The Effectiveness of an Alternative Alcohol Taxation Method in a Middle-Income County: A Case Study of Thailand

by

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Abstract

Background: While specific taxation has been found to be effective in reducing alcohol consumption and its related harms in High-Income Countries, it theoretically encourages drinking initiation in Low- and Middle-Income Countries (LMIC) with a high prevalence of lifetime abstainers. This dissertation aims to systematically review the existing evidence of the effects of taxation in LMIC on alcohol consumption, alcohol-related harms, and the rate of drinker initiation, and to examine how changes in Thailand's Two Chosen One (2C1) taxation rates affect alcohol consumption, related harms and drinking initiation.

Method: (1) A systematic review and meta-analysis that examines the effects of taxation policy on alcohol consumption, alcohol-related harms and the rate of drinker initiation in LMIC. (2) A quasi-experimental study using interrupted time-series analysis that examines the effects of alcohol taxation increases in Thailand on alcohol consumption and traffic fatalities. (3) An analysis of four consecutive national surveys on alcohol consumption behaviours to examine the effect of alcohol tax increases on drinking initiation prevalence in Thailand.

Result: There were only 10 published studies that quantitatively examined the effect of alcohol taxation policy on consumption in LMIC. In LMIC the price elasticity of demand was -0.64 for all alcohol consumption, -0.50 for beer consumption, and -0.79 for consumption of other alcohol. No studies were found that examined the effects of taxation policy on alcohol-related harms and drinking initiation in LMIC. Thailand's alcohol taxation increase in 2009 was associated with a reduction in alcohol consumption (tax elasticity of -1.95) and in traffic fatalities (tax elasticity of -1.90). Increased taxation prevented drinking initiation among young people 15 – 24 years of age during 2001-2011 in Thailand (tax elasticity of -0.40).

Conclusion: Increases in taxation under the 2C1 taxation method were associated with decreases in alcohol consumption, alcohol-related harms and drinking initiation.

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List of abbreviations

ARIMA	by means of an Autoregressive Integrated Moving Average Model
ATR	Actual Tax Rate
AV	Ad Valorem Taxation
DALY	Disability Adjusted Life Year
GDP-PPP	Gross Domestic Product – Purchasing Power Parity
HIC	High Income Countries
LIC	Low-Income Countries
LMIC	Low- and Middle-Income Countries
LPA	Litre of Pure Alcohol
MIC	Middle-Income Countries
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
RTD	Ready To Drink
SD	Standard Drink
Sp	Specific Taxation
THB	Thai Baht
WHO	World Health Organization
r	Pearson Correlation Coefficient
R^2	Coefficient of Determination
2C1	Two-Chosen-One Taxation
95% CI	95% Confidence Interval

Chapter 1
Introduction

1 Chapter 1: Introduction

1.1 The public health importance of preventing alcohol-related problems in low- and middle-income countries

Alcohol-related mortality, morbidity, and related social costs are important public health concerns in both high-income countries (HIC) and low- and middle-income countries (LMIC) [1, 2, 3]. Alcohol is the third leading risk factor for global disease burden in 2010 after only high blood pressure and tobacco smoking including second-hand smoke [3]. Alcohol accounted for 5.5% (95% Confidence Interval (CI): 5.0, 5.9) of global DALYs in 2010 while these numbers were 7.0% (95%CI: 6.2, 7.7) and 6.3% (95%CI: 5.5, 7.0) for high blood pressure and tobacco smoking including second-hand smoke respectively [3]. In addition, in 2010 alcohol consumption was responsible for 4.9 million deaths (1.7 million female deaths and 3.1 million male deaths) among a total of 52.8 million deaths worldwide, accounted for 9.2% (95%CI: 8.6% to 9.8%) of the total deaths globally [3]. The burden of alcohol consumption increased from 1990 to 2010, as alcohol was responsible for 8.0% of all deaths in 1990, and was responsible for 4.2% of all DALYs lost in 1990 [3]. An increase in the global burden of disease attributable to alcohol also was observed by Rehm and colleagues [4].

Alcohol consumption also creates a large economic burden (Rehm et al., 2009). Rehm and colleagues demonstrated that the weighted average economic cost attributable to alcohol consumption was 2.5% of GDP (PPP) among selected High-Income Countries (HIC) (Canada, France, Scotland, and the United States), and also demonstrated that the average social cost attributable to alcohol consumption was 2.1% of GDP-PPP for selected middle-income countries (South Korea and Thailand) [4].

There are marked between-country differences in alcohol consumption and alcohol-attributable harms, and these differences are associated with the economic wealth of nations [4-6]. Overall, the correlation between wealth as measured in Gross Domestic Product – Purchasing Power

Parity (GDP-PPP) and alcohol consumption is very strong up to a GDP-PPP of about $10,000 to $15,000 international dollars (standardized to a 2010 evaluation) and then this association levels off [5, 7]: see figure 1.1.

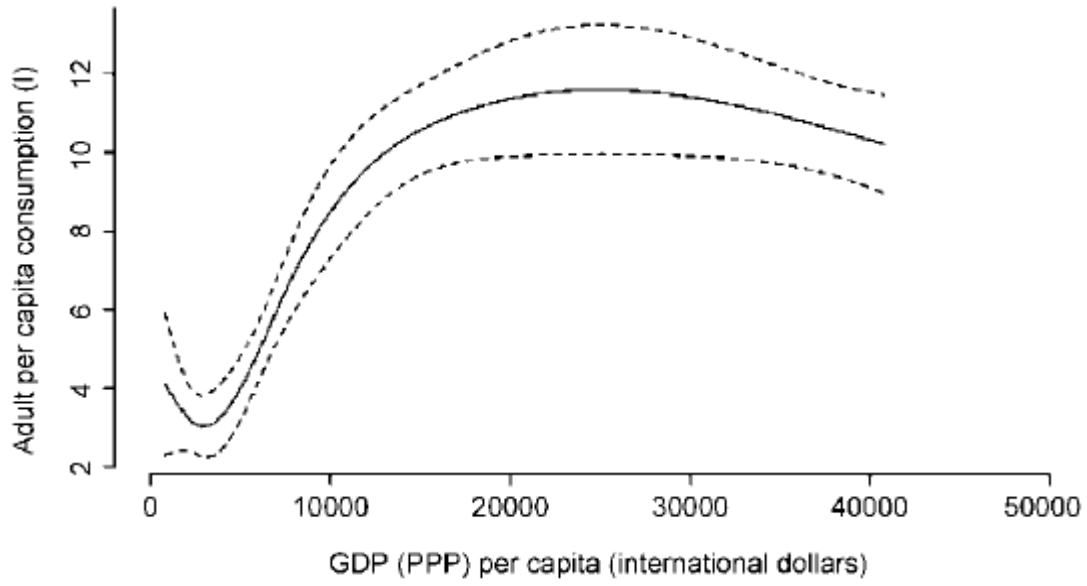
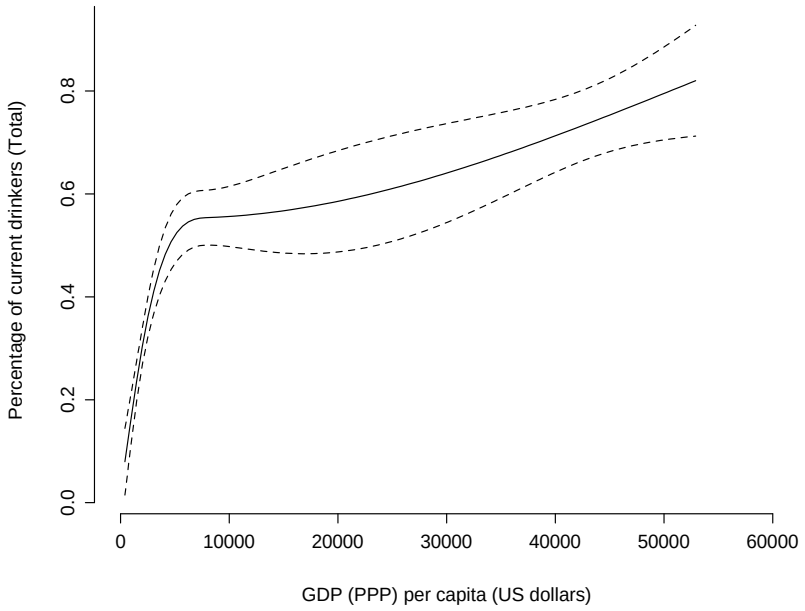


Figure 1.1 Relationship between total adult *per capita* alcohol consumption and gross domestic product (GDP-PPP) *per capita.* Reproduced from Shield K, Rehm M, Patra J, Sornpaisarn B, Rehm J. (2011) [7].

The relationship between alcohol consumption and GDP-PPP can be partly explained by income elasticity. Since income elasticity of alcohol demand is statistically significant positive figures [8.9], it means that consumers drink more when their incomes increased. This relationship also is partially attributed to a higher proportion of abstainers (of whom many are lifetime abstainers), in middle-income countries (MIC) and especially in low-income countries (LIC) [10]. Figure 1.2 describes the relationship between GDP-PPP and the prevalence of current drinkers in the adult population (based on 2005 rates of current drinkers from the ongoing Comparative Risk Assessment) [11].



Source: Reproduced from Sornpaisarn B, Shield KD, Rehm J (2012) [11].

Figure 1.2 Association between prevalence of current drinkers (total) and gross domestic product (GDP-PPP) *per capita*

As observed in figures 1 and 2, when the GDP-PPP *per capita* in LMIC increases so does alcohol consumption and the prevalence of current drinkers, which may lead to increases in the magnitude of alcohol-related harms due to more harmful patterns of alcohol consumption [12] and a higher risk of mortality and morbidity from causes where alcohol plays a role (such as injuries) in LMIC [13]. Thus, alcohol control policies in LMIC should aim to reduce consumption in drinkers and prevent initiation of drinking.

Two methods are generally used to reduce and/or control alcohol-related harms: (1) reducing alcohol consumption, and (2) preventing drinking initiation [11]. In contrast to reducing alcohol consumption, drinking initiation prevention is considered to be a long-term harm prevention method [11] (see figure 1.3).

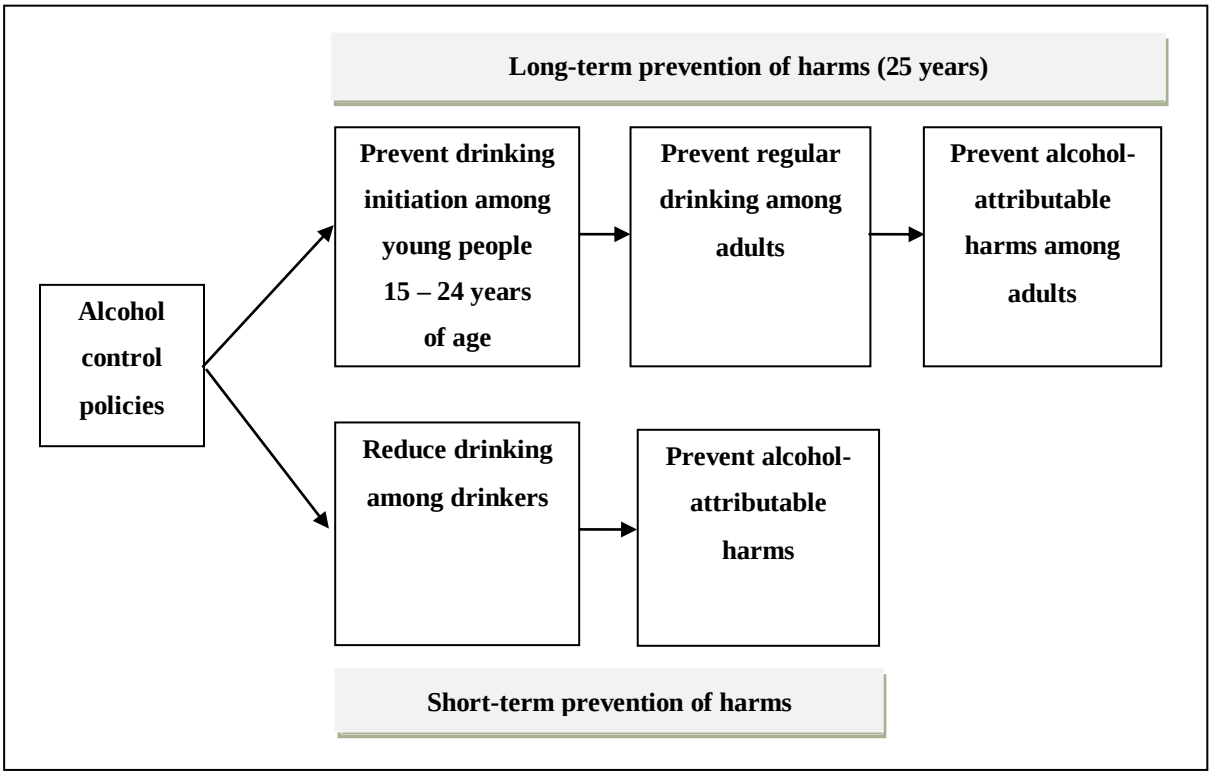


Figure 1.3 Diagram of the short- and long-term preventions of alcohol-attributable harms addressed by alcohol control policies. Reproduced from Sornpaisarn B, Shield KD, Rehm J (2012) [11].

Preventing drinking initiation may be especially important in LMIC where there are high rates of lifetime abstainers, such as countries in the Eastern Mediterranean, South-East Asia, and African WHO regions where the prevalence of lifetime abstainers (among people 18 years of age and older) is 88%, 80% and 57% as compared to the prevalence of lifetime abstainers in HIC which were 19%, 21% and 29% for the European, American and Western Pacific WHO regions in 2004 respectively [10].

1.2 The importance of common alcohol taxation method in controlling alcohol-related problems and its challenge in applying in the context of LMIC

The ecological model advocates that determinants of a particular health behaviour include individual factors and environmental factors (e.g. interpersonal, community, and society level, including policies) [14]. Under the ecological model, taxation is a social-level policy intervention that governments employ to influence alcohol consumption behaviours [14] by creating a barrier to the affordability of alcohol [15]. According to the behavioural economics theory, alcohol consumers may not always be able to decide to perform healthy behaviours based on their health or moral rationale, but rather are dependent on immediate environments which both encourage (friend, lover, party, etc.) and discourage (high alcohol price, little availability, etc.) consumption [16] .

Historically, taxation of alcohol has been one of the most effective measures at the societal level to control alcohol consumption [1, 10, 17-19]. Three recent systematic reviews found that alcohol taxation affects alcohol consumption and alcohol-related harms [10-22]. One indicator that is used to describe the effect of taxation is price elasticity. For example, a price elasticity of demand for beer of -0.46 means an increase of 10% in the price of beer is associated with a 4.6% reduction in beer consumption. Wagenaar and colleagues, in their review of 112 studies published in 2009, indicated that the mean of price elasticity of demand was -0.46 for beer, -0.69 for wine, and -0.80 for spirits [21]. Elder and colleagues, in a 2010 systematic review of 72 studies, observed that the median value of elasticity was -0.50 for beer, -0.64 for wine, -0.79 for spirits, and -0.77 for ethanol [20].

Wagenaar and colleagues summarized the results of 50 studies in terms of the effects of alcohol taxation or price on alcohol-related harms. From these studies, Wagenaar and colleagues observed that the elasticity of harms was -0.347 for alcohol-related disease and injury outcomes, -0.112 for traffic crash outcomes, -0.055 for sexually transmitted diseases, -0.048 for suicide, -0.022 for violence, -0.022 for other drug use, and -0.014 for crime and other misbehaviour [22].

The interaction between individuals and alcohol taxation policy is dynamic and reciprocal deterministic [15]; not only do alcohol price increases caused by taxation reduce alcohol consumption and its related harms [20-22], but the market can adjust for increases of alcohol prices [23-31]. Consumers can shift their purchases of alcohol towards cheaper beverage categories [1, 32, 33], and alcohol producers can change their production to reduce the taxation burden [27-31]. From an implementation perspective, different alcohol taxation methods yield different results because of these adjustments in the market [27-31].

There are two basic types of taxation: *specific* taxation and *ad valorem* taxation. *Specific* taxation is a function of alcohol content while *ad valorem* taxation is a function of beverage price [27-31]. *Specific* taxation is thought to be one of the best taxation methods to control and/or decrease the externalities of alcohol consumption [1, 20-22, 27-31]; however, the supporting analyses come primarily from HIC [1, 20-22]. Taxation policies in HIC focus on discouraging harmful patterns of alcohol consumption, rather than reducing drinking initiation, by promoting relatively inexpensive low alcohol content beverages [1, 17]. *Specific* taxation, which favors low alcohol content beverages, may result in long-term alcohol-related harms in countries with a high proportion of abstainers, by encouraging drinking initiation among youth, as initiation is often via low alcohol content beverages [34].

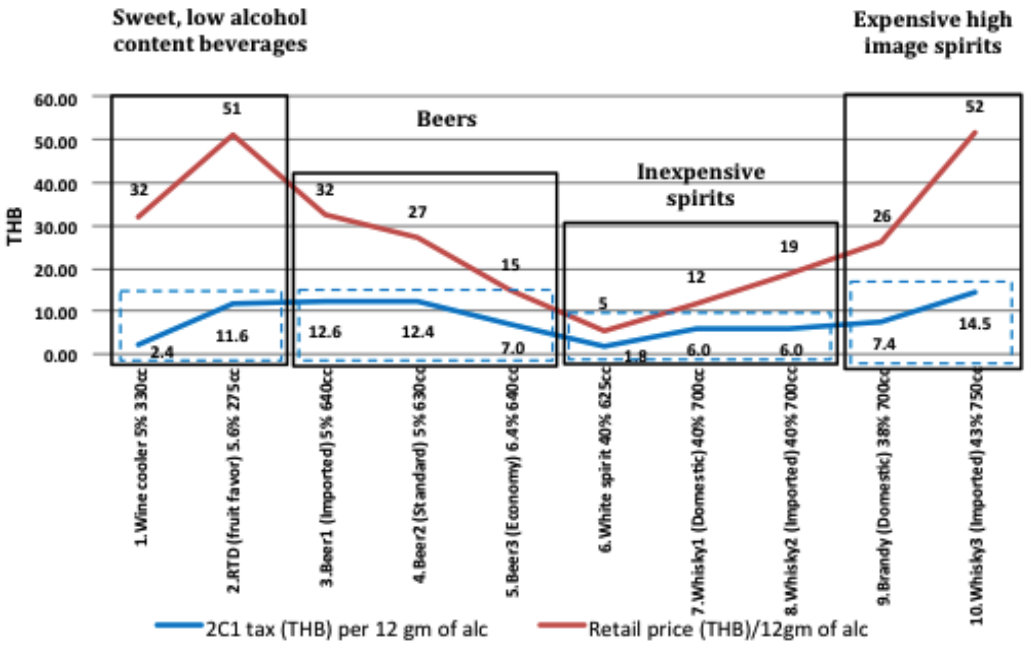
To effectively prevent short- and long-term harms in LMIC, taxation policies should both reduce alcohol consumption among current drinkers and prevent drinking initiation among young people, which in turn will reduce short- and long-term alcohol-attributable harms [11]. Currently, a systematic review on the effects of alcohol taxation on alcohol consumption, related-harms and drinking initiation in LMIC does not exist. Thus, the first aim of this PhD dissertation is to systematically review the published literature assessing the effects of alcohol taxation on alcohol consumption, alcohol-related harms and drinking initiation in LMIC.

1.3 Thailand's unique alcohol excise taxation system and its potential to simultaneously reduce alcohol consumption and its related harms and prevent drinking initiation

Thailand employs a unique method of taxation known as Two-Chosen-One taxation (2C1), a method of taxation that combines the properties of both *specific* taxation and *ad valorem* taxation [11, 35]. The 2C1 taxation method, outlined in the Alcohol Act 1950, calculates the excise tax due of each alcoholic beverage using both primary taxation methods – *specific* and *ad valorem* – and the excise tax due on an alcoholic beverage is the higher of the two calculations [11, 35] (See Appendix A and B for more details). For example, the calculated *specific* tax of a distilled spirit (a 700 cubic centimeter (cc) bottle with an alcohol volume concentration of 40%) is 112 Thai baht (THB) (equivalent to 6.08 Thai baht per standard drink (THB/Standard Drink (SD)) (one standard drink contains 12 grams of alcohol)) and the calculated *ad valorem* tax is 58 THB (equivalent to 3.15 THB/SD). The application of the 2C1 results in an actual excise tax of 6.08 THB/SD for this distilled spirit. For a second example, for a bottle of beer the calculated *specific* tax (a 630 cc bottle with alcohol concentration 5% by volume) is 3.15 THB (equivalent to 1.52 TBH/SD) and its *ad valorem* tax is 42.93 THB (equivalent to 12.42 THB/SD). The application of the 2C1 results in an actual excise tax of 12.42 THB/SD. Additional details of these calculations are provided in Box 1 of Appendix A.

