(45,216)	(201,102)	33.3
Ischemic heart diseases	118	1103	2687	2693	6601	1.27	8251	57,889	105,870	59,884	231,894	35.1
Hemorrhagic stroke	494	266	429	399	1589	0.31	32,158	14,386	17,795	8327	72,666	45.7
Cardiac arrhythmias	381	3874	3825	5081	13,160	2.53	26,713	219,096	155,883	105,113	506,805	38.5
Unspecified liver diseases	2032	3113	8001	2840	15,985	3.07	132,276	162,639	339,195	77,604	711,714	44.5
Acute and chronic pancreatitis	0	0	(35)	(23)	(58)	0.01	0	0	(1250)	(656)	(1905)	32.7
Cholelithiasis	0	0	0	(2)	(2)	0.00	0	0	0	(36)	(36)	23.6
Traffic accidents	5	3	13	0	21	0.00	337	170	551	0	1058	49.3
Fall injuries	0.0	0.0	0.5	0.0	0.5	0.00	0	0	17	0	17	35.6
Drowning	0	0	3	0	3	0.00	0	0	100	0	100	39.4
Intentional self-harm	12	1	2	0	15	0.00	778	63	80	0	921	60.0
Unspecified multiple injuries	5	2	8	0	15	0.00	375	89	349	0	813	53.9
Fibrosis and cirrhosis of liver	0	0	0	244	244	0.05	0	0	0	6950	6950	28.5
Total	**4136**	**11,617**	**10,585**	**8965**	**35,302**	**6.78**	**275,261**	**630,254**	**451,955**	**203,568**	**1,561,039**	**44.2**

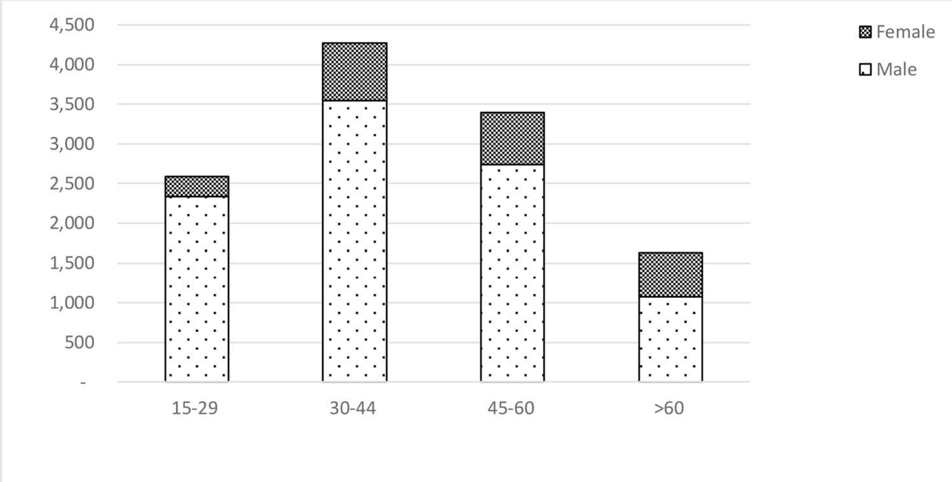

Fig. 1. Average annual number of deaths attributable to alcohol use, by sex and age group—Thailand, 2004–2019.

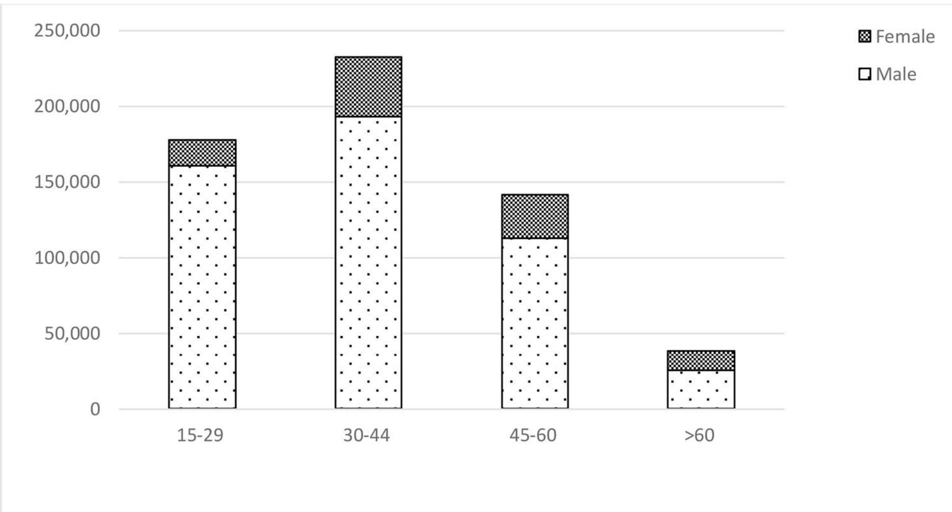

Fig. 2. Average annual number of PYLLs attributable to alcohol use, by sex and age group—Thailand, 2004–2019.

of drinking and higher RRs of deaths due to acute and chronic alcohol-related conditions in males than in females. However, it could be because males had poorer health status and lifestyle, were more likely to be current drinkers or died from other causes of death (Rogers *et al.*, 2013).