As demonstrated by the above two examples, under 2C1 taxation the excise tax on less expensive alcoholic beverages (the spirit example above) is equal to the calculated *specific* tax, while the excise tax on more expensive alcoholic beverages (the beer example above) is the calculated *ad valorem* tax. The costs of producing low alcohol content, high image beverages result in these beverages generally being more expensive than low image, high alcohol content beverages [36, 37]. In Thailand, beers, wines and other low alcohol content beverages (such as alcohol mixed with fruit juice, ready-to-drink (RTD) beverages), and high image spirits are more expensive compared to domestic low image spirits [11]. Figure 1.4 outlines the 2C1 tax rates and retail prices of ten alcoholic beverages, arranged by alcoholic beverage type and by alcohol content. The sweet, low alcohol content beverages and beers on the left, and the high image, high alcohol content spirits on the right are expensive relative to their alcohol content and, thus, the 2C1 taxation system dictates that the applicable excise taxes are calculated as *ad valorem* taxes which

are greater than their calculated *specific* taxes (see beverages #1-5, 9-10 in table 1.1). The applicable excise taxes on inexpensive spirits are calculated under the 2C1 taxation system as *specific* taxes (see beverages #6-8 in table 1.1). As a result, 2C1 taxation favors medium strength alcoholic beverages [11]. Consequently, under 2C1 taxation, the government can deter consumption of high alcohol content beverage consumption by adjusting the *specific* tax rate based on alcohol content and also prevent drinking initiation by taxing low alcohol content beverages and highly advertised, high image alcoholic beverages based on *ad valorem* taxation, which reduces the affordability of these beverages [11].



Source: The values of the 2C1 tax per 12 grams of alcohol for ten alcoholic beverages are adopted from table 1.1, while the values of retail prices per 12 grams of alcohol of these beverages are calculated using data from alcohol producers for 2010.

Figure 1.4 Graph of the 2C1 tax and retail prices per 12 grams of alcohol for ten alcoholic beverages, arranged by alcohol category and content (data from 2010). Reproduced from Sornpaisarn B, Shield KD, Rehm J (2012) [11].

Table 1.1 Ten examples of the excise tax calculation using the *2C1* taxation system. Reproduced from Sornpaisarn B, Shield KD, Rehm J (2012) [11].

Beverage	strength	volume	Ex-factory price	*Specific* tax	*Ad valorem* tax	Actual excise tax under 2C1	The tax method applied
			(THB / 12 gm of alcohol)				
1.Wine cooler	5.0%	300 c.c.	9.44	1.52	2.36	2.36	AV
2.RTD (fruit favor)	5.6%	275 c.c.	23.22	6.08	11.61	11.61	AV
3.Beer (imported)	5.0%	640 c.c.	20.93	1.52	12.56	12.56	AV
4.Beer (domestic)	5.0%	630 c.c.	20.7	1.52	12.42	12.42	AV
5.Beer (domestic)	6.4%	640 c.c.	11.72	1.52	7.03	7.03	AV
6.White spirit	40.0%	625 c.c.	2.93	1.82	1.47	1.82	Sp
7.Whisky (inexpensive - domestic)	40.0%	700 c.c.	6.29	6.08	3.15	6.08	Sp
8.Whisky (inexpensive - imported)	40.0%	700 c.c.	11.18	6.08	5.59	6.08	Sp
9.Brandy (expensive - domestic)	38.0%	700 c.c.	15.43	6.08	7.41	7.41	AV
10.Whisky (expensive - imported)	43.0%	750 c.c.	29.02	6.08	14.51	14.51	AV

Source: Alcohol ex-factory prices, alcohol strengths, *specific* excise tax rates and *ad valorem* excise tax rates data were obtained from the Excise Department; *specific*, *ad valorem* and actual 2C1 tax rates per 12 grams of alcohol were calculated by the author.

Abbreviations: THB, Thai baht; AV, ad valorem taxation; Sp, specific taxation

Note: Wine coolers (beverage number 1) are in the wine category, while RTDs (beverage number 2) are in the spirits category. Hence, these beverages have different tax rates.

Note: The low tax rates for wine coolers (beverage number 1) and white spirits (beverage number 6) are not the result of 2C1 taxation. Instead, they are the result of a government differential tax rate determination among different alcoholic beverages.

Even though 2C1 taxation theoretically is able to simultaneously reduce alcohol consumption and its related harms and prevent drinking initiation, there are no studies which examine if changes in Thailand's alcohol excise taxation rates are associated with changes in alcohol

consumption, alcohol-related harms, and/or drinking initiation. Thus, the further aims of this PhD dissertation are to examine whether changes in the rates of 2C1 taxation in Thailand are associated with changes in alcohol consumption, alcohol-related harms, and/or alcohol drinking initiation.

1.4 The objectives and the structure of this PhD dissertation

The objectives of this PhD dissertation are:

1. To systematically review published literature assessing the association between alcohol taxation and alcohol consumption, alcohol related-harms and drinking initiation in LMIC.
2. To examine if changes in the rates of Thailand's alcohol excise taxation (2C1) are associated with changes in alcohol consumption and alcohol-related harms.
3. To examine if changes in the rates of Thailand's alcohol excise taxation (2C1) are associated with changes rates of drinking initiation.

This PhD dissertation applies a journal format, consisting of three journal articles that have been published or are under review in peer-reviewed journals. Chapter 1 provides an explanation of the public health importance of preventing alcohol-related problems in LMIC, the need for alcohol policy interventions that can decrease overall alcohol consumption and prevent drinking initiation, and how these aims can be achieved through taxation. Chapter 2 is a journal article entitled "Elasticity of alcohol consumption, alcohol-related harms, and drinking initiation in low- and middle-income countries: a systematic review and meta-analysis," published in the International Journal of Alcohol and Drug Research. This paper systematically reviews previous research on the effects of taxation on alcohol consumption, alcohol-related harms and drinking initiation in LMIC. Chapter 3 contains the submitted journal article entitled "The effectiveness of alcohol taxation on alcohol consumption and on traffic fatalities in Thailand." This paper examines the association between changes in the rate of alcohol taxation in Thailand and alcohol consumption and alcohol-related harms. Chapter 4 contains the submitted journal article entitled "The impact of alcohol taxation on drinking initiation in youths and young adults: the first evidence from a middle-income country." This paper examines the association between changes

in alcohol taxation rates and the prevalence of ever drinkers in Thailand. Chapter 5 is a discussion of the limitation, implications and recommendations that arise from the findings of the three studies that comprise this dissertation.

Approval for this dissertation protocol reference #28321 was granted by the Research Ethics Boards of the University of Toronto.

1.5 Involvement of the author in the PhD dissertation

The PhD candidate, Bundit Sornpaisarn, undertook study design; data access, cleaning, analysis, and interpretation; and wrote the first and the final draft of the PhD dissertation. The supervisor, Prof.Dr. Jürgen Rehm, supervised the whole process of all research studies. The supervisory committee and coauthors of each research article contributed to the study design and revised and approved the final manuscript of the paper they involved.

Chapter 2
Elasticity of alcohol consumption, alcohol-related harms, and drinking initiation in low- and middle-income countries: a systematic review and meta-analysis

2 Chapter 2: Paper 1

2.1 Abstract

Aims: To systematically review research outlining the effects of price and taxation on alcohol consumption, alcohol-related harms and drinking initiation in low- and middle-income countries (LMIC).

Design: The systematic review and meta-analyses were conducted according to internationally standardized protocols (Preferred Reporting Items for Systematic Review and Meta-Analysis; PRISMA). Data were collected up to June 2011 by searching the peer-reviewed article databases MEDLINE, EMBASE, PsycINFO and EconLit, along with the World Health Organization's gray literature Database of Abstracts of Reviews of Effects, and by reference tracking. The meta-analyses were performed using random effects analysis, tests for publication bias and sensitivity analyses.

Measures: Any type of association between alcohol price and/or taxation and alcohol consumption, alcohol-related harms and alcohol drinking initiation in LMIC.

Findings: Our systematic search disclosed 12 studies that outlined an association between alcohol price or taxation and alcohol consumption in LMIC, while no articles were found that outlined a relationship between taxation and/or price and alcohol-related harms or drinking initiation in LMIC. The elasticity estimates were –0.64 (95% CI: –0.80 to –0.48) for total consumption of alcohol, –0.50 (95% CI: –0.78 to –0.21) for consumption of beer and –0.79 (95% CI: –1.09 to –0.49) for consumption of other alcoholic beverages. Publication bias did not significantly affect the estimated elasticities.

Conclusion: Price elasticity of demand for alcohol in LMIC is similar to that found in high-

income countries. There is an imperative need for research on the association between alcohol price or taxation and alcohol-related harms and drinking initiation in LMIC.

2.2 Background

Historically, taxation has been one of the most cost-effective measures used to control alcohol consumption and the resulting related harms [1, 10, 17-19]. Three systematic reviews of studies of the effects of price and/or taxation on the consumption of alcohol found that alcohol price elasticities are negative values, meaning that alcohol price negatively affects alcohol consumption and alcohol-related harms [20-22]. Elasticity measures the degree of change in one variable that is caused by one unit of change in another. For example, a price elasticity of demand of –0.5 means that a 0.5% reduction in alcohol consumption follows a 1.0% increase in alcohol price; similarly, a tax elasticity of fatal traffic accidents of –0.8 means 1.0% increase in alcohol tax results in a 0.8% reduction in the number of fatal traffic accidents. Wagenaar and colleagues demonstrated that the mean of price elasticity of demand is –0.46 for beer, –0.69 for wine and –0.80 for spirits [21]. Elder and colleagues observed that the median price elasticity is –0.50 for beer, –0.64 for wine, –0.79 for spirits and –0.77 for ethanol [20]. In addition, Wagenaar and colleagues observed that the price elasticity of harms was –0.347 for alcohol-related disease and injury outcomes, –0.112 for traffic crash outcomes, –0.055 for sexually transmitted diseases, –0.048 for suicide, –0.022 for violence, –0.022 for other drug use, and –0.014 for crime and other misbehaviour [22].

Given this evidence, it is not surprising that alcohol taxation has consistently been recommended as a public policy option to control alcohol-related harms [1, 10, 17-19, 38]. At the First Global Ministerial Conference on Healthy Lifestyles and Non-Communicable Disease Control, held in Moscow in April 2011, and in the High-Level Meeting of the General Assembly on the Prevention and Control of Non-Communicable Disease, held in New York in September 2011, the World Health Organization (WHO) recommended alcohol taxation as one of the three “best buy” policies for controlling the harmful use of alcohol [38]; however, most of the literature upon which these conclusions are based is from high-income countries (HIC).

There are marked between-country differences in alcohol consumption and alcohol-attributable harms, and these differences are related to the economic wealth of nations [4, 5, 39]. The association between wealth—as measured in gross domestic product – purchasing power parity (GDP-PPP)—and alcohol consumption is very strong up to a GDP-PPP of $10,000 to $15,000, above which this association levels off [5, 7]. This correlation is due mainly to a much higher proportion of abstainers in middle- and especially low-income countries (LIC) [10]. As a result, the lowest-income countries tend to consume the least alcohol on an adult per capita basis [39]. In middle-income countries (MIC) adult per capita consumption is higher than in LIC; however, consumption is still much lower than in high-income countries (HIC). Not only do the prevalence of current drinkers and the adult per capita consumption vary with economic wealth, but also the proportion of alcohol consumed by men vs. women: ceteris paribus (other things being equal), the lower the GDP-PPP, the higher the relative proportion of alcohol consumption by men [39]. Thus, due to differences in affordability and the characteristics of those individuals who consume alcohol, there may be different elasticities for alcohol consumption, alcohol-related harms and drinking initiation in low- and middle-income countries (LMIC) compared to HIC.

While less alcohol is consumed in LMIC, the relative harm associated with each liter consumed per capita is much greater [40] due to more harmful consumption patterns [12], and there is a higher risk of mortality and morbidity in LMIC from causes in which alcohol plays a role (such as injuries) [13]. In addition, alcohol interacts with other risk factors such as poverty, crowding and malnutrition [5]. Thus, LMIC-specific research is needed to formulate the best public policies to decrease the harms related to alcohol consumption.

Because the overwhelming majority of people who drink live in HIC [10, 41], the goal of preventing people from drinking at all is rarely formulated and, thus, there is a surprising lack of research on drinking initiation; most of the focus seems to be on determining age of initiation and assessing potential consequences of different ages of initiation [42-46]. There is a resulting need to examine how price and taxation affects drinking initiation in LMIC.

To address the needs noted above, we performed a systematic review of studies which examined the association between alcohol price / taxation with alcohol consumption, alcohol-related harms

and drinking initiation in LMIC. Additionally, to establish a quantitative estimate of the effects of price and taxation on alcohol consumption in LMIC, we performed a meta-analysis using estimates obtained from our systematic review.

2.3 Methods

The systematic review was conducted and reported according to the standards set out in Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (www.prisma-statement.org/) [47].

Search strategy and study selection

Three public health databases—MEDLINE, EMBASE and PsycINFO—as well as the economics database EconLit were queried up to June 2011 for articles that tested the association between alcohol taxation/price and alcohol consumption, alcohol-related harms and drinking initiation. Where * is the truncation indicator to include all forms of the root word, search terms for alcohol were “alcohol,” “beer*,” “wine*,” and “spirit*.” For LMIC the search terms were “low income country,” “middle income country,” and “developing country.” For the intervention we used the search terms ‘taxation,“ “”tax*” and “price*.” No limitations were put on comparison groups, outcomes and study design for articles included in this review and, thus, no search terms were included for these variables in our systematic review. Articles were restricted to those published in English or Thai before June 2011.

Other sources examined were WHO’s Database of Abstracts of Reviews of Effects (DARE), which catalogues grey literature; all studies included in the systematic reviews of the effects of price on alcohol consumption (namely Wagenaar et al. [21, 22] and Elder et al. [20]; the reference lists from all of the above literature, as well as from Babor et al. [1].

For peer-reviewed articles, retention was based on the following inclusion scheme: (i) any article returned in the systematic search was retained for abstract screening; (ii) if the abstract contained any information about alcohol taxation in LMIC, the paper was retained for full article analysis; (iii) if the article examined the association between alcohol price and/or taxation with either

alcohol consumption, alcohol-related harms or drinking initiation, it was retained for quality criteria analysis.

Quality criteria

The minimum quality criteria for inclusion were as follows: (i) a longitudinal study had to have enough time points to provide a meaningful result; and (ii) the results were not confounded by any other large changes in alcohol control policies that were not taken into account.

Data collection

Data extracted for each study included the sample population, intervention (price or tax), other independent variables (including socio-economic and demographic characteristics), comparison groups, outcomes (including elasticity of alcohol consumption, elasticity of related harms and rate of drinking initiation), country of study, and own price or tax elasticity of demand and of related harms. Own price or tax elasticity is the percentage change in consumption for an alcoholic beverage that results from a 1% change in the price or tax. The potential sources of bias for studies that quantify price elasticity were assessed, and included selection bias, measurement bias and problems with statistical analysis. To ensure consistency, data collection was performed using a data extraction form, created by the authors, consisting of the above-mentioned study variables and potential sources of bias assessment.

Statistical analysis

Our meta-analysis analyzed the reported price elasticities by means of DerSimonian & Laird's random effects [48]. For studies that provided a probability value less than an α threshold, a conservative threshold of 0.001 was taken as the p-value. The overall point estimates and the 95% confidence intervals (CIs) were based on weighted pooled measures. Heterogeneity between studies was assessed using the Cochran Q test and the I^2 statistic. Publication bias was tested by the visual inspection of funnel plots for a skewed distribution, and by using a ranked correlation test proposed by Begg & Mazumdar [49] and a weighted regression test proposed by Egger et al. [50]. To adjust estimates for publication bias, the trim and fill method was used [51]. All data analysis was performed using STATA version 11.0 [52].

2.4 Results

Study selection and study characteristics

The results of the literature search are outlined in Figure 2.1. Search results of the databases MEDLINE, EMBASE, PsycINFO and EconLit yielded 29 articles, which were reduced to 26 after elimination of duplicate articles. Titles and abstracts were reviewed for these 26 articles, and 4 papers were retained for full paper reviews. After the full paper reviews, no articles met the eligibility criteria of containing quantitative data relating to the price and/or taxation of alcohol and resulting effects on alcohol consumption, alcohol-related harms, and drinking initiation.

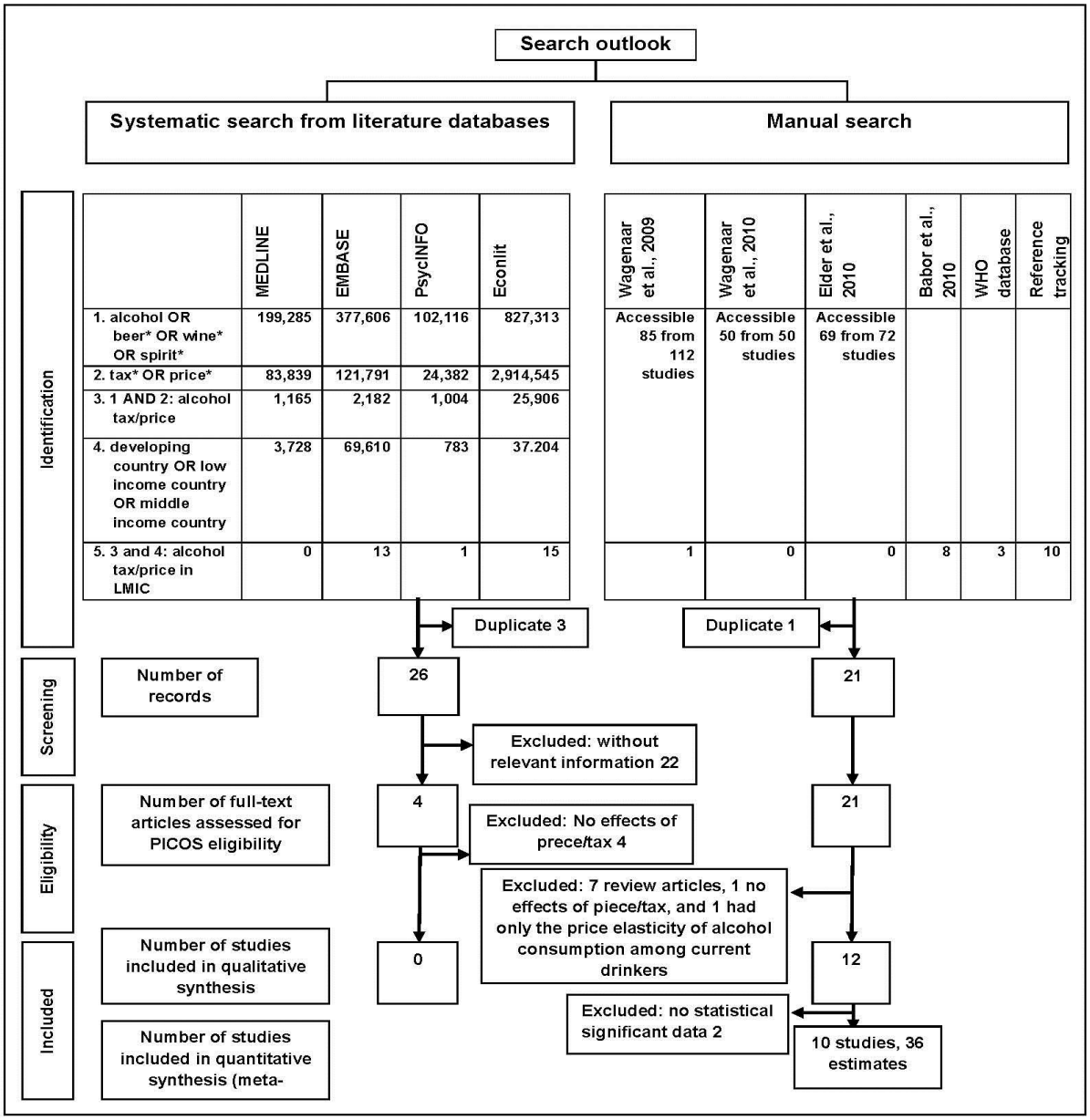


Figure 2.1 Search strategy for studies that assessed the relationship between alcohol price and / or taxation with alcohol consumption, alcohol-related harms and drinking initiation. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].

From a search of previous systematic reviews, the WHO grey literature database DARE, and

reference tracking, 22 articles were identified, which were reduced to 21 after the elimination of 1 duplicate article. Titles and abstracts of the remaining 21 articles were reviewed and all were retained for full paper reviews. After assessing the 21 articles, 7 reviews were excluded for not meeting eligibility criteria and 2 articles due to lack of relevant information. The remaining 12 articles contained relevant information on alcohol price and/or taxation and resulting effects on alcohol consumption in LMIC and, thus, were included in the information synthesis [9, 53-63]. Table 2.1 shows that all 12 articles contained information on the effects of alcohol price and/or taxation on alcohol consumption, while not one study contained information on the effects of alcohol price and/or taxation on alcohol-related harms or drinking initiation. Eleven of the studies analyzed only alcohol price as the intervention of interest, while 1 of the studies analyzed the effects on alcohol consumption of both alcohol price and taxation. Of the 12 studies, 1 had a cross-sectional design, 3 were quasi-experimental using a series of cross-sectional surveys, and 8 were quasi-experimental using time series data. One study contained data on 19 developing countries, while 11 studies focused on a single country. Overall the studies yielded 23 estimates for the effects of alcohol price and/or taxation on total alcohol consumption, 9 estimates of the effects on the consumption of beer, and 11 estimates of the effects on the consumption of other alcoholic beverages (including spirits and wine). Several estimates did not include a p-value, t-value or any other statistic whereby a standard error could be calculated and, thus, were excluded from our meta-analysis: they comprised 1 estimate of the effects of alcohol price and/or taxation on total alcohol consumption, 2 estimates of the effects on the consumption of beer, and 4 estimates of the effects on the consumption of other alcoholic beverages. In addition, no mention of the significance of these elasticities was made in Pan et al. [53] and Fan et al. [54], so these two papers were excluded from the quantitative analysis. In total, 10 studies covering 36 price elasticity estimates—22 for total alcohol consumption, 7 for beer and 7 for other alcoholic beverages—were included in the quantitative analysis (see Figure 2.1).