Of both sexes, unspecified liver diseases were the highest cause of alcohol-attributable deaths and PYLL. The main factors associated with alcohol-related liver diseases at the population level are the percentage of heavy drinkers among the population and early onset of drinking (Ventura-Cots *et al.*, 2019). This group of diseases is a chronic condition which may take 10–30 years for a disease to develop after exposure to risk factors (Liu *et al.*, 2021). Our study has a 16-year follow-up period, and 7% of all subjects at baseline were heavy drinkers with highest percentage in the youngest age group (15–29 years) in both males and females. Although alcohol-attributable deaths due to liver diseases here may be underestimated as the follow-up period may not be long enough for heavy drinkers to develop the disease and progress until death, the high number in this disease group should be paid attention. Prevention strategies to control heavy drinking and delay the onset of drinking in the population are suggested.

Comparing between diseases, intentional self-harm and assault by unspecified mean had the highest PYLL per death (67.4 and 66.9 years per one death) among men, as the largest number of deaths from these conditions occurred in the youngest age group which had the highest proportion of heavy drinkers. Acute use of alcohol, particularly at high dose, and chronic alcohol use disorder are strongly associated with suicide and suicide attempt (Borges *et al.*, 2017). A study in two emergency departments in Thailand found a dose–response relationship between alcohol use and unintentional injury, intentional injury inflicted by someone else or experiencing a road traffic injury (among drivers) (Sornpaisarn *et al.*, 2020). Our study, thus, confirms the role of alcohol use and injury risk in Thailand and suggests cost-effective interventions be needed to reduce drinking, especially heavy or binge drinking among young males.

Among women, one death from HIV/AIDS caused the highest life years lost due to premature mortality (61.6 years). Alcohol use is strongly associated with the incidence and course of HIV/AIDS, with a causal effect being explained via the intention to engage in condomless sex and a biological pathway being mediated by adherence to antiretroviral medication (Rehm *et al.*, 2017b). This certainly sets an alarm to the country as the highest number of HIV-related deaths occurred among those aged between 15 and 29 years, the youngest age group, among whom premature deaths would result in a negative effect to the country economy in terms of loss of labor market and productivity loss.

Limitations of the study

In this study, the completeness and accuracy of causes of deaths are not perfect. This might result in misclassification of diagnosis for some causes. For chronic diseases, such as liver cirrhosis and cancer, they were more likely to be underestimated rather than overestimated as it may take >16 years for drinkers to develop those conditions. This might lead to the underestimation of the overall mortality and PYLL attributable to alcohol. Measurement of drinking status, associated health conditions and other socio-demographic variables was taken only at baseline in 2004; changes over time were not accounted for and the risk associated with alcohol consumption was assumed to be constant over time. Furthermore, the respondents were asked about their alcohol consumption in the past 12 months, which might be subject to recall the bias and underreporting of the amount and frequency of consumption, especially by infrequent drinkers (Stockwell *et al.*, 2016). This may also lead to misclassification for occasional drinkers and result in the underestimation of the mortality and PYLL attributable to alcohol. Further study is thus needed to examine the health effect of changing patterns of alcohol consumption during the aging years. The volume and duration of drinking for former drinkers should be estimated to calculate dose–response relationships among former drinkers. Finally, we included only health conditions caused by drinkers themselves but not those caused by others' drinking, such as due to road traffic accidents and assaults, which could constitute a large proportion of the burden of deaths attributable to alcohol.

Despite our study's limitations, this study had its strength as it used individual data on alcohol consumption and deaths of nationally representative data from the national survey to study the proportion of alcohol consumption and their premature deaths in the Thai population. The implication of this study is the evidence that alcohol consumption has a significant public health impact. It contributes to a high proportion of mortality and PYLL in the Thai population, the mortality due to alcohol consumption occurs primarily in adults of working age and results in a negative economic impact. A monitoring system on alcohol consumption and alcohol-related harms is mandatory to evaluate the effectiveness of public health policies and to identify those areas where targeted alcohol policies would have the greatest impact as well as to help estimate alcohol-attributable burdens in the future. The burden of alcohol-attributable harms in Thailand could be reduced if effective public health policies were implemented. These policies, as suggested by the WHO SAFER initiatives, includes interventions to strengthen restrictions on alcohol availability, advance and enforce drink-driving countermeasures; facilitate access to screening, brief interventions and treatment; enforce bans or comprehensive restrictions on alcohol advertising; sponsorship and promotion and raise prices on alcohol through excise taxes and pricing policies (World Health Organization, 2019).