Table 1

Study characteristics for each of the included studies

Author/year (source)	Country of study	Study design / year and source of data	Population	Intervention	Other independent variables	Comparison	Outcome	Type of publication
Quasi-experimental study with analysis using time series data								
Selvanathan & Selvanathan, 2005 (from Babor et al., 2010)	43 countries	Quasi-experiment; time series analysis, with data from yearbooks of National Account Statistics (UN), National Accounts of OECD Countries, and International Financial Statistics Yearbook	N.A.	Price (average food, alcohol price)	Income (GDP)	Between 24 developed and 19 developing countries	Consumption (budget share of alcohol to total food consumption)	Book
Okello, 2001 (from Babor et al., 2010)	Kenya	Quasi-experiment; using monthly time series data of sale and price during July 1987 to August 1996, data from the Ministry of Finance	N.A.	Price (Guinness and other beers)	Income (GDP)	—	Consumption (Guinness and other beer sale)	Report (working paper)
Partanen, 1991	Kenya	Quasi-experiment; time series analysis, with annual consumption, price, and income data (1963–1985) from Statistical Abstracts	N.A.	Price (beer)	Income (regular wage income)	—	Consumption (beer)	Book
Osoro et al., 2001 (from Babor et al., 2010)	Tanzania	Quasi-experiment; quantity of alcohol consumption data series used were yearly from 1990 to 1998; alcohol price data series used were quarterly from 1990 to 1998. Data from Ministry of Finance, Tanzania Breweries Co. Ltd., Tanzania Distilleries Co. Ltd.	N.A.	Price (beer, Chibuku, Konyagi)	Income (GDP)	—	Consumption (beer, Chibuku, Konyagi)	Report (working paper)
Ozguven, 2004 (from Babor et al., 2010)	Turkey	Quasi-experiment; sets of 60 monthly time series data observations, during 1997–2002, of sale volume and price, data from a leading market information firm.	N.A.	Price (beer)	Income (GDP), seasonal, # of foreign tourists, Muslim holy month of Ramadan	—	Consumption (beer sale)	Masters degree thesis
Yu & Abler, 2010	China	Quasi-experiment; the panel dataset from Rural Household Survey Statistics (RHSS) consist of data for 10 years (1994–2003) for rural areas of 26 Chinese provinces	N.A.	Price (alcohol)	Income, household characteristics (average household size, house area (in m^2) per capita, average cropland area (in mu, a Chinese unit of area) per capita, and the fraction of the adult population with more than a primary school education	—	Alcohol consumption (measured as kg per capita combining spirits, beer and wine)	Journal article (European Journal of Health Economics)
Musgrave & Stern, 1998 (from Wagenaar et al., 2009 and Babor et al., 2010)	India	Quasi-experiment; annual time series data from 1971/72 to 1980/81	N.A.	Price and tax (tax expressed as a proportion of market price)	Income (SDP: state domestic product)	—	Consumption (arak production)	Journal article (Journal of Development Economics)

Author/year (source)	Country of study	Study design / year and source of data	Population	Intervention	Other independent variables	Comparison	Outcome	Type of publication
Poapongsakorn et al., 2007	Thailand	Quasi-experiment; yearly data during 1989–2003 from Department of Excise, Department of Custom, Bureau of Trade and Economic Indices, a marketing research company, and the Bank of Thailand	N.A.	Price (beer, domestic spirit, imported spirit, domestic spirit, wine)	Income and alcohol advertising budget	—	Consumption (beer, domestic spirit, imported spirit, domestic spirit, wine)	Report (research)
Quasi-experimental study with analysis using series of cross-sectional data								
Andrienko & Nemtsov, 2005 (from Babor et al., 2010)	Russia	Quasi-experiment; longitudinal surveys, 7 surveys conducted almost annually (1994, 95, 96, 98, 2000, 01, 02)	General: About 10,000 observations per survey	Price of beer, wine, spirits (calculated from expense divided by alcohol consumed)	Income, age, gender, rural/urban, region of residence	—	Consumption (beer, wine, spirits) -Participation, frequency	Report (working paper)
Pan et al., 2006	China	Quasi-experiment; two cross-sectional urban household surveys in 1993 and 1998	General: a total of 2,298 household observations	Price of wine, wine cooler and beer	Income, gender of household head, age, education, employment, region	—	Consumption of wine, wine cooler and beer	Journal article (Applied Economics Letters)
Fan et al., 1995	China	Quasi-experiment; expenditure data are from the Rural Household Sample Surveys from 1982 to 1990; provincial price data are from provincial price indices for commodity groups (food, clothing, housing, and fuel) and come from China's Commodity Price Statistical Yearbooks from 1986 to 1990; national data were used to estimated provincial prices during 1982 to 1985 because provincial data were unavailable.	General rural people: 66,960 sampled in the year 1990 survey (number of households surveyed increased each year)	Price (alcohol)	Other food prices and expenditure	—	Consumption (alcohol)	Journal article (American Journal of Agricultural Economics)
Cross-sectional study								
John, 2005	India	A cross-sectional nationwide sample survey in 1999/2000	General: 120,309 households covering 10,140 villages	Price	Income and household size	—	Consumption (alcohol)	Report (working paper)

Risk of bias within studies

All 12 studies have potential selection bias. An evaluation of this bias is outlined in Table 2.2. Eight studies that used time series data may have selection bias due to their not taking into consideration unrecorded alcohol consumption data and thus excluding low socio-economic status populations [64], and 4 studies that used survey data did not include important minority or high-risk groups. All 12 studies also have potential measurement bias. Six of the time series studies used alcohol sales or production data as surrogates of consumption, which may have led to an overestimation of consumption, and 1 time series study used budget share of alcohol as a proportion of total food costs as a determination of consumption, which may have led to bias: a smaller budget share of alcohol consumption may not translate into a lower quantity of consumption if people instead consume less expensive alcoholic beverages. All 12 studies are limited by the narrow scope of variables analyzed—mainly economic and partly demographic variables. Although each study is susceptible to bias, these biases are hard to avoid in non-experimental research, and thus each study met the eligibility criteria and minimal standard. Hence, 12 and 10 studies were included in the qualitative and quantitative syntheses respectively, as explained above in the study selection section.

Table 2.2 Assessment of the risk of bias for each of study included in the systematic review. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].

Author/year (source)	Potential selection bias	Potential measurement bias
Quasi-experimental study with analysis using time series data		
Selvanathan & Selvanathan, 2005 (from Babor et al., 2010)	No unrecorded alcohol consumption data; excludes some countries with poor databases that may have different profiles of alcohol drinking from the included countries	Smaller budget share of alcohol consumption may not mean lower quantity of consumption if one consumes cheaper alcoholic beverage
Okello, 2001 (from Babor et al., 2010)	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Partanen, 1991	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Osoro et al., 2001 (from Babor et al., 2010)	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Ozguven, 2004 (from Babor et al., 2010)	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Yu & Abler, 2010	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Musgrave & Stern, 1988 (from Wagenaar et al., 2009, and Babor et al., 2010)	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Poapongsakorn et al., 2007	No unrecorded alcohol consumption data	Alcohol sales data may overestimate consumption data
Quasi-experimental study with analysis using series of cross-sectional data		
Andrienko & Nemtsov, 2005 (from Babor et al., 2010)	No sample of minority groups such as homeless people or immigrants who have higher possibility of heavy drinking	Subject to recall bias
Pan et al., 2006	This study is an urban household survey and does not include rural population	Subject to recall bias
Fan et al., 1995	This study is a rural household survey that does not include urban population	Subject to recall bias
Cross-sectional survey		
John, 2005	No sample of minority groups who have higher possibility of heavy drinking	Subject to recall bias

Note. Problem(s) with statistical analysis for all papers were restricted to mainly economic and partly demographic variables.

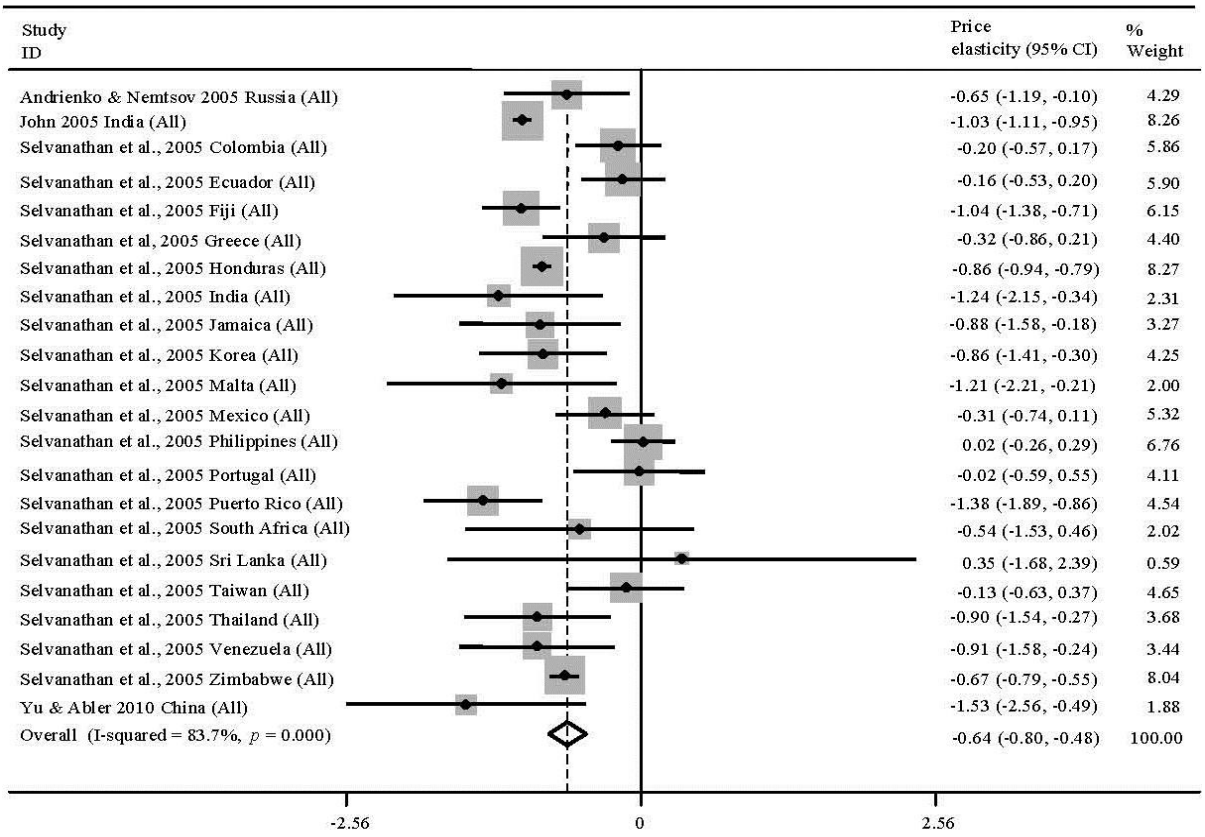
Other bias/problem – no comparison group (no counterfactual effect) for all papers except for John (2005) where there was a temporal bias and no comparison group (no counterfactual effect). Summaries of all papers were included in the result synthesis, with no unacceptable severe error.

Meta-analysis

Random effects analysis indicated a significant negative elasticity for alcohol consumption. Tests demonstrated that heterogeneity in the estimates was present for consumption in all studies [$Q_{(35)}$

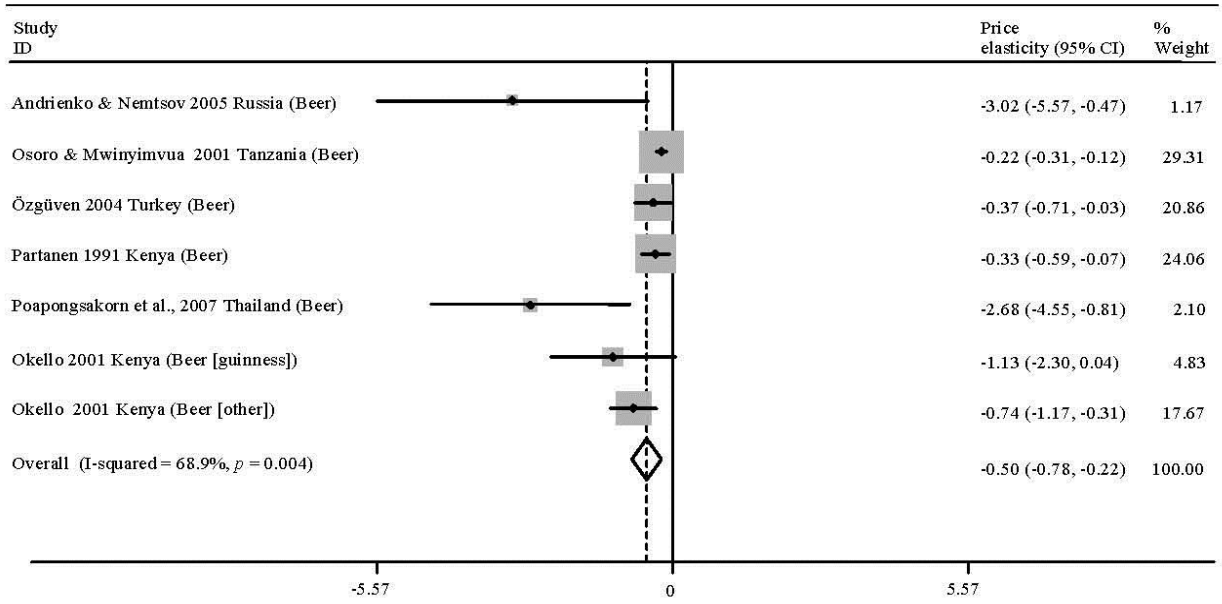
= 289.57, P = 0.000; I^2 = 87.9%], for total alcohol consumption [$Q_{(21)}$ = 129.08, P = 0.000; I^2 = 83.7%] and for consumption of beer [$Q_{(6)}$ = 19.31, P = 0.004; I^2 = 68.9%], but not for consumption of other alcoholic beverages [$Q_{(6)}$ = 5.94, P = 0.430; I^2 = 0.0%].

The forest plots for total consumption of alcohol, consumption of beer and consumption of other alcoholic beverages are outlined in figures 2 to 4 respectively. The forest plot for all studies can be found in Appendix 1.1. Our analysis showed an elasticity in LMIC of –0.66 (95% CI: –0.82 to–0.50) for consumption of all alcoholic beverages, –0.64 (95% CI: –0.80 to –0.48) for total consumption of alcohol, –0.50 (95% CI: –0.78 to –0.21) for consumption of beer, and –0.79 (95% CI: –1.09 to –0.49) for consumption of other alcoholic beverages. Only 2 estimates, for total consumption of alcohol in Sri Lanka and the Philippines, had a positive elasticity estimate of alcohol consumption, and 11 had elasticity estimates that were non-significant.



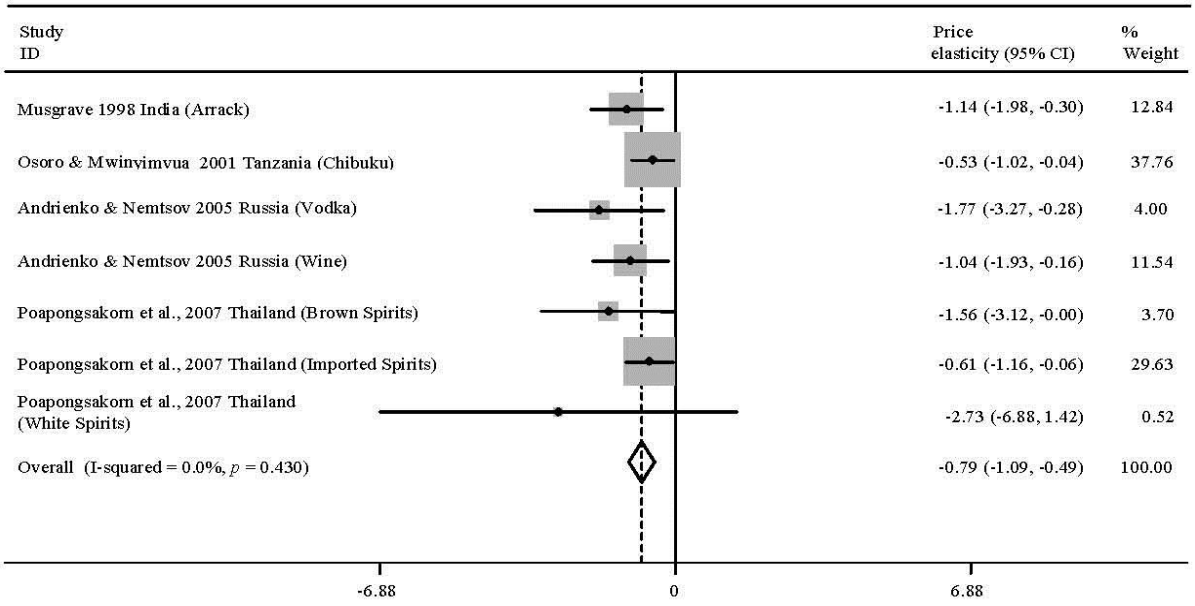
Note. Weights are from random effects analysis. The size of the box around the estimate is representative of the weight of the estimate in calculating the aggregate point estimate.

Figure 2.2 Forest plot of the 22 estimates used in the meta-analysis and the weighted point estimates for the price elasticity of total alcohol consumption. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



Note. Weights are from random effects analysis

Figure 2.3 Forest plot of the 7 estimates used in the meta-analysis and the weighted point estimates for the price eleasticity for the consumption of beer. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



Note. Weights are from random effects analysis

Figure 2.4 Forest plot of the 7 estimates used in the meta-analysis and the weighted point estimates for the price elasticity for the consumption of other alcoholic beverages. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].

Publication bias appeared to be present for the elasticities of all studies (Egger [P = 0.761] and Begg [P = 0.002]), total consumption of alcohol (Egger [P = 0.073], Begg [P = 0.159]), consumption of beer (Egger [P = 0.001], Begg [P = 0.035]), and consumption of other alcoholic beverages (Egger [P = 0.003], Begg [P = 0.072]); however, the extent of publication bias was not enough to initiate a fit and trim adjustment. The funnel plots for the elasticities of the consumption in all studies, total alcohol consumption, consumption of beer and the consumption of other alcoholic beverages can be found in Appendices 2 to 5.

2.5 Discussion

Our systematic review found 12 original studies that investigated alcohol price/taxation elasticity in LMIC, but no articles that investigated the association between alcohol price/taxation and alcohol-related harms or drinking initiation.

The review found an inverse relationship between alcohol price and/or taxation and alcohol consumption, similar to what has been observed in HIC [1, 20-22], with similar estimates for price elasticity. Specifically, price elasticities in HIC are –0.46 for beer, –0.69 for wine, –0.80 for spirits and –0.77 for median price elasticity of ethanol [20, 21]. For LMIC, we observed price elasticities of –0.50 for beer, –0.79 for other alcoholic beverages, –0.64 for total alcohol consumption and –0.66 for all studies. This finding is counter-intuitive, given that alcoholic beverages are less affordable in LMIC than in HIC [1]. For example, in Thailand, a middle-income country, a worker has to work six times longer (48 minutes) than does a Canadian worker (8 minutes) to accumulate sufficient funds to purchase a can of beer (calculated based on the lowest price of a can of beer and the minimum wage for both countries as of September 2011).

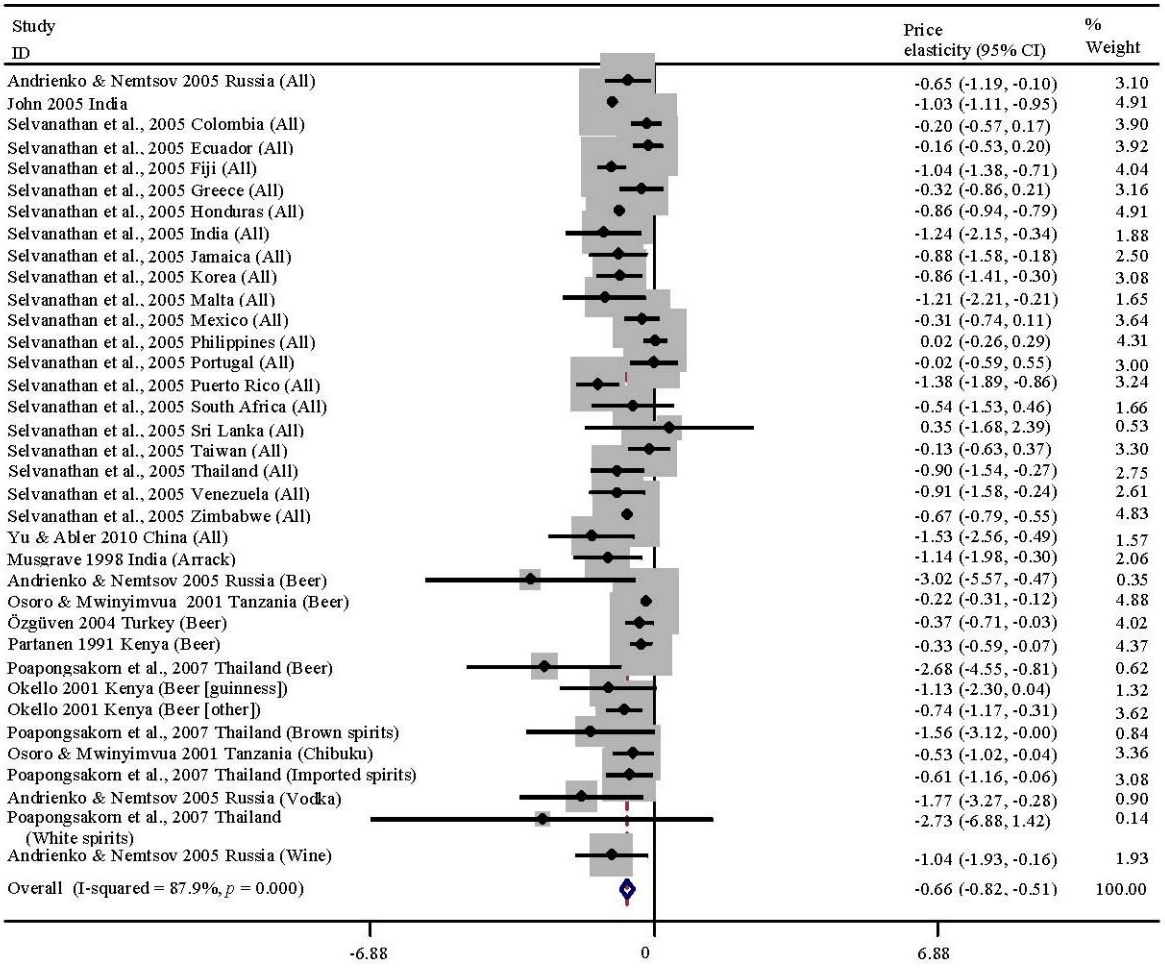
The observation that there are similar price elasticities in HIC and LMIC may be confounded by unrecorded consumption, because the substitution of unrecorded alcohol consumption may occur in both LMIC and HIC when prices of recorded alcoholic beverages increase [65]. More research

is needed to determine the relationship between the unrecorded and the recorded alcohol markets to characterize how taxation and/or price is associated with total alcohol consumption. Specifically there is a need to quantify the association between the taxation of alcohol, and informal production and smuggling. This may be especially important for LMIC, which often have a limited capacity to deter illegal production [66].

No study has examined the effect of alcohol price and/or taxation on drinking initiation in LMIC. Studies examining this issue are needed, because the effects of alcohol price and taxation may differ between HIC and LMIC due to differing prevalence of abstainers. Currently, *specific* taxation, based on alcohol content (% of alcohol by volume), is suggested in LMIC [19]; however, this type of taxation favours low alcohol content beverages, which works well in HIC, but may encourage drinking initiation among youth in LMIC [11]. Thus, original research studies should be conducted to examine the effects of alcohol price and/or taxation on drinking initiation in LMIC.

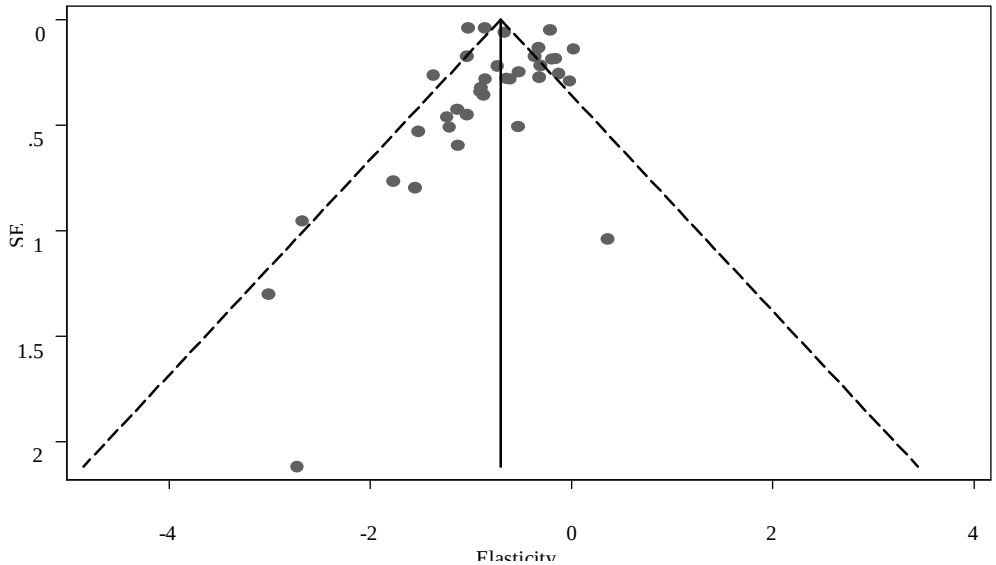
There are a number of limitations of this systematic review. First, only a small number of studies examine the effects of alcohol price and/or taxation in LMIC, so if there are regional differences in LMIC we are unable to detect them based on the available data. Second, there may be studies in LMIC published in languages other than English or Thai that were consequently excluded from our review. Finally, the question of unrecorded consumption has not been addressed sufficiently and thus measurement error cannot be excluded [67].

2.6 Appendices

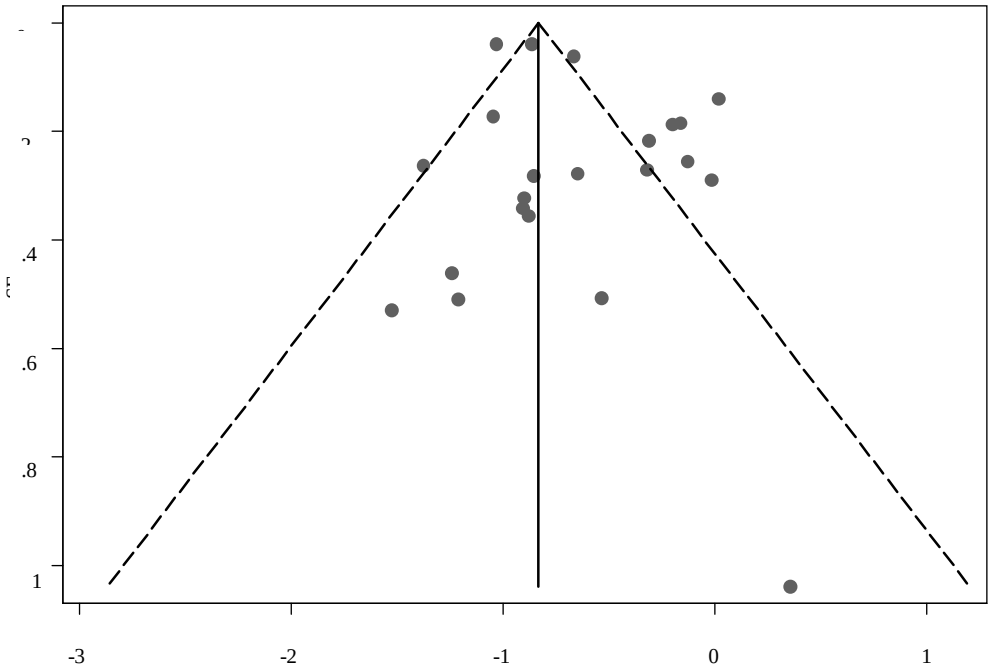


Note. Weights are from random effects analysis

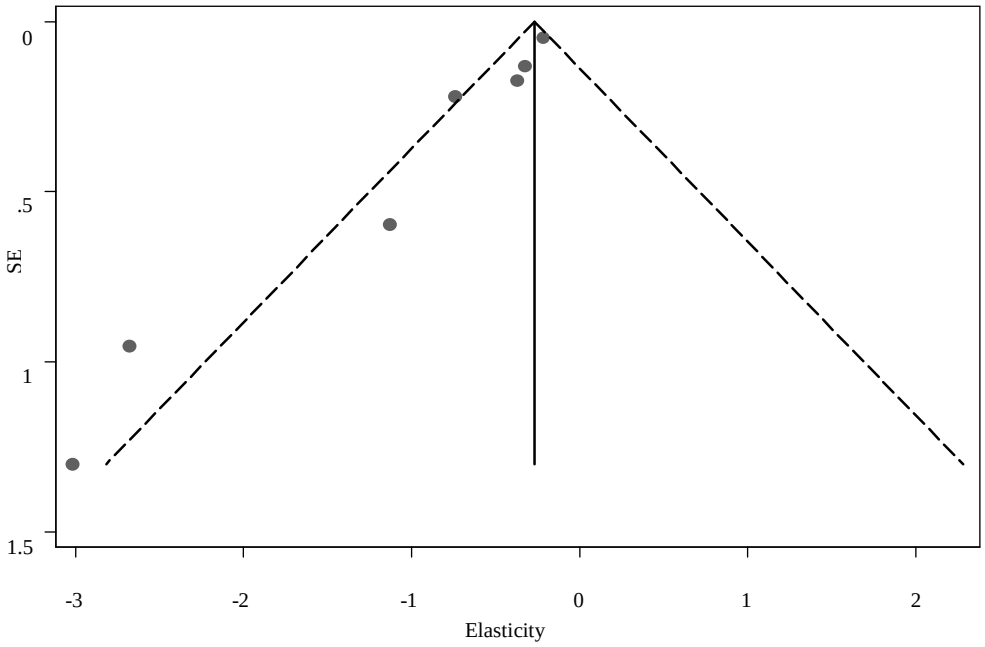
Appendix Figure 2.1 Forest plot of all estimates used in the meta-analysis and the weighted point estimates for the price elasticity of alcohol consumption. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



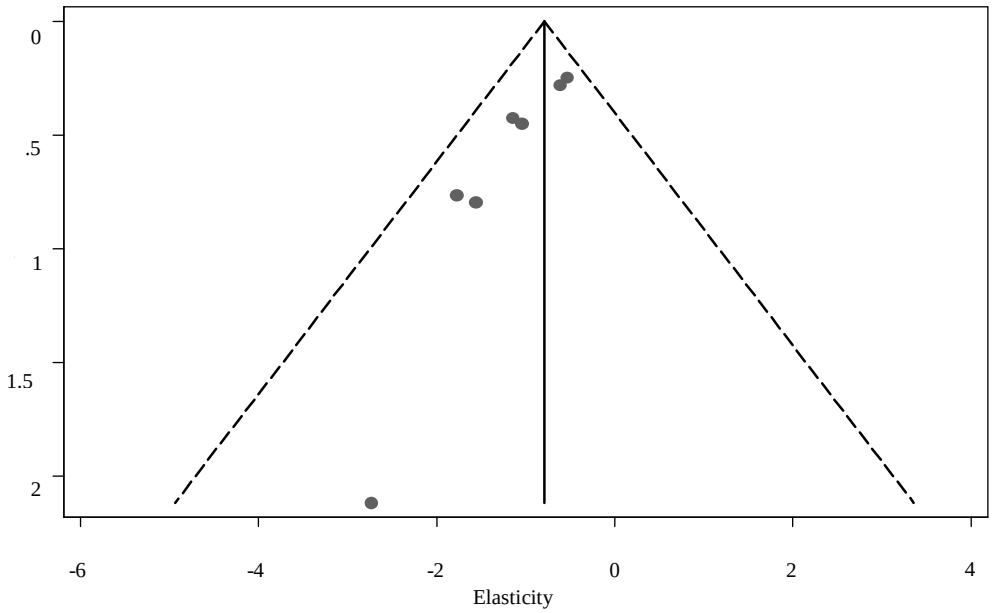
Appendix Figure 2.2 Funnel plot of all estimates used in the meta-analysis for the price elasticity of alcohol consumption with pseudo 95% confidence intervals. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



Appendix Figure 2.3 Funnel plot of the 22 estimates used in the meta-analysis for the price elasticity of total alcohol consumption with pseudo 95% confidence intervals. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



Appendix Figure 2.4 Funnel plot of the 7 estimates used in the meta-analysis for the price elasticity for the consumption of beer with pseudo 95% confidence intervals. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].



Appendix Figure 2.5 Funnel plot of the 7 estimates used in the meta-analysis for the price elasticity for the consumption of other alcoholic beverages with pseudo 95% confidence intervals. Reproduced from Sornpaisarn B, Shield KD, Cohen J, Schwartz R, Rehm J (2013) [69].

Chapter 3
The association between taxation increases and the changes of alcohol consumption and traffic fatalities in Thailand

3 Chapter 3: Paper 2

3.1 ABSTRACT

Aim: To examine if alcohol taxation increases in 2005, 2007, and 2009 are associated with changes in alcohol consumption and changes in the rate of traffic fatalities in Thailand.

Design: A quasi-experimental interrupted time-series study.

Setting: Thailand, October 2004 to September 2009.

Measurements: The independent measure of interest was the average tax rate of eight alcoholic beverage categories. The dependent measures of interest were per capita consumption of alcohol (for which alcohol production data from the Excise Department were used as a surrogate measure) and the rate of traffic fatalities (for which data were obtained from the National Police Institute).

Findings: In 2005, 2007, and 2009 the percentages of the alcohol market affected by taxation increases were approximately 15%, 56% and 95%, respectively. These three taxation increases were associated with an abrupt and permanent reduction in the rate of traffic fatalities of 7.1% (95% Confidence Interval (CI): 0.3%–13.9%), 19.2% (95% CI: 8.7%–29.7%), and 22.4% (95% CI: 9.3%–35.5%) respectively. The 2009 taxation increase was associated with a 22.9% (95% CI: 2.7%–43.1%) abrupt and permanent reduction in alcohol consumption. There were strong correlations (R^2 >0.90) between the percentage of the alcohol market affected by taxation and the magnitude of the associated change in alcohol consumption and fatal traffic accident rates.

Conclusion: Taxation increases in Thailand were associated with reductions in alcohol consumption and the rate of traffic fatalities. In order to maximize the effects of taxation, rate increases across the majority of the alcohol market are required.

Keywords: Alcohol; Consumption; Elasticity; Traffic Fatalities; Low-income Countries; Middle-income countries; Price; Taxation; Thailand.

3.2 INTRODUCTION

Increases in alcohol taxation are one of the most effective ways to reduce alcohol consumption and its related harms [1, 10, 20-22, 68]. Until recently, systematic reviews on the effectiveness of alcohol taxation policies almost exclusively used data from high-income countries (HIC) to assess the associations between taxation and consumption or alcohol-related harms [20-22]. Sornpaisarn and colleagues therefore conducted a systematic review and meta-analysis specifically for low- and middle-income countries (LMIC), and identified 10 analyses with an average decrease of 6% in consumption per 10% increase in taxation [69]. Furthermore, they found no investigations of the effect of taxation on alcohol-related harms in LMIC [69]. Since the relative harm associated with each liter consumed *per capita* is generally larger in LMIC as compared to HIC [4, 70] due to more harmful patterns of alcohol consumption [12] and a higher risk of mortality and morbidity from causes where alcohol plays a role (such as injuries) in LMIC [13], the relationship between alcohol taxation and alcohol-attributable harms should be larger in LMIC when compared to HIC.

An alcohol taxation system was developed in 1950 in Thailand (a middle-income country, where a large proportion of the population abstains from consuming alcohol [71]) that applies a unique excise tax method named *Two-Chosen-One (2C1)* to address alcohol consumption and its related harms [11, 35]. In the period covered by this paper, three taxation increases were implemented in 2005, 2007, and 2009, covering three, three and four out of eight beverage categories, respectively (see table 3.1). These increases amounted to 18%, 9% and 12% increases in the average taxation rate, covering 14.9%, 55.9%, and 95.3% of the total alcohol market (excluding imported beverages), respectively). The effectiveness of these three taxation increases in decreasing alcohol consumption and alcohol-attributable harms has yet to be investigated.

Given the absence of studies that investigate the effects of taxation on alcohol-attributable harms in LMIC in general [69], and the absence of empirical data assessing the effectiveness of alcohol taxation in Thailand specifically, it is the objective of this paper to test if the alcohol taxation rate

changes in 2005, 2007, and 2009 were associated with a change in alcohol consumption and in the rate of traffic fatalities. Traffic fatalities have been selected as an example for alcohol-attributable health harm, as they are strongly impacted by consumption [72], they show full effects without any time delay contrary to more chronic disease outcomes [73], and reliable monthly data are available to conduct time-series analyses.

Based on the above reasoning, the following hypotheses were tested: higher taxation will lead to lower adult *per capita* consumption and to a lower rate of traffic fatalities. In addition, we postulated that the larger the coverage of the alcohol market by taxation, the larger the effect on outcomes.

3.3 Materials and methods

Data source

To statistically test whether there is an association between alcohol taxation and each of alcohol consumption and traffic fatalities, we used ecological data for alcohol taxation rates, alcohol production, and traffic fatalities that were measured monthly from October 2004 to September 2009.

Data concerning tax rates over time for each alcoholic beverage category and alcohol producer (ex-factory) prices for beverages within each beverage category were obtained from the Thailand Excise Department [74]. Table 3.1 outlines the Actual Tax Rate (ATR) of the eight alcoholic beverage categories and the average ATR for the total of these eight categories. Average ATRs of the eight beverage categories were the sum of the weighted ATRs of all categories; the weighted-ATR is the value of each category's ATR multiplied by the average percentage of its market share during the three months prior to each tax increase. Web appendix 3.1 outlines the three taxation rate changes by beverage category.

Alcohol production data were obtained from the Excise Department of Thailand. The analysis of the effects of taxation on alcohol production used a series of monthly adult *per capita* alcohol production data [74]. The Thai government, for taxation purposes, divides alcoholic beverages into two main categories (fermented and distilled spirits) and eight sub-categories according to

production methods and ingredients (see figure 3.1). Fermented spirits include beer, wine and community fermented spirits. Distilled spirits include white spirits, mixed spirits, special blend spirits and special spirits. Special spirits include brandy and whisky. Data on alcohol production were available for all these categories; however, alcohol production data did not include data for imported alcohol.

Figure 3.1 Alcoholic beverage categories in Thailand[a]

International alcoholic beverage category	Wine	Beer	Spirits

Thailand alcoholic beverage category	Fermented spirits			Distilled spirits				
	Wine	Community fermented spirits	Beer	Special spirits		Special blend spirits	Mixed spirits	White spirits
				Brandy	Whisky			

Production method and ingredients of each of Thailand's categories	Fermented spirits (made from grape or other fruits)	Fermented spirits (made from grain)	Fermented spirits (made from malt)	Distilled spirits (made from fermented grapes)	Distilled spirits (made from cane juice, sugar, molasses or malt; ripened in oak barrels at least one year)	Dilution of high-concentration distilled alcohol (more than 80 proof) mixed with a concentrate of fine herbs (made from molasses, broken glutinous rice)	White spirits mixed with herbs and coloring	Pure distilled alcohol (less than 80 proof)
				brown spirits				

[a] Data source: the Excise Department and Thai-Bev Company's website

Monthly data on traffic fatalities in Thailand from October 2004 to September 2009 were obtained from the National Police Institute of Thailand [75]. All traffic fatalities – where death occurred immediately at the accident site, during transportation to the hospital, or at the hospital – were registered in the police data system [75]. Monthly data on traffic fatalities were transformed into a rate using population data from the United Nations Populations Division [76] to correct for any potential changes in population size.

Statistical methods

To determine if taxation was associated with alcohol consumption and/or the rate of traffic fatalities in Thailand, we used an interrupted time-series analysis by means of an Autoregressive Integrated Moving Average Model (ARIMA). The associations of interest were tested using dummy variables for an abrupt temporary change, gradual permanent change, and abrupt permanent change. As suggested by Cook & Campbell (1979), if the abrupt temporary change model was not found to be appropriate, we tested for a gradual permanent change. If a gradual permanent change model was not found to be appropriate, we tested for an abrupt permanent effect [77]. The phase (i.e. stationary or non-stationary) and parameters of the ARIMA models were determined based on autocorrelations and partial autocorrelations through analysis of correlograms and the Q-statistic [77]. The goodness-of-fit of the ARIMA models was assessed using two procedures: an examination of autocorrelations and partial autocorrelations and the Q-statistic. The significance of an association was tested using an α of 0.05 [77].

All statistics were performed using STATA 11.1 [52].

3.4 Results

Patterns and effects of three tax rate increases from 2004 to 2009

Table 3.1 outlines the differential alcohol tax rate determination policy employed by the Thai government from October 2004 to September 2009.