In conclusion, the estimated mortality and YLL attributable to alcohol consumption in Thailand were substantial, with alcohol-attributable deaths from traffic accidents, unspecified multiple injuries, cardiac arrhythmia and ischemic heart diseases being the largest contributors to this burden. Our results confirm that Thailand needs to reinforce public health policies aiming to reduce alcohol consumption and its adverse consequences, especially to prevent premature death at young age. Accordingly, it is necessary to quantify and monitor the burden of mortality due to alcohol consumption in order to formulate and evaluate public health policies aimed at reducing harmful effects of alcohol use.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Alcohol and Alcoholism* online.

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CONFLICT OF INTEREST STATEMENT

None declared.

ETHICS

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethical Review Committee for Research in Human Subjects, Faculty of Public Health, Mahidol University (Rec:95/2564) and the Ethics Committee for Research in Human Subjects of the Faculty of Medicine, Prince of Songkla University (EC: 62-054-18-1).

AUTHORS' CONTRIBUTIONS

Conceptualization was by J.N., W.A. and S.A.; formal analysis, project administration and writing of the original draft were done by J.N.; methodology was undertaken by J.N., S.A., W.A. and A.F.G.; resources were obtained by S.A.; supervision was by S.A. and A.F.G.; and the review and editing of the writing process were done by S.A., A.F.G. and W.A.

References

Aekplakorn W, Abbott-Klafter J, Premgamone A *et al.* (2007) Prevalence and management of diabetes and associated risk factors by regions of Thailand: Third National Health Examination Survey 2004. *Diabetes Care* **30**:2007–12.

Ashton S, Belsman L, Blawat A, *et al.* (2020) Alcohol-attributable fractions for England: an update. London: UK Health Forum and Public Health England.

Bagnardi V, Rota M, Botteri E, *et al.* (2015) Alcohol consumption and site-specific cancer risk: a comprehensive dose-response meta-analysis. *Br J Cancer* **112**:580–593.

Borges G, Bagge C, Cherpitel CJ *et al.* (2017) A meta-analysis of acute alcohol use and the risk of suicide attempt. *Psychol Med* **47**:949–57.

Cherpitel CJ, Ye Y, Bond J *et al.* (2015) Relative risk of injury from acute alcohol consumption: modeling the dose-response relationship in emergency department data from 18 countries. *Addiction* **110**: 279–88.

GBD 2019 Risk Factors Collaborators. (2020) Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. **396**: 1223–49.

Griswold MG, Fullman N, Hawley C *et al.* (2018) Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* **392**: 1015–35.

Holmes J, Angus C, Buykx P *et al.* (2016) Mortality and morbidity risks from alcohol consumption in the UK: analyses using the Sheffield Alcohol Policy Model (v. 2.7) to inform the UK Chief Medical Officers' review of the UK lower risk drinking guidelines. Sheffield: ScHARR University of Sheffield, 74.

Liu S-Y, Tsai I-T, Hsu Y-C. (2021) Alcohol-related liver disease: basic mechanisms and clinical perspectives. *Int J Mol Sci* **22**:5170.

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

Rehm J, Probst C, Shield KD *et al.* (2017b) Does alcohol use have a causal effect on HIV incidence and disease progression? A review of the literature and a modeling strategy for quantifying the effect. *Popul Health Metr* **15**: 1–7.

Rogers RG, Krueger PM, Miech R *et al.* (2013) Nondrinker mortality risk in the United States. *Popul Res Policy Rev* **32**:325–52.

Samokhvalov AV, Irving H, Mohapatra S *et al.* (2010) Alcohol consumption, unprovoked seizures, and epilepsy: a systematic review and meta-analysis. *Epilepsia* **51**:1177–84.

Shield KD, Taylor B, Kehoe T *et al.* (2012) Mortality and potential years of life lost attributable to alcohol consumption in Canada in 2005. *BMC Public Health* **12**:1–12.

Sornpaisarn B, Sornpaisarn S, Shield KD *et al.* (2020) Alcohol use and injury risk in Thailand: a case-crossover emergency department study. *Drug Alcohol Rev* **39**:539–45.

Stockwell T, Zhao J, Panwar S *et al.* (2016) Do 'moderate' drinkers have reduced mortality risk? A systematic review and meta-analysis of alcohol consumption and all-cause mortality. *J Stud Alcohol Drugs* **77**:185–98.

Taylor B, Irving HM, Baliunas D *et al.* (2009) Alcohol and hypertension: gender differences in dose-response relationships determined through systematic review and meta-analysis. *Addiction* **104**: 1981–90.

Ventura-Cots M, Ballester-Ferré MP, Ravi S *et al.* (2019) Public health policies and alcohol-related liver disease. *JHEP Rep* **1**: 403–13.

Workgroup for the Study of Burden of Diseases Attributable to Risk Factors 2014. (2018) *Thailand Burden of Diseases Attributable to Risk Factors 2014*. Nonthaburi: International Health Policy Program Foundation, 60.

World Health Organization. (2019) *The SAFER Technical Package: Five Areas of Intervention at National and Subnational Levels*. Geneva: World Health Organization.

World Health Organization, Management of Substance Abuse Unit. (2014) *Global Status Report on Alcohol and Health, 2014*. Geneva: World Health Organization.