Table 3.1 Actual tax rates of the eight alcoholic beverage categories, the average actual tax rates of the total eight beverage categories, and the percentage of volume of taxed beverages to the total of the eight beverage categories, during 2005 – 2009[a]

Beverage category	Actual tax rate				Number of tax rate increases for each category
	Baseline (2003)	First tax increase (Sep 6, 2005)	Second tax increase (Aug 27, 2007)	Third tax increase (May 6, 2009)	
	THB/LPA (percentage increase from the previous tax rate)				
1. Beer	460	460	460	534 (=+16%)	1
2. White spirits	70	70	110 (=+57%)	120 (=+9%)	2
3. Mixed spirits	240	240	280 (=+17%)	300 (=+7%)	2
4. Special blend spirits	240	400 (=+67%)	400	400	1
5. Whisky	240	400 (=+67%)	400	400	1
6. Brandy	271	400 (=+47%)	427 (=+7%)	488 (=+14%)	3
7. Community fermented spirits	156	156	156	156	0
8. Wine	1098	1098	1098	1098	0
Number of beverage categories where tax rates were increased		3	3	4	
% of volume of taxed beverages to the total of the eight beverage categories		14.9%	55.9%	95.3%	
Average ATRs[b] of the eight beverage categories during each period	224	264 (=+18%)	289 (=+9%)	323 (=+12%)	

Abbreviations: THB/LPA, Thai baht per litre of pure alcohol; ATR, actual tax rate

[a] Data source: The Excise Department of Thailand; numbers were calculated by the authors

[b] Average ATR of the eight beverage categories are the sum of the weighted ATRs of all categories; weighted ATR is the value of each category's ATR multiplied by the average percentage of its market share during the three months prior to each tax increase.

Table 3.2 outlines the effects of the three taxation increases on the total volume of alcohol consumption of eight beverage categories. The first and the second tax increases were not significantly associated with a reduction in alcohol consumption, whereas the third tax increase was significantly associated with an abrupt permanent 22.9% (95% Confidence Interval (CI): 2.7%–43.1%, $P = 0.027$) reduction in alcohol consumption with an estimated tax elasticity of

demand of -1.95 (95% CI: -3.67 to -0.23) (i.e., a 1% increase in the tax rate was associated with a 1.95% reduction in alcohol consumption).

Table 3.2 Effects[a] of three tax increases on the total consumption of the eight alcoholic beverage categories

	Alcohol consumption[b] (liters of pure alcohol per month)				**Resulting percentage change of alcohol consumption (%)**			**Estimated tax elasticity of demand**		
Tax rate increase	**Esti-mated size of effect**	**95% Confidence Interval**		***P*-value**	**Esti-mated size of effect**	**95% Confidence Interval**		**Esti-mated size of effect**	**95% Confidence Interval**	
First	-0.035	-0.088	0.018	0.198	-7.6%	-19.1%	3.9%	-0.43	-1.08	0.22
Second	-0.058	-0.117	0.001	0.055	-12.9%	-26.0%	0.2%	-1.36	-2.74	0.02
Third	-0.110	-0.207	-0.013	0.027	-22.9%	-43.1%	-2.7%	-1.95*	-3.67	-0.23

[a] Type of effect is abrupt permanent for all three tax increases.

[b] ARIMA model for alcohol consumption = (0,0,1)(0,0,1,12)

* Statistically significance with P-value < 0.05

Table 3.3 outlines the associations between the three taxation increases and the rate of traffic fatalities. The first, second, and third taxation rate increases were significantly associated with a 7.1% (95% CI: 0.3%–13.9%, *P* = 0.040), 19.2% (95% CI: 8.7%–29.7%, *P* = 0.000), and 22.4% (95% CI: 9.3%–35.5%, *P* = 0.001) abrupt permanent reduction in the rate of traffic fatalities rates respectively. The tax elasticities of the rate of traffic fatalities were -0.40 (95% CI: -0.78 to -0.02), -2.03 (95% CI: -3.14 to -0.92), and -1.90 (95% CI: -3.01 to -0.79) for the three taxation increases respectively. Differences in the association between taxation increases and reductions in traffic fatality rates were also examined by sex. The first two taxation increases were significantly associated with the rate of deaths of females from traffic fatalities, resulting in a 12.5% (95% CI: 0.7%–24.3%, *P* = 0.037) and a 15.6% (95% CI: 0.1%–31.1%, *P* = 0.049) abrupt permanent reduction, respectively. For men, we observed a statistically significant association between fatal traffic accident rates and the second and third taxation increases resulting in a

19.5% (95% CI: 9.6%–29.4%, *P* = 0.000) and a 23.4% (95% CI: 11.4%–35.4%, *P* = 0.000) abrupt permanent reduction respectively.

Table 3.3 Effects[a] of three tax increases on traffic fatality rates

	Traffic accident death rate (deaths per 100,000 population per month)			**Resulting percentage change in fatal traffic accident rate (%)**		**Estimated tax elasticity of fatal traffic accident rate**	
Tax rate increase	**Esti-mated size of effect**	**95% Confidence Interval**	***P*-value**	**Esti-mated size of effect**	**95% Confidence Interval**	**Esti-mated size of effect**	**95% Confidence Interval**
Effect of tax increase on **total** traffic fatalities[b]							
First	-0.116	-0.227 -0.005	0.040	-7.1%	-13.9% -0.3%	-0.40	-0.78 -0.02
Second	-0.286	-0.443 -0.130	0.000	-19.2%	-29.7% -8.7%	-2.03	-3.14 -0.92
Third	-0.374	-0.593 -0.156	0.001	-22.4%	-35.5% -9.3%	-1.90	-3.01 -0.79
Effect of tax increase on **male** traffic fatalities[c]							
First	-0.148	-0.318 0.216	0.087	-5.6%	-12.0% 8.2%	-0.31	-0.67 0.45
Second	-0.459	-0.693 -0.226	0.000	-19.5%	-29.4% -9.6%	-206	-3.11 -1.01
Third	-0.612	-0.926 -0.299	0.000	-23.4%	-35.4% -11.4%	-1.99	-3.01 -0,97
Effect of tax increase on **female** traffic fatalities[d]							
First	-0.087	-0.169 -0.005	0.037	-12.5%	-24.3% -0.7%	-0.70	-1.36 -0.04
Second	-0.106	-0.211 -0.001	0.049	-15.6%	-31.1% -0.1%	-1.65	-3.28 -0.02
Third	-0.142	-0.306 0.023	0.092	-18.3%	-39.4% 3.0%	-1.56	-3.36 0.25

Abbreviation: ARIMA, Autoregressive Integrated Moving Average

[a] Type of effect is abrupt permanent for all three tax increases.

[b] ARIMA model for the total fatal traffic accident rate = (1,0,0)(1,0,0,12)

[c] ARIMA model for male fatal traffic accident rate = (1,0,0)(1,0,0,12)

[d] ARIMA model for female fatal traffic accident rate = (0,0,1)(0,0,1,12)

Factors affecting the effectiveness of increases in alcohol taxation

A correlation was observed between the percentage of the alcoholic beverage market (by volume) affected by a taxation increase and the associated reductions in alcohol consumption and fatal traffic accident rates (see web appendix 3.2). This finding was demonstrated by Pearson correlation coefficients (r) and the coefficient of determination (R^2) calculated for the association

between the percentage of the market covered during the taxation increases and both overall alcohol consumption (*r* = -0.983, R^2 = 96.5%) and the rate of traffic fatalities (r = -0.952, R^2 = 90.5% for the total population deaths, r = -0.955, R^2 = 91.1% for male deaths, and r = -1.000, R^2 = 99.9% for female deaths).

3.5 Discussion

This is the first empirical study which examines the association between taxation increases and the reduction of alcohol-related harms in a low- to middle- income country. The authors found abrupt permanent reductions of fatal traffic accident rates with 7.1%, 19.2%, and 22.4% reductions due to taxation increases in 2005, 2007, and 2009 respectively. The finding that alcohol taxation increases are associated with the abrupt permanent reduction of alcohol-related harms is similar to the findings of a study in the United States [78]. Wagenaar and colleagues found that two alcohol taxation increases in 1983 and 2002 in Alaska resulted in immediate and sustained 29% and 11% reductions respectively in the numbers of alcohol-related and alcohol-caused deaths [78]. It should be noted that changes in traffic fatality is a useful indicator for measuring changes in alcohol-related harms since they are strongly impacted by consumption [72], they show full effects without any time delay contrary to more chronic disease outcomes [73], drink-driving contributed to 12% of total road traffic injuries among different regions around the world [79].

Our study also found that an increase in alcohol taxation in 2009 was associated with a significant 22.9% reduction in alcohol consumption of the total eight beverage categories. These results are similar to what has been observed in HIC [20-22] and in other LMIC [69].

The authors found that the reduction in traffic fatalities associated with a percent increase in taxation was greater for Thailand than has been observed in HIC. Tax elasticity is a good indicator to demonstrate the impact of taxation increases on the outcome of interest: for example, tax elasticity of traffic fatalities of -0.4 means that a 10% taxation increase results in a 4% reduction of traffic fatalities. Our estimated tax elasticities of the rate of total traffic fatalities were found to be -0.40, -2.03, and -1.90 for three taxation increases respectively while the tax elasticities of motor vehicle fatalities were -0.10 to -0.27 reported in a systematic review

performed by Elder et al. [20]. These results may reflect that drinkers in LMIC have more harmful alcohol consumption patterns [12] and have a higher risk of injury mortality [13].

One interesting finding of our study is that the rate of traffic fatalities was more sensitive to taxation increases than was alcohol consumption. A possible explanation is that tax increases may have more of an effect on the consumption of binge drinkers who are at a greater risk of injury than are social drinkers [80]. Additionally, the effects of taxation may be beverage dependent [18, 81], with increases in taxation of certain beverages affecting the behaviours of population subgroups differently, such as people who are at a higher risk for drinking and driving. Aramrat and Thaikla examined the past 30 day beverage preferences of arrested drunk drivers in Thailand and found that the most preferred beverages across all age groups were those beverages which were taxed most heavily [82].

There are two other policies that may affect traffic fatalities in Thailand; however, these two policies did not significantly confound the effects of alcohol taxation in this study. The first policy is a measure of alcohol sale prohibition in gas station which is contained in the first national alcohol control law namely the Alcohol Control Act 2008 enacted in February 2008 [83]. See [83] for details of this law. The effect of this law was not significant when it was incorporated with taxation increases in the analytical models both for abrupt and gradual transfer function analyses. The second policy is the national campaign on reducing traffic accidents during two national long holidays (the International New Year Festival during December 31st – January 1st and the Thai Traditional New Year Festival during April 13-15th). The ARIMA analytical model employed in this study had already taken this seasonal effect into account.

The effectiveness of alcohol taxation increases can be diminished if consumers substitute their normal alcoholic beverage of choice with another alcoholic beverage. This substitution effect has been observed in previous studies [32, 33] which found that consumers shifted their consumption towards cheaper alcoholic beverages (both within and across beverage categories for beer, wine, and spirits) after a tax system change in Sweden in 1992. Our study observed a substitution effect between taxed versus untaxed alcoholic beverage categories. The comparison of the three tax increases demonstrated that the proportion of the market that taxation affects is strongly positively correlated with the associated reduction of total alcohol consumption and fatal traffic accident rates. This relationship was hypothesized to be the result of a substitution of

consumption towards untaxed alcohols. Hence, a government aiming to effectively control alcohol consumption should increase alcohol taxation across the majority of the alcohol market when implementing taxation increases.

Our study was limited by several factors. Generally, either production or sales data are commonly used as a surrogate for alcohol consumption data; alcohol consumption data are often not available, and if available are based on self-reporting which severely underestimates real consumption [41, 84]. In our study, alcohol production data were used as a surrogate for alcohol consumption data even though alcohol sales data are generally considered to be a better measure of alcohol consumption. The amount of alcohol consumed in Thailand when using alcohol production data versus alcohol sales data is noticeably different, with alcohol sales data estimating less alcohol consumption [74]. Differences in data may stem from the fact that sales data are obtained from wholesalers' self-reports, whereas production data are derived from monitoring data directly obtained by Excise Department personnel [74]. These differences in data cannot be explained by alcohol which is produced and not sold [74] and, thus, alcohol sales data were not used in our analysis.

Production data in Thailand do not provide information on the amount of alcohol imported monthly into Thailand or on unrecorded alcohol consumption [74]. According to yearly alcohol production data, imported alcoholic beverages accounted for approximately 13% of the total recorded alcohol market in 2009 [74]. Unrecorded alcohol consumption in Thailand during 2003-2005 was estimated to be 10% of the total alcohol consumption according to the WHO alcohol database [85]. Due to the absence of data on the amount of alcohol imported monthly and on unrecorded consumption, we were unable to quantify the likely substitution of domestic alcoholic beverages with imported alcoholic beverages and/or unrecorded alcoholic beverages. Therefore, caution should be exercised when interpreting the effect size of the association between alcohol taxation and alcohol consumption as the magnitude of this association may be overestimated due to substitution towards untaxed imported alcohol and unrecorded alcohol.

Our analysis also is limited due to the small number of observations before the first taxation increase and after the third taxation increase. This may affect the reliability of the analysis results [86]. Lastly, the absence of a control country reduces the ability to compare the effects of alcohol taxation increases with the counterfactual situation in this study.

Despite these limitations, this study can conclude that alcohol taxation rate increases in Thailand were associated with abrupt and permanent reductions in alcohol consumption and in fatal traffic accident rates. The effectiveness of taxation increases in reducing both alcohol consumption and traffic fatalities was strongly correlated with the percentage of the alcoholic beverage market affected by the taxation change. Accordingly, in order to maximize the effectiveness of alcohol taxation policies, governments must increase alcohol tax rates across the majority of the alcoholic beverage market.

3.6 Appendices

Web appendix 3.1 Patterns of actual tax rate increases among eight beverage categories during the study period of 2004 to 2009[a]

Types of alcoholic Beverages	**Effective tax method (unit)**	**Tax rate**			
		Baseline (2003)	**2005** (September 6th)	**2007** (August 27th)	**2009** (May 6th)
1.White Spirits	Sp (THB/LPA)	70		110	120
2.Mixed Spirits	Sp (THB/LPA)	240		280	300
3.Special Blended Spirits	Sp (THB/LPA)	240	400		
4.Whisky – cheap	Sp (THB/LPA)	240	400		
– expensive	AV (%)[b]	50%			
5.Brandy	AV (%)	35%	40%	45%	48%
6.Community Fermented beverages	Sp (THB/LPA)	70			
7.Beer	AV (%)	55%			60%
8.Wine	AV (%)	60%			

Abbreviation: Sp, specific taxation; AV, ad valorem taxation; THB/LPA, Thai baht per litre of pure alcohol

[a] Data source: The Excise Department of Thailand

[b] Ad valorem tax rates are determined using inclusive rates of the beverage's producer (or ex-factory) price

Web appendix 3.2 Pearson's correlation coefficient and coefficient of determination between the percentage of taxed coverage and the percentage change of alcohol consumption and traffic fatalities

	First tax rate increase	**Second tax rate increase**	**Third tax rate increase**	**Pearson's correlation coefficient (r)**	**Coefficient of determination (R^2)**
The percentage of taxed coverage	14.9%	55.9%	95.3%		
The percentage change of alcohol consumption	-7.6%	-12.9%	-22.9%	-0.983	96.5%
The percentage change of total traffic fatalities	-7.1%	-19.2%	-22.4%	-0.952	90.5%
The percentage change of male traffic fatalities	-5.6%	-19.5%	-23.4%	-0.955	91.1%
The percentage change of female traffic fatalities	-12.5%	-15.6%	-18.3%	-1.000	99.9%

Chapter 4
The impact of alcohol taxation on drinking initiation in adolescents and young adults: the first evidence from a middle-income country

4 Chapter 4: Paper 3

4.1 Abstract

Background

Alcohol taxation is used to reduce alcohol consumption and its resulting burden of disease; however, the effects of taxation on preventing drinking initiation have yet to be investigated. We aimed to test if a relationship exists between alcohol taxation and drinking initiation in adolescents and young adults using data from the middle-income country of Thailand.

Method

We employed a quasi-experimental design using four large-scale national surveys performed in Thailand of alcohol consumption from 2001, 2004, 2007 and 2011 (n=87,176) to test the hypothesis that increases in the taxation of alcohol can prevent drinking initiation. Logistic regression was used to examine the association between the effects of taxation increases and the prevalence of lifetime drinkers.

Findings

Drinking initiation in Thailand remained stable from 2001 to 2011. After adjusting for covariates, a 10% increase of the average taxation rate of the total alcohol market was significantly associated with a 4% reduction of the odds of lifetime drinking among Thai people 15 to 24 years of age. The effect was stronger in the age group of 20 to 24 years, and, in particular, in males of those ages.

Interpretation

Taxation rate increases from 2001 to 2011 in Thailand were associated with drinking initiation prevention among young Thai people 15 to 24 years of age. Applying Thailand's unique alcohol taxation system, supplementary to other age-specific alcohol control policies, may support

drinking initiation prevention among young people in countries with a high rate of abstainers in addition to reducing alcohol-attributable harm.

4.2 Introduction

Alcohol is one of the most important risk factors for the burden of disease in Low- and Middle-Income Countries (LMIC) [2]. In 2004 alcohol was the first (7.6% of the total) and eighth (2.1% of the total) leading cause of Disability Adjusted Life Years (DALYs) lost in middle- and low-income countries, respectively [2]. Moreover, in middle-income countries alcohol consumption creates a large monetary cost, with initial evidence suggesting these costs amount to about 2% of gross domestic product annually [4]. The impact of alcohol on the burden of disease and on costs led the World Health Organization (WHO) to emphasize LMIC in the recently adopted global strategy to reduce the impact of harmful drinking [10]. As part of this strategy, the WHO recommends taxation of alcohol as a key preventative measure [10], as systematic reviews and meta-analyses have found that increasing alcohol taxation is one of the most effective ways of reducing alcohol consumption and its resulting harms [20-22, 69].

Taxation works by increasing alcohol prices and thereby decreasing consumption and its related harms [20-22, 69]. Additionally, as with the effect of taxation of cigarettes on the prevention of smoking initiation [87], taxation of alcohol is also hypothesized to prevent harms in the long term by preventing drinking initiation (see Figure 1.3) [11]. Preventing drinking initiation may be especially important in LMIC where there are high rates of lifetime abstainers, such as countries in the Eastern Mediterranean, South-East Asia, and African WHO regions where the prevalence of lifetime abstainers (among people 18 years of age and older) is 88%, 80% and 57% respectively [10]. Young lifetime abstainers (15 to 24 years of age) are vulnerable to becoming drinkers, which can lead to frequent or problematic drinking causing alcohol-related harms in the long term. For example, once Thai adolescents start to drink, they tend to become regular drinkers: two thirds of male students and almost one half of female students who have had at least one alcoholic drink in their lifetime have consumed alcohol within the past 30 days [88]. Furthermore, drinking patterns in LMIC are often more problematic compared to those in High Income Countries (HIC) [12], contributing to much greater relative harms associated with each

liter consumed *per capita* [4, 70]. Hence, alcohol taxation that can prevent drinking initiation is a strategic policy to prevent alcohol-related harms in countries with high rates of abstainers.

Alcohol-related harms are a substantial problem in Thailand. For example, during 2006 to 2010 there were more than 18 traffic accident deaths per 100,000 people per year [89]; 40% to 60% of those deaths were attributable to drunk-driving [90], which is higher than would be expected given Thailand's alcohol consumption profile [91]. Moreover, there was a fourfold increase in the likelihood of domestic violence where alcohol was involved [92], and 40% of adolescent crimes were related to alcohol [93]. While the prevalence of lifetime abstainers is high in Thailand, especially among Thai adolescents (70% of male and 82% of female secondary school students [94]), the drinking habits of young Thai people are problematic [88, 93, 94]. As a result, Thailand's unique alcohol excise taxation system aims to prevent drinking initiation among young people [11] by imposing higher taxes on low alcohol content beverages (adolescents' preferred beverages). See a description of Thailand's alcohol taxation system in Web appendix 4.1.

Our aim for this study was to determine if an increase in the taxation of alcoholic beverages under Thailand's taxation system leads to a decrease in the prevalence of lifetime drinkers among adolescents (15–19 years of age) and young adults (20–24 years of age) in Thailand.

4.3 Methods

Study design

We employed a quasi-experimental study design that used survey data on the prevalence of current drinking and taxation data from 2001 to 2011 to test our hypothesis that alcohol taxation can prevent drinking initiation among adolescents and young adults.

Data Sources

Data on alcohol consumption were obtained from four large-scale national surveys performed in Thailand on alcohol consumption behaviours in 2001 (n= 31,849), 2004 (n= 8,629), 2007 (n= 25,493), and 2011 (n= 21,205) conducted by the National Statistics Office (NSO) of Thailand. The authors had access to all data collected in the four surveys due to the relationship between the Centre for Alcohol Studies in Thailand (the first author's primary affiliation) and the NSO. All surveys used a two-stage stratified probability sampling design. In the 2001, 2007, and 2011 surveys, Thailand was stratified into 76 provinces, and then further into urban and rural areas. In the 2004 survey, Thailand was stratified into five regions (North, Northeast, Central, South and Bangkok) and then into urban and rural areas. Within each stratified area, the primary sampling unit was residential blocks for urban areas and villages for rural areas, and the secondary sampling unit was households. Every person 15 years of age and older in the household was interviewed by trained NSO field researchers using a standardized questionnaire. Response rates were 83%, 83%, 87%, and 85% for the 2001, 2004, 2007, and 2011 surveys respectively. Details of the survey sampling are outlined in Table 4.1.

Table 4.1 Details of survey sampling

	Survey year				**Total**
	2001	**2004**	**2007**	**2011**	
Study design	Cross-sectional survey				
Sampling scheme	two-stage stratified random sampling with probabilities proportional to size: the primary sampling unit was a block or village; the secondary sampling unit was a household				
Samples were representative of	Provincial, regional, and national level	Regional, and national level	Provincial, regional, and national level	Provincial, regional, and national level	
Overall sample size (aged 15 years and over)	168,141	51,330	168,285	142,235	529,991
Sample size aged 15-24 years	31,849	8,629	25,493	21,205	87,176

Source: National Statistics Office of Thailand

Drinking initiation was measured through the variable "lifetime drinking" with respondents being classified as drinkers, if they consumed at least one drink in their lifetime.

Data on alcohol tax rates and market share of all alcoholic beverages in 2003, 2005, 2007, and 2009 were obtained from the Department of Excise of Thailand. Average tax rate changes for the total alcohol market each year were calculated by summing all alcohol beverage category tax rate changes which were weighted by each category's market share of pure alcohol for that year. Calculated average tax changes for the total alcohol market were –12%, 9%, 20% and 31% for 2003, 2005, 2007, and 2009 respectively when compared to the average tax rate in 2001 (see Table 4.2).

Statistical analysis

Logistic regression [95] was used to examine the association between average tax rate changes and the odds of lifetime drinking for people 15 to 24 years of age, and these regression analyses were adjusted for year of survey and several demographic variables (gender, age, marital status, education, occupation, region of the country (North, East, South, Central, and Bangkok), and living area (urban or rural)). Because the available national survey data on alcohol consumption behaviours were designed mainly for assessing current alcohol drinking behavioural patterns and not drinking initiation behaviours, potential determinants for drinking initiation (such as parental and peer approval and model for drinking, and adolescents' behaviours of drug use and involvement in delinquency) [46] were not included in the survey questionnaires. We included the year of survey in our model because economic growth in LMIC has been found to be associated with *per capita* alcohol consumption [7]. Previous studies in Thailand found that male gender, age groups of 20 to 24 and 25 to 44 years, not being married, living in Bangkok, and living in a rural area, were predictors of hazardous, harmful and dependent drinking [94]; level of education attained predicted current drinking status and problem drinking patterns [88]; and occupation also predicted frequency of drinking [55].

We also performed more detailed analyses by sex and two age subcategories (15 to 19 and 20 to 24 years of age). For the 'n' sub-population comparisons we used the conservative Bonferroni correction [96]. We used STATA version 11.2 for data management and analysis [52].

Ethical considerations

Approval for this study by the Research Ethics Boards of the Centre for Addiction and Mental Health and of the University of Toronto was waived, as this study only involved the analysis of secondary data.

4.4 Results

Changes in alcohol excise taxation in Thailand occurred in 2003, 2005, 2007, and 2009 (detailed in Web appendix 4.2) and, for the majority of beverage types, excise tax increased; however, in 2003 the Thai government decreased taxation by 30% for white spirits and community fermented beverages. Table 4.2 outlines the percentage changes in taxation rates in 2003, 2005, 2007, and 2009 for eight beverage categories compared to the amount of taxation in 2001. Tax rate changes from 2001 to 2009 were differentiated, and varied from –30% for white spirits and community fermented beverages to 127% for brandy.

Table 4.2 Percentage changes in tax rates of eight beverage categories compared to the tax rates in 2001

Types of alcoholic Beverages	Year of tax change				
	2001	**2003**	**2005**	**2007**	**2009**
1.White Spirits	0%	-30%	-30%	10%	20%
2.Mixed Spirits	0%	0%	0%	17%	25%
3.Special Blended Spirits	0%	0%	67%	67%	67%
4.Whisky – cheap	0%	0%	67%	67%	67%
– expensive	0%	25%	25%	25%	25%
5.Brandy	0%	27%	58%	98%	127%
6.Community Fermented beverages	0%	-30%	-30%	-30%	-30%
7.Beer	0%	0%	0%	0%	27%
8.Wine	0%	0%	0%	0%	0%
Average tax rate changes of the total alcohol market*	0%	-12%	9%	20%	31%

Source: Excise Department of Thailand

* Average tax changes of the total alcohol market each year were calculated by summing all category tax rate changes weighted by each category's market share of pure alcohol for that same year. Data are calculated by the authors based on data from the Excise Department.

Sampled individuals were 19.1 years of age on average, 49.5% were male, 50.5% were female, most of the sampled individuals were single (79.6%), had graduated at the early secondary school level (grade 9) (44.1%), did not work (58.5%), were from the Central region of Thailand (32.8%), and lived in a rural area (60.4%). Details of the sample characteristics of four large-scale surveys can be found in Web appendix 4.3. The prevalence of lifetime drinkers by year and unadjusted Odds Ratios (ORs) for the odds of lifetime drinking by socio-demographic variables can be found in Web appendix 4. As shown in Web appendix 4, the prevalence of lifetime drinkers among our group of interest was 19.3% (95% Confidence Interval (CI): 18.9% – 20.0%), 21.1% (95% CI: 20.3% – 22.0%), 19.7% (95% CI: 19.2% – 20.2%), and 21.0% (95% CI: 20.4% – 21.5%) in the years 2001, 2004, 2007, and 2011 respectively. The prevalence of lifetime drinkers from all surveys combined was 3.3% (95% CI: 2.9% – 3.6%) at 15 years of age up to 33.8% (95% CI: 32.7% – 34.8%) at 24 years of age, close to the prevalence of lifetime

drinkers among people aged 15 years and older, which was 35.7% (95% CI: 35.5% – 35.8%). Thus, almost all drinking initiation has happened by age 24 in Thailand.

Table 4.3 outlines the association between average tax rate increases of the total alcohol market and the odds of lifetime drinking among people 15 to 24 years of age adjusted for confounders. The association between covariates and the odds of lifetime drinking can be found in Web appendix 4.4. We observed that an average alcohol excise tax rate increase of 10% was significantly negatively associated with a 4% reduction of the odds of lifetime drinking at α = 0.05 (95% CI: 1% - 7%) (see Table 4.3). When this association was analyzed for men and women separately, we observed similar effect sizes of a 4% reduction for both sexes in response to a taxation increase of 10%; however, the results were significant only for men (reduction of 4%, 95% CI: 0.4% – 7.3%; for women: reduction of 4%, 95% CI: -2% – 10%).

Table 4.3 Odds Ratios of lifetime drinking for a 10% tax rate increase, age and sex

Predictor variable	OR	(95% CI)	p value
Average 10% tax increase (compared to the tax rate in year 2001)	0.96	(0.93 –0.99)	0.011
– Tax effect among male (15–24 years of age)	0.961	(0.927–0.996)	0.028
– Tax effect among female (15–24 years of age)	0.96	(0.90–1.02)	0.247
Sex (0- male : 1-female)	0.075	(0.071–0.079)	0.000
Age – 15 years (reference)			
– 16 years	2.2	(1.9–2.6)	0.000
– 17 years	4.2	(3.7–4.8)	0.000
– 18 years	6.7	(5.9–7.6)	0.000
– 19 years	10.6	(9.2–12.0)	0.000
– 20 years	13.4	(11.7–15.3)	0.000
– 21 years	15.4	(13.5–17.6)	0.000
– 22 years	16.4	(15.9–20.8)	0.000
– 23 years	18.2	(15.9–20.8)	0.000
– 24 years	18.9	(16.5–21.6)	0.000

Note: All Odds Ratios in this table are adjusted for the following covarates: sex, age, marital status, education, occupation, region of living in Thailand (North, East, South, Central, and Bangkok), area of living (urban/rural), and year of survey.

Table 4.4 shows a comparison of the effects of taxation on subgroups determined by age and sex. After adjusting for covariates, we observed that alcohol excise taxation significantly prevents drinking initiation among young adults aged 20 to 24 years: a 10% increase in the average tax rate of the total alcohol market resulted in a 5% reduction of the odds of lifetime drinking at α =

0.025 (95% CI: 1%–9%, p=0.008). Moreover, this effect was stronger for males than for females: at $\alpha = 0.0125$, a significant 6% reduction among young adult males (95% CI: 2–11%, p=0.007) and a non-significant 2% reduction among young adult females (95% CI: -5–10%, p=0.546).

Table 4.4 Odds Ratios of lifetime drinking for a 10% tax rate increase, stratified by age and sex

	Age 15–19 years			**Age 20–24 years**		
	OR	**95% CI**	**p value**	**OR**	**95% CI**	**p value**
Total	0.98	(0.93–1.02)	0.323	0.95	(0.91–0.99)	0.008
Male	0.98	(0.93–1.04)	0.573	0.94	(0.89–0.98)	0.007
Female	0.94	(0.83–1.06)	0.304	0.98	(0.90–1.05)	0.546

Note: All Odds Ratios in this table are adjusted for the following covarates: sex, age, marital status, education, occupation, region of living in Thailand (North, East, South, Central, and Bangkok), area of living (urban/rural), and year of survey.

4.5 Discussion

Panel: Research in context

Systematic review

We conducted a systematic review and meta-analyses of the effects of taxation on alcohol consumption, its related harms, and drinking initiation in LMIC using internationally standardized protocols [69]. Data were collected up to June 2011 by searching the peer-reviewed article databases MEDLINE, EMBASE, PsycINFO and EconLit, along with the WHO's gray literature Database of Abstracts of Reviews of Effects, and by reference tracking. We identified, screened, checked against inclusion and exclusion criteria, and included eligible studies to perform both qualitative and quantitative analyses. We found ten studies which quantitatively examined the effects of taxation on alcohol consumption, and our meta-analysis showed that an increase in alcohol taxation resulted in a decrease in alcohol consumption. There was no published literature which examined the effects of taxation on alcohol-related harms and drinking initiation in LMIC.

Interpretation

Our study is the first to investigate the effects of alcohol taxation on drinking initiation in LMIC. Moreover, since this study used four large-scale nationally representative surveys performed in Thailand, with a combined sample size of 87,176 people, we were able to empirically test a potential relationship between alcohol taxation and drinking initiation. Our findings demonstrate that increases in alcohol taxation can prevent drinking initiation among adolescents and young adults. The effects of taxation contributed to a relatively stable prevalence of lifetime abstention in this age group in Thailand, even though a decrease was expected due to economic growth.

Through the analysis of data from four large-scale population surveys, with a combined sample size of 87,176 people, this study is the first to observe that alcohol taxation can prevent drinking initiation. The prevalence of lifetime drinkers among young Thai people 15 to 24 years of age remained relatively stable over the study period at 19.3% (95% CI: 18.9 – 20.0) in 2001 and 21.0% (95% CI: 20.4 – 21.5) in 2011, while during that same time period Thailand's GPD (PPP) *per capita* increased 87% from $5,195 to $9,221 international dollars [97]. The slight increase in prevalence of lifetime drinkers is less than would be expected given the increase in Thailand's GDP (PPP) and given the relationship between economic wealth and the prevalence of drinking [11]. Thus, taxation should be considered as a measure to control increasing drinking prevalence in other LMIC. Our study found that the prevalence of lifetime drinkers among young Thai people was low compared to most HIC; with about 2/3 of the Thai population abstaining at age 24. These comparisons are indicative of Thailand's culture of a low prevalence of current drinkers and a delayed age of drinking initiation. For comparison purposes, it should be noted that the mean age of drinking initiation was 19.4 and 24.4 years for Thai males and females, respectively [98], while these figures were 15.3 and 15.6 years of age for Finnish males and females respectively [99], and were between 15 and 16 years of age for both American males and females [100].

The differential tax effects by age and sex may be explained as follows. Adolescents in Thailand are deterred from drinking by other alcohol control measures: under Thai laws and regulations, adolescents who are less than 18 years of age cannot legally consume alcohol [101] and

adolescents younger than 20 years of age cannot legally purchase alcohol [83]. Thus, taxation is more relevant for young adults above the legal drinking/purchasing ages. To explain the gender differences: females purchase alcohol less often than do males and their drinking initiation is later in life (see above) [102].

Further evidence which supports our findings on drinking initiation prevention in Thailand is that Thailand's recorded adult *per capita* consumption increased slightly from 1990 to 2008 from 5.0 to 6.5 liters of pure alcohol [85], while GDP (PPP) *per capita* increased from $2,900 to $8,200 international dollars [97]. *Per capita* consumption is strongly correlated to the prevalence of drinkers. This increase in recorded adult *per capita* consumption is less than would be expected given the increase in Thailand's GDP (PPP) and given the relationship between GDP (PPP) and total adult *per capita* consumption [7], and thus indirectly corroborates our findings that high taxation of beverages popular among adolescents and young adults was an effective measure [37].

There were some limitations to our study. First, data were absent for some potential confounding variables, such as parental and peer impact, or drug use, so that there may be remaining residual confounding. Second, since no experimentation is possible, we are prone to the limitations associated with all quasi-experimental studies, since control is limited [103]. Third, we relied on subjective measures of drinking, which may introduce bias [104]. However, objective measures, such as *per capita* consumption, corroborated our findings (see above).

In addition to preventing long-term harm by preventing drinking initiation, Thailand's taxation system also reduces alcohol consumption and its related harms in the short term. A previous empirical study examined the effect of Thailand's alcohol excise taxation increases from 2004 to 2009 using monthly data of alcohol consumption *per capita* and fatal traffic accident rates. We observed that a 1% increase in the average tax rate of the total alcohol market in Thailand in 2009 was associated with a 1.95% reduction in total alcohol consumption and a 1.90% reduction in total fatal traffic accident rates [105]. In summary, Thailand's alcohol excise taxation system was found to both reduce alcohol consumption and prevent drinking initiation. The finding that taxation or pricing can deter drinking initiation seems to be highly relevant for other LMIC countries. In addition, this may also be a mechanism for delaying the age of drinking initiation in HIC with a high prevalence of drinkers [106].

In conclusion, taxation rate increases from 2001 to 2011 in Thailand were associated with drinking initiation prevention among young Thai people 15 to 24 years of age. Thus, applying an alcohol taxation system similar to the one described, supplementary to other age-specific alcohol control policies, could prevent drinking initiation among young people in countries with a high rate of abstainers.

4.6 Appendices

Web appendix 4.1

Thailand applies a unique alcohol excise taxation method, named Two-Chosen-One (2C1) [107], which calculates the tax to be applied to each alcoholic beverage using two primary methods – *specific* taxation and *ad valorem* taxation; however, the actual excise tax due for a particular beverage is the higher of the two resulting calculations [108]. *Specific* taxation is based on the volume of pure alcohol in a beverage, while *ad valorem* taxation is a function of the price of the beverage. For example, the *specific* tax of a distilled spirit is 6.1 Thai baht per standard drink (THB/SD) (one SD = 12 g of alcohol) and the *ad valorem* tax is 3.1 THB/SD; application of Thailand's taxation system results in an excise tax of 6.1 THB/SD. The *specific* tax of a beer is 1.5 THB/SD and the *ad valorem* tax is 12.4 THB/SD; application of Thailand's taxation system results in an excise tax of 12.4 THB/SD. See Sornpaisarn et al [11] for an overview of Thailand's alcohol excise taxation system. Thailand's taxation system imposes relatively higher tax rates on expensive alcoholic beverages, which include low alcohol content beverages (such as beer), since the costs of producing these beverages are generally higher than the production costs of high alcohol content beverages [36, 37]. Normally, low alcohol content beverages are gateway beverages for adolescents' drinking initiation [71]. For example, young Thai people tend to consume low alcohol content beverages, specifically beer [71], alcohol mixed with fruit juice, and ready-to-drink beverages [94]. Moreover, when initiating drinking, Thai adolescents are most likely to first consume low alcohol content beverages [109]. Hence, Thailand's alcohol taxation system imposes higher taxes on low alcohol content beverages (adolescents' preferred beverages) to create a barrier to drinking initiation.

Web appendix 4.2 Patterns of actual tax rate increases among eight beverage categories during the study period of 2001 to 2011

Types of alcoholic Beverages	Effective tax method (unit)	Year of tax change				
		2001	**2003**	**2005**	**2007**	**2009**
1.White Spirits	Sp (THB/LPA)	100	70		110	120
2.Mixed Spirits	Sp (THB/LPA)	240			280	300
3.Special Blended Spirits	Sp (THB/LPA)	240		400		
4.Whisky – cheap	Sp (THB/LPA)	240		400		
– expensive	AV[a] (%)	45%	50%			
5.Brandy	AV (%)	30%	35%	40%	45%	48%
6.Community Fermented beverages	Sp (THB/LPA)	100	70			
7.Beer	AV (%)	55%				60%
8.Wine	AV (%)	60%				

Source: Excise Department of Thailand

Abbreviation: Sp, *specific* taxation; AV, *ad valorem* taxation; THB/LPA, Thai baht per litre of pure alcohol

[a] *Ad valorem* tax rates are determined using inclusive rates of the beverage's ex-factory price

Web appendix 4.2 shows the actual tax rates (the higher calculation between the *specific* and *ad valorem* taxation of each beverage) of eight alcoholic beverage categories, and shows only tax rates in the years that they were changed; the unit of *specific* tax is the Thai baht per liter of pure alcohol (THB/LPA), whereas the unit of *ad valorem* tax is the tax-inclusive percentage of the beverage's ex-factory price. Under Thailand's alcohol taxation system, cheap alcoholic beverage categories (including white spirits, mixed spirits, special blend spirits, cheap whisky, and community fermented beverages) were taxed with *specific* taxation, while expensive categories (including expensive whisky, brandy, beer and wine) were taxed with *ad valorem* taxation. The Thai government determined differential tax rates among the eight alcohol categories during the study period.

Web appendix 4.3 Socio-demographic characteristics of respondents 15–24 years of age across four national surveys of alcohol consumption in Thailand

Variable		2001	2004	2007	2011	Total
Sample size	Number of respondents	31,849	8,629	25,493	21,205	87,176
Sex	0-Male	15,542 (48.8%)	4,233 (49.1%)	12,660 (49.7%)	10,713 (50.5%)	43,148 (49.5%)
	1-Female	16,307 (51.2%)	4,396 (50.9%)	12,833 (50.3%)	10,492 (49.5%)	44,028 (50.5%)
Age	Mean (SD) (year)	19.3 (2.9)	19.2 (2.9)	19.0 (2.9)	19.1 (2.9)	19.1 (2.9)
Marital status	0-single	25,703 (80.7%)	6,733 (78.3%)	19,922 (78.1%)	17,038 (80.4%)	69,396 (79.6%)
	1-married	5,834 (18.3%)	1,774 (20.6%)	5,255 (20.6%)	3,896 (18.4%)	16,759 (19.2%)
	2-widowed	42 (0.1%)	19 (0.2%)	49 (0.2%)	27 (0.1%)	137 (0.2%)
	3-divorced	78 (0.2%)	22 (0.3%)	79 (0.3%)	77 (0.4%)	256 (0.3%)
	4-separated	155 (0.5%)	48 (0.6%)	187 (0.7%)	158 (0.7%)	558 (0.6%)
	5-ever married, but present status unknown	19 (0.1%)	0 (0.0%)	1 (0.0%)	3 (0.01%)	23 (0.03%)
Education	0-never attended school	459 (1.4%)	128 (1.5%)	415 (1.6%)	375 (1.8%)	1,377 (1.6%)
	1-before primary school	682 (2.1%)	169 (2.0%)	329 (1.3%)	230 (1.1%)	1,410 (1.6%)
	2-primary school (g 1-6)	7,309 (23.0%)	1,785 (20.8%)	5,067 (19.9%)	4,840 (22.8%)	19,001 (21.8%)
	3-secondary school-earlier grades (g 7-9)	12,930 (40.6%)	3,669 (42.7%)	12,250 (48.1%)	9,532 (45.0%)	38,381 (44.1%)
	4-secondary school-later grades (g 10-12)	7,809 (24.5%)	2,142 (24.9%)	3,905 (15.3%)	3,936 (18.6%)	17,792 (20.4%)
	5-secondary school-later grades/occupation	13 (0.04%)	0 (0.0%)	1,569 (6.2%)	1,148 (5.4%)	2,730 (3.1%)
	6-occupation school-high degree	1,522 (4.8%)	352 (4.1%)	924 (3.6%)	369 (1.7%)	3,167 (3.6%)
	7-undergraduate	1,078 (3.4%)	330 (3.8%)	924 (3.6%)	740 (3.5%)	3,072 (3.5%)
	8-postgraduate	8 (0.03%)	10 (0.1%)	16 (0.06%)	14 (0.07%)	48 (0.06%)
	9-others	9 (0.03%)	8 (0.09%)	60 (0.2%)	8 (0.04%)	85 (0.1%)
Occupation	0-legislators/managers	1 (0.0%)	45 (0.5%)	110 (0.4%)	2 (0.01%)	158 (0.2%)
	1-professionals	132 (0.4%)	103 (1.2%)	172 (0.7%)	35 (0.2%)	442 (0.5%)
	2-technicians	366 (1.1%)	177 (2.0%)	481 (1.9%)	237 (1.1%)	1,261 (1.4%)
	3-clerks	575 (1.8%)	219 (2.5%)	659 (2.6%)	217 (1.0%)	1,670 (1.9%)
	4-service workers	723 (2.3%)	871 (10.1%)	2,642 (10.4%)	394 (1.9%)	4,630 (5.3%)
	5-agriculture	3,049 (9.6%)	911 (10.6%)	2,432 (9.5%)	2,071 (9.8%)	8,463 (9.7%)
	6-craft	4,383 (13.8%)	566 (6.6%)	1,705 (6.7%)	2,032 (9.6%)	8,686 (10.0%)
	7-plant and machine	2,102 (6.6%)	487 (5.6%)	1,224 (4.8%)	1,118 (5.3%)	4,931 (5.7%)
	8-general labor	1,424 (4.5%)	660 (7.6%)	1,672 (6.6%)	815 (3.9%)	4,571 (5.2%)
	9-unknown work	0 (0.0%)	0 (0.0%)	10 (0.04%)	1,305 (6.2%)	1,315 (1.5%)
	10-does not work	19,094 (59.9%)	4,590 (53.2%)	14,386 (56.4%)	12,871 (61.0%)	50,941 (58.5%)
Region	0-South	5,884 (18.5%)	1,635 (18.9%)	4,689 (18.4%)	3,871 (18.3%)	16,079 (18.4%)
	1-Bangkok	1,999 (6.3%)	555 (6.4%)	1,600 (6.3%)	1,288 (6.1%)	5,442 (6.2%)
	2-Central (no BKK)	9,668 (30.4%)	2,896 (33.6%)	8,859 (34.7%)	7,205 (34.0%)	28,628 (32.8%)
	3-North	6,001 (18.8%)	1,603 (18.6%)	4,755 (18.6%)	3,901 (18.4%)	16,260 (18.6%)
	4-Northeast	8,297 (26.0%)	1,940 (22.5%)	5,590 (21.9%)	4,940 (23.3%)	20,767 (23.8%)
Area	0-urban	19,764 (62.0%)	5,124 (59.4%)	15,322 (60.1%)	12,417 (58.6%)	52,627 (60.4%)
	1-rural	12,085 (38.0%)	3,505 (40.6%)	10,171 (39.9%)	8,788 (41.4%)	34,549 (39.6%)

Web appendix 4.3 shows the characteristics of the respondents of four large-scale national surveys. Survey sample size for the year 2004 was much lower than for the other three surveys because its sampling was designed to be representative of four regions and Bangkok, while the

other three surveys were designed to be representative of each of the 76 provinces. The average age of respondents was 19·1 years. In addition, most of the respondents were single (79·6%), had graduated at the early secondary school level (grade 9) (44·1%), did not work (58·5%), lived in the Central region (32·8%), and lived in a rural area (60·4%).

Web appendix 4.4 Prevalence of lifetime drinkers and unadjusted Odds Ratios by socio-demographic characteristics among people aged 15-24 years, by year of survey

Predictor		2001	2004	2007	2011		Total	Unadjus-ted OR	p value
Total		19.3% (18.9–20.0)	21.1% (20.3–22.0)	19.7% (19.2–20.2)	21.0% (20.4–21.5)		20.0% (19.7–20.3)		
Sex	0-Male	34.2% (33.4–34.9)	37.2% (35.7–38.6)	34.8% (33.9–35.6)	35.2% (34.3–36.1)		34.9% (34.4–35.3)	Reference	
	1-Female	5.2% (4.8–5.5)	5.7% (5.0–6.4)	4.8% (4.4–5.2)	6.5% (6.0–6.9)		5.4% (5.2–5.6)	0.107 (0.102–0.111)	0.000
Age	15 years	2.6% (2.1–3.1)	2.8% (1.8–3.8)	3.7% (3.1–4.4)	3.8% (3.1–4.5)		3.3% (2.9–3.6)	Reference	
	16 years	5.0% (4.3–5.8)	7.2% (5.5–8.8)	7.8% (6.8–8.7)	6.6% (5.6–7.6)		6.5% (6.0–7.0)	2.1 (1.8–2.3)	0.000
	17 years	9.5% (8.5–10.5)	12.1% (10.0–14.1)	11.6% (10.5–12.6)	12.5% (11.2–13.7)		11.2% (10.6–11.8)	3.7 (3.3–4.2)	0.000
	18 years	15.1% (14.0–16.3)	15.2% (13.0–17.4)	17.9% (16.6–19.3)	17.0% (15.6–18.4)		16.4% (15.7–17.1)	5.8 (5.2–6.5)	0.000
	19 years	20.3 (18.8–21.8)	25.0% (22.0–28.0)	24.8% (23.0–26.7)	25.3% (23.3–27.3)		23.3% (22.3–24.3)	9.0 (8.0–10.1)	0.000
	20 years	24.1% (22.6–25.6)	27.2% (24.1–30.3)	26.4% (24.6–28.3)	27.1% (25.1–29.1)		25.8% (24.8–26.8)	10.3 (9.1–11.6)	0.000
	21 years	30.9% (29.2–32.6)	29.6% (26.2–33.0)	29.5% (27.5–31.5)	33.3% (31.1–35.5)		31.0% (29.9–32.1)	13.3 (11.8–15.0)	0.000
	22 years	29.8% (28.1–31.5)	31.1% (27.9–34.4)	30.9% (28.9–32.9)	32.5% (30.3–34.7)		30.9% (29.8–31.9)	13.2 (11.7–14.9)	0.000
	23 years	33.1% (31.4–34.8)	35.2% (31.9–38.6)	32.4% (28.9–32.9)	33.9% (31.7–36.0)		33.3% (32.2–34.3)	14.8 (13.1–16.6)	0.000
	24 years	32.3% (30.6–34.0)	37.7% (34.4–41.1)	32.4% (30.4–34.4)	36.0% (33.8–38.2)		33.8% (32.7–34.8)	15.1 (13.4–17.0)	0.000
Marital status	0-single	18.2% (17.7–18.7)	19.5% (18.5–20.4)	18.2% (17.7–18.7)	19.1% (18.5–19.7)		18.5% (18.3–18.8)	Reference	
	1-married	24.1% (23.0–25.2)	27.4% (25.4–29.5)	25.2% (24.0–26.4)	28.9% (27.5–30.4)		25.9% (25.3–26.6)	1.53 (1.48–1.60)	0.000
	2-widowed	23.8% (10.8–36.8)	5.3% (-5.1–15.6)	10.2% (1.6–18.8)	18.5% (3.6–33.4)		15.3% (9.7–22.5)	0.8 (0.5–1.3)	0.335
	3-divorced	23.1% (13.7–32.5)	31.8% (11.9–51.7)	19.0% (10.3–27.7)	29.9% (19.6–40.2)		24.6% (19.5–30.4)	1.4 (1.1–1.9)	0.013
	4-separated	21.2% (15.0–27.5)	29.2% (16.2–42.2)	24.6% (17.4–30.7)	24.0% (10.1–53.1)		23.8% (20.4–27.6)	1.3 (1.1–1.7)	0.001
	5-ever married, but do not know the present status	31.6% (12.6–56.6)	-	100.0% (2.5–)*	0.0% (–70.8)*		30.4% (13.2–52.9)	1.9 (0.8–4.7)	0.149

Predictor		2001	2004	2007	2011		Total	Unadjus-ted OR	p value
Edu-cation	0-never studied	11.3% (8.4–14.2)	15.6% (9.3–21.9)	9.4% (6.6–12.2)	16.8% (13.0–20.6)		12.6% (10.9–14.5)	Reference	
	1-before primary school	20.0% (17.0–23.0)	22.5% (16.2–28.8)	17.9% (13.8–22.1)	16.5% (11.7–21.3)		19.2% (17.2–21.4)	1.6 (1.3–2.0)	0.000
	2-primary school (g 1-6)	25.0% (24.0–26.0)	25.5% (23.5–27.5)	19.0% (17.9–20.1)	18.2% (17.2–19.3)		21.7% (21.1–22.3)	1.9 (1.6–2.3)	0.000
	3-secondary school-earlier grades (g 7-9)	14.2% (13.6–14.8)	16.5% (15.3–17.7)	17.0% (16.3–17.7)	19.0% (18.2–19.8)		16.5% (16.1–16.9)	1.4 (1.2–1.6)	0.000
	4-secondary school-later grades (g 10-12)	21.7% (20.7–22.6)	23.5% (21.7–25.3)	25.2% (23.9–26.6)	24.9% (23.6–26.3)		23.4% (22.8–24.0)	2.1 (1.8–2.5)	0.000
	5- secondary school-later grades /occupation	53.8% (25.6–82.1)	-	26.4% (24.2–28.6)	32.5% (29.8–35.2)		29.1% (27.4–30.8)	2.8 (2.4–3.4)	0.000
	6-occupation school-high degree	26.4% (24.1–28.6)	34.4% (29.4–39.3)	30.9% (28.0–33.9)	38.5% (33.5–43.5)		30.0% (28.4–31.6)	3.0 (2.5–3.5)	0.000
	7-undergraduate	18.3% (16.0–20.7)	22.1% (17.6–26.6)	18.1% (15.6–20.6)	20.1% (17.2–23.0)		19.1% (17.7–20.5)	1.6 (1.4–2.0)	0.000
	8-postgraduate	12.5% (-0.1–37.0)	20.0% (-6.1–46.1)	6.2% (-6.0–46.1)	28.6% (4.0–53.1)		16.7% (7.5–30.2)	1.4 (0.6–3.0)	0.413
	9-others	-	25.0% (-7.1–57.1)	18.3% (8.5–28.2)	12.5% (-0.1–37.0)		16.5% (9.3–26.1)	1.4 (0.8–2.5)	0.307
Occupa tion	0-does not work	12.4% (11.9–12.8)	10.3% (9.4–11.2)	9.8% (9.3–10.3)	10.9% (10.3–11.4)		11.9% (10.8–11.4)	Reference	
	1- legislators/ managers	-	42.2% (27.6–56.8)	37.3% (28.2–46.4)	100.0% (NA)		39.2% (31.6–47.3)	5.2 (3.8–7.1)	0.000
	2-professionals	36.4% (28.1–44.6)	23.3% (15.1–31.5)	18.0% (12.3–23.8)	51.4% (34.6–68.2)		27.4% (23.3–31.8)	3.0 (2.4–3.7)	0.000
	3-technicians	18.1% (14.2–22.1)	32.8% (25.8–39.7)	31.0% (26.8–35.1)	25.3% (19.8–30.9)		26.4% (24.0–29.0)	2.9 (2.5–3.3)	0.000
	4-clerks	31.5% (27.7–35.3)	22.4% (16.8–27.9)	23.1% (19.8–26.3)	24.4% (18.7–30.2)		26.0% (24.0–28.2)	2.8 (2.5–3.2)	0.000
	5-service workers	17.8% (15.0–20.1)	25.3% (22.4–28.1)	24.0% (22.4–25.6)	23.6% (19.4–27.8)		23.2% (22.0–24.5)	2.4 (2.3–2.6)	0.000
	6-agriculture	22.5% (21.0–24.0)	31.8% (28.8–34.9)	33.5% (31.6–35.3)	29.0% (27.1–31.0)		28.3% (27.3–29.2)	3.2 (3.0–3.3)	0.000
	7-craft	31.8% (30.4–33.2)	44.3% (40.2–48.4)	45.7% (43.3–48.1)	39.4% (37.2–41.9)		37.1% (36.1–38.1)	4.7 (4.5–5.0)	0.000
	8-plant and machine	39.4% (37.3–41.5)	37.4% (33.1–41.7)	35.9% (33.2–38.6)	51.0% (48.1–53.9)		41.0% (39.6–42.4)	5.6 (5.2–5.9)	0.000
	9-elementary	31.8% (29.4–34.3)	38.9% (35.2–42.7)	33.5% (31.3–35.8)	39.4% (36.0–42.7)		34.8% (33.5–36.2)	4.3 (4.0–4.6)	0.000
	10-unknown work	-	-	20.0% (-6.1–46.1)	40.1% (37.5–42.8)		40.0% (37.3–42.7)	5.3 (4.8–6.0)	0.000
Region	0-South	12.3% (11.4–13.1)	13.0% (11.4–14.7)	11.9% (11.0–12.8)	12.2% (11.2–13.2)		12.2% (11.7–12.7)	Reference	
	1-Bangkok	18.4% (16.7–20.1)	17.1% (14.0–20.3)	13.9% (12.2–15.6)	17.1% (15.2–19.1)		16.6% (15.6–17.6)	1.4 (1.3–1.6)	0.000
	2-Central (no BKK)	14.4% (13.7–15.1)	18.3% (16.9–19.7)	17.2% (16.4–18.0)	18.4% (17.5–19.3)		16.6% (16.2–17.1)	1.4 (1.3–1.6)	0.000
	3-North	25.0% (23.9–26.1)	30.5% (28.3–32.8)	26.2% (24.9–27.4)	26.3% (24.9–27.7)		26.2% (25.5–26.9)	2.5 (2.4–2.7)	0.000
	4-Northeast	26.2% (25.3–27.2)	25.5% (23.6–27.5)	26.2% (25.1–27.4)	28.4% (27.2–30.0)		26.7% (26.1–27.3)	2.6 (2.5–2.8)	0.000
Area	0-urban	18.8% (18.3–19.4)	21.2% (20.1–22.3)	19.7% (19.1–20.4)	20.2% (19.5–20.9)		19·6% (19·3–20·0)	Reference	
	1-rural	20.2% (19.4–20.9)	21.0% (19.7–22.4)	19.6% (18.8–20.4)	22.1% (21.3–23.0)		20·6% (20·2–21·0)	1.06(1.03–1.1)	0.001

* One-sided, 97.5% confidence interval

Web appendix 4.4 demonstrates the prevalence of lifetime drinkers by socio-demographic characteristics, by year of survey, along with unadjusted ORs and p-values of each variable of the total samples. The data show that factors associated with lifetime drinking (surrogate of drinking initiation prevention) are: age, marital status, education, employment, region, and area where a person currently resides.

Web appendix 4.5 The odds of lifetime drinking, adjusted for all covariates among people aged 15 – 24 years

Predictor variable	OR	95% CI	p value
Average tax increase (10% change of exclusive rate compared to the tax rate in the year 2001)	0.96	(0.93–0.99)	0.011
Sex (0- male : 1-female)	0.075	(0.071–0.079)	0.000
Age – 15 years (reference)			
– 16 years	2.2	(1.9–2.6)	0.000
– 17 years	4.2	(3.7–4.8)	0.000
– 18 years	6.7	(5.9–7.6)	0.000
– 19 years	10.6	(9.2–12.0)	0.000
– 20 years	13.4	(11.7–15.3)	0.000
– 21 years	15.4	(13.5–17.6)	0.000
– 22 years	16.4	(15.9–20.8)	0.000
– 23 years	18.2	(15.9–20.8)	0.000
– 24 years	18.9	(16.5–21.6)	0.000
Marital status (0-single)			
1-married	1.3	(1.2–1.3)	0.000
2-widowed	1.2	(0.7–2.1)	0.508
3-divorced	1.5	(1.1–2.1)	0.024
4-separated	1.5	(1.1–1.8)	0.002
5-ever married, but do not know the present status	1.3	(0.4–3.8)	0.637
Education (0-never study)			
1-before primary school	1.7	(1.4–2.2)	0.000
2-primary school (g 1-6)	2.9	(2.4–3.5)	0.000
3-secondary school-earlier grades (g 7-9)	2.5	(2.1–3.0)	0.000
4-secondary school-later grades (g 10-12)	2.3	(1.9–2.7)	0.000
5- secondary school-later grades /occupation	2.7	(2.2–3.3)	0.000
6-occupation school-high degree	2.3	(1.9–2.8)	0.000
7-undergraduate	1.6	(1.3–2.0)	0.000
8-postgraduate	0.9	(0.4–2.3)	0.890
9-others	0.9	(0.4–1.7)	0.740
Occupation (0- does not work)			
1- legislators/managers	1.9	(1.3–2.8)	0.004
2-professionals	2.1	(1.6–2.7)	0.000
3-technicians	2.6	(2.2–3.1)	0.000
4-clerks	2.6	(2.3–3.0)	0.000
5-service workers	2.0	(1.8–2.2)	0.000
6-agriculture	2.0	(1.8–2.1)	0.000
7-craft	2.1	(2.0–2.3)	0.000
8-plant and machine	2.6	(2.4–2.8)	0.000
9-elementary	2.5	(2.3–2.8)	0.000
10-unknown work	2.9	(2.5–3.3)	0.000

Predictor variable	OR	95% CI	p value
Region (0-South)			
1-Bangkok	1.5	(1.4–1.7)	0.000
2-Central (no BKK)	1.5	(1.4–1.6)	0.000
3-North	4.0	(3.8–4.3)	0.000
4-Northeast	4.1	(3.9–4.4)	0.000
Area (0-urban)			
1-rural	0.96	(0.92–1.01)	0.097
Year of survey	1.03	(1.02–1.04)	0.000

Note: All Odds Ratios in this table are adjusted for all covariates in the logistic regression model: sex, age, marital status, education, occupation, region of living in Thailand (North, East, South, Central, and Bangkok), area of living (urban/rural), and year of survey.

Web appendix 4.5 shows that being female decreased the odds of lifetime drinking 92% as compared to being male. The relationship between age and the odds of lifetime drinking was curvilinear, so that this variable was treated as a categorical variable for easier interpretation. The odds of lifetime drinking increase with age with deceleration rates and are almost stable at the end of this age range, with the odds of lifetime drinking among people 24 years of age being 18.9 times the odds of lifetime drinking among people 15 years of age. Married, widowed and separated individuals increased the odds of lifetime drinking 27%, 48% and 46% as compared to single people. All levels of education up to the undergraduate level increased the odds of lifetime drinking between 57% and 187% as compared to people who did not have any education. People in all occupations increased the odds of lifetime drinking between 95% and 190% as compared to people without any occupation. As compared to people living in the Southern region of Thailand, people living in other regions increased the odds of lifetime drinking 48% to 315%. No difference of the odds of lifetime drinking was observed for people living in urban or rural areas after adjustment for other predictors.

Chapter 5
Discussion

5 Chapter 5: Discussion

5.1 Summary of the rationale and study approach

In LMIC (which have high prevalence of abstainers), an alcohol taxation policy that can reduce alcohol consumption and prevent drinking initiation is needed in order to achieve short- and long-term prevention of alcohol-related harms. Thailand's unique alcohol excise taxation, namely Two Chose One taxation (2C1) which combines the properties of both *specific* taxation and *ad valorem* taxation, is hypothesized to be able to decrease alcohol consumption and drinking initiation [11, 35]. This PhD dissertation aims to (1) systematically review published literature assessing the association between alcohol taxation and alcohol consumption, alcohol related-harms and drinking initiation in LMIC, (2) examine if changes in the rates of Thailand's alcohol excise taxation (2C1) are associated with changes in alcohol consumption and alcohol-related harms, and (3) examine if changes in the rates of Thailand's alcohol excise taxation (2C1) are associated with changes in the rates of drinking initiation.

To achieve these aims, paper 1 (presented in chapter 2) systematically reviewed published literature according to internationally standardized protocols (Preferred Reporting Items for Systematic Review and Meta-Analysis; PRISMA) [69]. Paper 2 (presented in chapter 3) employed a quasi-experimental study design using a series of sixty time-points of monthly data on alcohol tax rates, alcohol production *per capita*, and rates of traffic fatalities from October 2004 to September 2009 [105]. Paper 3 (presented in chapter 4) analyzed data from a series of four national surveys on tobacco and alcohol consumption behaviours in 2001, 2004, 2007, and 2011 using a logistic regression [110].

5.2 Summary of the results

This section summarizes the overall findings of this PhD dissertation.

Chapter 2: "Elasticity of alcohol consumption, alcohol-related harms, and drinking initiation in low- and middle-income countries: a systematic review and meta-analysis," published in the International Journal of Alcohol and Drug Research.

Finding #1: There is no published literature examining the effects of alcohol taxation on alcohol-related harms and/or drinking initiation in LMIC [69]. Most of the literature used in three recent systematic reviews of studies on the effects of alcohol taxation was from HIC [20-22]. No results were presented separately for LMIC [20-22].

Finding #2: Only twelve published studies [9, 53-63] have examined the association between taxation and/or price on alcohol consumption in LMIC and among these studies only ten [55-63] quantified the effect of alcohol taxation on alcohol consumption in LMIC [69]. The average price elasticity of demand for LMIC was estimated to be -0.5 for beer (95%CI: -0.78 to -0.21), -0.79 for other alcohol (including wine and spirits) (95%CI: -0.79 to -0.49), and -0.64 for total alcohol consumption (95%CI: -0.80 to -0.48) [69]. These estimates of elasticity were found to be similar to those published for HIC as reported by Wagenaar et al. (2009) [21], and Elder et al. (2010) [20].

Chapter 3: "The effectiveness of alcohol taxation on alcohol consumption and on traffic fatalities in Thailand."

Finding #3: The alcohol taxation increase in Thailand in 2009 which covered 95% of the alcohol market was significantly associated with a 1.95% (95% CI: 0.23%, 3.67%) reduction in alcohol consumption (tax elasticity of demand -1.95) [105]. Thus, an alternative excise taxation system (the 2C1) currently employed in Thailand showed evidences that it could reduce alcohol consumption [105].

Finding #4: A 1% increase of alcohol taxation under the 2C1 in 2005, 2007, and 2009 were statistically significantly associated with 0.4% (95% CI: 0.02%, 0.78%), 2.0% (95% CI: 0.9%,

3.1%), and 1.9% (95% CI: 0.8%, 3.0%) reductions of the rates of traffic fatalities (tax elasticity of traffic fatalities -0.4, -2.0, and -1.9 respectively) [105]. Hence, alcohol taxation increases under the 2C1 were associated with the reductions in the rates of traffic fatalities [105].

Finding #5: Tax elasticity of demand was -1.95 for the alcohol taxation increase in 2009 in Thailand (see paper 2) [105], while price elasticity of demand for total alcohol consumption was -0.77 in HIC [20] and was -0.69 in LMIC [69]. Tax elasticity of traffic fatalities was estimated to be -0.4 to -2.0 for Thailand (see paper 2) [105], whereas the elasticity of traffic crash outcomes estimated in two systematic reviews, which studies included in the analyses were from HIC, was -0.112 [22] and -0.10 to -0.29 [20]. Thus, the reduction in traffic fatalities and alcohol consumption associated with a one percent increase in taxation was greater for Thailand than has been observed in HIC [20-22, 69, 105].

Finding #6: The Pearson's correlation coefficients 'r' and the coefficients of determination 'R^2' for the relationship between the percentage of taxed coverage of the alcohol market and the percentage change of the rate of total, male, and female traffic fatalities and the percentage change of alcohol consumption *per capita* were r = -0.952 (R^2 = 90.5%), -0.955 (R^2 = 91.1%), -1.000 (R^2 = 99.9%), and -0.983 (R^2 = 96.5%) respectively [103]. Hence, the percentage of taxed coverage of the alcohol market was associated with the percentage change of traffic fatalities and of alcohol consumption [105].

Finding #7: The reductions in the rates of traffic fatalities were statistically significant after all three taxation increases in 2005, 2007, and 2009 with tax elasticities of -0.4 (95%CI: -0.78 to -0.02), -2.0 (95%CI: -3.14 to -0.92), and -1.9 (95%CI: -3.01 to -0.79) respectively, while the reduction in alcohol consumption *per capita* was only statistically significant after the taxation increase in 2009 with tax elasticity of -1.9 (95%CI: -3.67 to -0.23) (tax elasticity was not statistically significantly different from zero in 2005 (-0.43, 95%CI: -1.08 to 0.22) or in 2007 (-1.36, 95%CI: -2.74 to 0.02)) [105]. Thus, the rate of traffic fatalities was more sensitive to taxation increases than was alcohol consumption [105].

Chapter 4: "The impact of alcohol taxation on drinking initiation in youths and young adults: the first evidence from a middle-income country."

Finding #8: After adjusting for socio-demographic covariates, a 10% increase in the average alcohol excise tax rate of the total alcohol market during 2001 to 2011 was associated with a 4% reduction in the odds of lifetime drinking among young people 15 – 24 years of age [110]. Hence, increases in the 2C1 taxation rates may be able to prevent drinking initiation among young people 15 – 24 years of age [110].

Finding #9: A 10% increase in the average tax rate of the total alcohol market resulted in a 5% reduction of the odds of lifetime drinking (95% CI: 1%–9%, p=0.008); this effect was stronger for males than for females, a significant 6% reduction among young adult males (95% CI: 2–11%, p=0.008) and a non-significant 2% reduction among young adult females (95% CI: -5–10%, p=0.546) [110]. Thus, the effect on drinking initiation prevention was stronger for young adults (20 – 24 years of age) than for adolescents (15 – 19 years of age) and greater for males than for females [110].

5.3 Discussions

This dissertation is the first to systematically review the effects of alcohol taxation on alcohol consumption, alcohol-related harms and drinking initiation in LMIC. During the review, no studies that examined the effects of alcohol taxation on alcohol-related harms and drinking initiation were found. [69]. As a result, this PhD dissertation is the first study that examines the effects of taxation policy on alcohol-related harms in LMIC (paper 2) [105] and on drinking initiation in all countries (paper 3) [110].

The observation that the average price elasticity of demand is similar for HIC and LMIC may be due to the impact of the addictive attributes of alcohol on individuals at the population level regardless of income status; these addictive attributes may result in price inelasticity of alcoholic beverages for people addicted to alcohol in both HIC and LMIC [1, 27].

The effect size of price elasticity of alcohol consumption in Thailand reported in this PhD dissertation was greater than those found in other countries [20-21, 69, 105]. This result can be explained by the fact that 2C1 has higher average tax rates than either specific or ad valorem

taxation when applied alone [11]. 2C1 taxes low image, and high alcoholic content beverages using the *specific* taxation method and taxes low alcohol content beverages (i.e. beer) using the *ad valorem* taxation method, resulting in higher average tax rates per unit of ethanol as compared to either primary taxation [11]. High price elasticity for beer under 2C1 taxation was also observed by Poapongskorn et al. (2004). Poapongskorn and colleagues estimated the price elasticity of beer to be -2.7 by examining the association between price and alcohol consumption in Thailand using data from 1978 to 2003 and controlling for the effects of *per capita* income and annual alcohol advertising budgets [55].

The effect sizes of price elasticity of traffic fatalities in Thailand reported in this PhD dissertation were greater than those found in other countries [20, 22, 105]. This result can be explained by the fact that drinkers in LMIC have more harmful alcohol consumption patterns [12] and have a higher risk of injury mortality compared to drinkers in HIC [13]. With the facts that Thailand's adult *per capita* consumption was estimated to be 7.08 liters of pure alcohol in 2008 [7] and the prevalence of drinkers who consumed alcohol in the past 12 months was 31.5% in 2011 [111], the amount of alcohol consumed by a drinker in Thailand was 22.5 liters per drinker. The amount of alcohol consumed per drinker in Thailand is an amount greater than is consumed per drinker in countries in the WHO regions of Western Pacific A (Australia, New Zealand, Japan) (11.9 liters/drinker), Europe A (Germany, French, UK) (14.7 liters/drinker), Americas A (Canada, Cuba, United States) (16.4 liters/drinker), Africa E (Ethiopia, South Africa) (18.8 liters/drinker), South East Asia D (Bangladesh, India) (16.6 liters/drinker), South East Asia B (Indonesia) (18.4 liters/drinker), and Africa D (Nigeria, Algeria) (20.3 liters/drinker) [1]. Thus, as the risk between alcohol and injuries and other diseases is exponential [112], the same reduction in alcohol consumption per drinker would yield a higher corresponding harm reduction in Thailand when compared to the corresponding harm reduction in HIC.

The association between the percentage of the alcohol market that a taxation change affects and the percentage change in alcohol consumption and/or traffic accident rates was hypothesized to be due to the substitution towards beverages with a lower tax burden in the case where only part of the alcohol market experienced a tax increase [105]. This substitution effect has been observed in previous studies which found that consumers shifted their consumption towards cheaper

alcoholic beverages (both within and across beverage categories for beer, wine, and spirits) after a tax system change in Sweden in 1992 [32, 32].

A possible explanation for the finding that the rate of traffic fatalities was more sensitive to taxation increases than was alcohol consumption [105] is that tax increases may have more of an effect on the consumption of binge drinkers who are at a greater risk of injury than are social drinkers [80, 113]. Using two large sets of national surveys among adolescents in the United States during 1996-1998, Saffer and Dave (2003) found that a 10% increase in alcohol taxation resulted in a 2.8% reduction in the prevalence of adolescents who consumed alcohol in the past month and a 5.1% reduction in the prevalence of adolescents who binge drank in the past month [113]. Based on data from a nationally representative survey of students in the United States in 1993, Chaloupka and Wechsler (1996) found that binge drinking by female college students was sensitive to the price of beer [80].

The finding that alcohol excise taxation increases in Thailand during 2001 to 2011 were able to prevent drinking initiation among young people 15 – 24 years of age [110] may be attributable, in part, to the structure of 2C1 taxation which taxes heavily youth-preferred beverages (low alcohol content, high image beverages) thereby decreasing the affordability of these beverages [11].

The differential tax effects on drinking initiation prevention by age and sex may be explained as follows. Adolescents in Thailand are deterred from drinking by other alcohol control measures: under Thai laws and regulations, adolescents who are less than 18 years of age cannot legally consume alcohol [101] and adolescents younger than 20 years of age cannot legally purchase alcohol [83]. Thus, taxation may have more of an impact on young adults above the legal drinking/purchasing ages. The observation of a gender difference in the effect of alcohol taxation on drinking initiation may be due to the observation that females purchase alcohol less often than do males in Thailand [102] and the average age of drinking initiation for a Thai female is later in life (the mean age of drinking initiation was 19.4 and 24.4 years for Thai males and females respectively) [98].

The ecological model advocates that human health behaviours are determined by multi-level determinations [14]. The findings that taxation is able to reduce alcohol consumption [69, 105], reduce alcohol-related harm [105], and prevent drinking initiation [110] confirm that alcohol taxation policies are an effective societal level intervention (see [1, 15-17] for an outline of the effectiveness of other alcohol control policies). Determinants of alcohol consumption other than taxation are comprised of individual factors (including having more problem behaviours, a view that alcohol has a net favorable outcome, having poor executive function [114], and having poor religious affiliation or cultural pride and spirituality [115]), family factors (including family members' substance problems [115], an absence of or little parental monitoring, vaguely defined family rules for behaviour and inappropriate parental rewards for good behaviours [114]), peer factors (including peers' misbehaviours [114, 115]), and community factors (including poor participation in generic cultural activities [115]).

As advocated by the social cognitive theory, health behaviours are determined by individual psychological factors, environmental factors, and the interaction between these factors [14]. Taxation – increasing alcohol price, decreasing affordability, reducing alcohol consumption – acts as a negative reinforcement [14]. An important construct in the social cognitive theory is reciprocal determinism: the two-way interaction between individual level factors and environmental factors [14, 116]. As shown in paper 2, taxation increases which resulted in reductions of alcohol consumption and traffic fatalities were ineffective when only part of the alcohol market experienced a tax increase as consumers shifted their consumption towards untaxed alcohol [105].

Taxation increases under the 2C1 taxation system are able to prevent drinking initiation by increasing the immediate cost of drinking which has been shown to be an important strategy by the behavioural economic theory of "hyperbolic time discounting." This concept reveals that people pursue immediate gratification rather than well-being in the medium- and long-term, even though they are aware of the future negative consequences of today's behaviours [117, 118]. This concept also suggests that young people may initiate their drinking of alcohol due to devalued potential negative consequences if the immediate consequences are not high. Thus, by

increasing taxation and the immediate consequences of drinking (i.e. monetary loss), governments can achieve long-term prevention of alcohol-related harms.

Maintaining the high prevalence of lifetime abstainers in LMIC is important for the long-term prevention of alcohol-related harms, because in countries where drinking is not the norm, abstention is a strong informal control method [119]. For example, the prevalence of current drinkers in Thailand in 2011 was 31.5% [111]; this low prevalence of current drinkers was due, in part, to the practice of Buddhist behaviours by Thai people. Buddhist beliefs affecting the behaviours of individuals and groups in Thailand can be observed during the 'Buddhist Lent Period' (BLP) which takes place from July to September. Associated to practicing stop drinking alcohol by a number of drinkers during BLP, a 15% reduction in fatal traffic accidents from 1,044 deaths per month to 892 deaths per month have been observed [119]. Moreover, the social image that it is unacceptable to consume alcohol in Thailand informally influences alcohol control policy advocacy, and these influences were instrumental in establishing the prohibition of the sale of alcohol during four national religious days [119].

5.4 Limitations

There are five main limitations for this PhD dissertation.

Limitation #1: There were limitations related to the systematic review and meta-analysis (paper 1) as follows. First, only a small number of studies examined the effects of alcohol price and/or taxation in LMIC, so it is statistically impossible to detect if regional differences exist based on the available data [69]. Second, there may be studies in LMIC published in languages other than English or Thai, and these studies were excluded from our review [69]. Finally, unrecorded consumption was not sufficiently accounted for in the studies that were used in the meta-analysis and, thus, substitution bias could not be controlled for [67].

Limitation #2: The study that examined the association between alcohol taxation and alcohol consumption (paper 2) is limited by the absence of a measurement for monthly unrecorded alcohol consumption. This study is also limited by inaccuracies in the monthly alcohol sales data

[105], and, thus, the best surrogate of alcohol consumption was alcohol production. Alcohol production data were limited by the fact that there were no monthly data available for imported alcohol [105]. According to yearly alcohol production data, imported alcoholic beverages accounted for approximately 13% of the total recorded alcohol market in 2009 [74]. Unrecorded alcohol consumption in Thailand during 2003-2005 was estimated to be 10% of the total alcohol consumption according to the WHO alcohol database [85]. Due to the absence of data on the amount of alcohol imported monthly and on unrecorded consumption, it was impossible to account for the likely substitution of domestic alcoholic beverages with imported alcoholic beverages and/or unrecorded alcoholic beverages [105]. Therefore, caution should be exercised when interpreting the effect size of the association between alcohol taxation and alcohol consumption as the magnitude of this association may be overestimated due to substitution towards untaxed imported alcohol and unrecorded alcohol [105]. In addition, paper 2 is limited by the small number of observations before the first taxation increase and after the third taxation increase. The small number of observations during these time periods may affect the reliability of results [86].

Limitation #3: The study that examined the association between alcohol taxation and alcohol drinking initiation (paper 3) is limited by the fact that the routine national surveys on tobacco and alcohol consumption behaviours did not include any questions about predictors of alcohol drinking initiation (i.e. parental and peer approval, adolescents' drug use behaviours and prior incidents of delinquency [46]). Since it was impossible to control for these variables in the statistical analysis, there may be remaining residual confounding [110]. Furthermore, two limitations of the survey data utilization are that there is the potential for bias related to surveys (i.e. exclusion bias and response bias), and as these were multiple, cross-sectional surveys that did not use the same participants, it is impossible to establish a temporal effect [103].

Limitation #4: Both papers 2 and 3 were lack of behavioural variables so that they were not able to test other behavioural theories other than taxation.

Limitation #5: Both papers 2 and 3 are limited as they are quasi-experimental studies that do not use a control country. The absence of a control country reduces the ability to compare the effects of alcohol taxation increases with the counterfactual situation in this study [103].

5.5 Policy implications and recommendations

Policy implication and recommendation #1: Since the average effect sizes of taxation on alcohol consumption for LMIC is similar to HIC [20-22, 53-63, 69], governments in LMIC should consider taxation as one of the most important alcohol policy interventions to reduce alcohol consumption.

Policy implication and recommendation #2: Taxation was more effective in reducing fatal traffic accidents in Thailand when compared to HIC [105]. Thus, governments in LMIC should take into consideration the effect size of taxation on fatal motor vehicle accidents when deciding on effective alcohol control policies and traffic injury reduction policies.

Policy implication and recommendation #3: Governments of LMIC which aim to reduce alcohol consumption and its related harms may want to consider policies that prevent drinking initiation in order to achieve both long- and short-term preventions of alcohol-related harms [11, 110]. Policies that deter drinking initiation are important as (1) there is a trend towards a decrease in the prevalence of lifetime abstainers in LMIC as these countries grow economically [10], and (2) in LMIC, alcohol drinking patterns per liter of alcohol are more harmful [12] and have a higher risk of injury mortality [13]. One such policy that can prevent drinking initiation, as described in this PhD dissertation, is 2C1 taxation [110]. However, it should be noted that the 2C1 may not affect people who are legally unable to drink or who drink alcohol provided by other people [110]. Accordingly, additional policies that deter drinking initiation (for example, minimum legal drinking and purchasing age, alcohol sale permission only at on- and off-premises that are prohibited for adolescents, alcohol advertising permission only at the sale venues that are prohibited for adolescents) should be implemented in conjunction with 2C1 taxation.

Policy implication and recommendation #4: Since the proportion of the market that is affected by taxation is strongly positively correlated with the associated reduction in total alcohol consumption and fatal traffic accident rates [105], governments must increase alcohol tax rates across the majority of the alcoholic beverage market in order to maximize the effectiveness of alcohol taxation policies.

5.6 Research implications and future directions

Research implication and future direction #1: There is a lack of research on the effects of alcohol taxation on drinking initiation in HIC [20-22]. Additionally new studies that examine the effects of taxation rate increases on drinking initiation in HIC are needed.

Research implication and future direction #2: This PhD dissertation is the first study to examine the association between alcohol taxation and alcohol-related harms and drinking initiation in LMIC [105, 110]. Thus, a research study that examines the association between alcohol taxation and alcohol-related harms and drinking initiation in LMIC other than Thailand is a potential future research topic.

Research implication and future direction #3: If 2C1 taxation were to be adopted by other countries, a comparative study of the effects of 2C1 and previously utilized taxation methods in terms of alcohol consumption, alcohol-related harms and drinking initiation would contribute to the academic and public health field of alcohol taxation policy.

Research implication and future direction #4: Since there were limitations with the data used in studies 2 and 3 of this PhD dissertation, the following recommendations to improve the validity and the reliability of future studies on alcohol taxation in Thailand are as follows: (1) generating a series of estimated monthly unrecorded alcohol consumption, (2) establishing a database of monthly imported alcohol, (3) creating a valid and reliable database of alcohol sales by beverage and by total market, and (4) including variables in the national survey on tobacco and alcohol consumption behaviours which are known to affect alcohol drinking initiation. In addition, to

quantify the effects of other alcohol control policies on alcohol consumption, alcohol-related harms and drinking initiation is an interesting topic to be pursued for Thailand.

5.7 Conclusion

LMIC that need to achieve both short- and long-term prevention of alcohol-related problems might consider 2C1, which is currently employed in Thailand. This method of taxation has been associated with a reduction in alcohol consumption, its related harms and drinking initiation. To maximize the effects of 2C1 taxation rate increases, governments should increase taxation across the majority of the alcoholic beverage market to prevent substitution. Moreover, governments also should apply additional, complementary, age-specific alcohol control measures (for example, minimum legal drinking and purchasing age, alcohol sale permission only at on- and off-premises that are prohibited for adolescents, alcohol advertising permission only at the sale venues that are prohibited for adolescents) in order to prevent drinking initiation. Future research opportunities include conducting new studies that examine the effects of taxation rate increases on drinking initiation in HIC; examining the effects of alcohol taxation on alcohol-related harms and on drinking initiation in other LMIC; producing studies to evaluate the effect of the 2C1 compared to other methods of taxation on alcohol consumption and its related harms and on drinking initiation.

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Alcohol taxation policy in Thailand: implications for other low- to middle-income countries

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ABSTRACT

Aim Prevention of drinking initiation is a significant challenge in low- and middle-income countries that have a high prevalence of abstainers, including life-time abstainers. This paper aims to encourage a debate on an alternative alcohol taxation approach used currently in Thailand, which aims specifically to prevent drinking initiation in addition to reduce alcohol-attributable harms. **Methods** Theoretical evaluation, simulation and empirical analysis. **Result** The taxation method of Thailand, 'Two-Chosen-One' (2C1) combines specific taxation (as a function of the alcohol content) and *ad valorem* taxation (as a function of the price), resulting in an effective tax rate that puts a higher tax both on beverages which are preferred by heavy drinkers and on beverages which are preferred by potential alcohol consumption neophytes, compared to either taxation system alone. As a result of these unique properties of the 2C1 taxation system, our simulations indicate that 2C1 taxation leads to a lower overall consumption than *ad valorem* or specific taxation alone. In addition, it puts a relatively high tax on beverages attractive to young people, the majority of whom are currently abstaining. Currently, the abstention rates in Thailand are higher than expected based on its economic wealth, which could be taken as an indication that the taxation strategy is successful. **Conclusion** 'Two-chosen-one' (2C1) taxation has the potential to simultaneously reduce alcohol consumption and prevent drinking initiation among youth; however, additional empirical evidence is needed to assess its effectiveness in terms of the public health impact in low- and middle-income countries.

Keywords Alcohol, drinking initiation, low and middle income countries, prevention, pricing, taxation, Thailand.

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CONCISE STATEMENT

Alcohol taxation and other alcohol control policies in high-income countries aim mainly to reduce alcohol-attributable harms by reducing harmful alcohol consumption in current drinkers [1]. The goal of preventing people from drinking at all is rarely formulated, whereas delay of initiation is a major focus of prevention (e.g. [2,3]). Low- and middle-income countries not only aspire to reduce consumption and associated harm in drinkers, but are equally in need of alcohol taxation policies directed towards preventing initiation of drinking and maintaining high rates of abstention, including life-time abstention. The alcohol taxation system in Thailand tries to combine both aims, and is discussed in detail in this report.

ALCOHOL CONSUMPTION AND ATTRIBUTABLE HARMS IN LOW- AND MIDDLE-INCOME COUNTRIES—IMPLICATIONS FOR ALCOHOL CONTROL POLICIES

There are marked between-country differences in alcohol consumption and alcohol-attributable harms, and these differences are related to the economic wealth of nations [4–6]. Overall, the association between wealth as measured in gross domestic product—purchasing power parity (GDP–PPP) and alcohol consumption is very strong up to a GDP–PPP of about $10 000 to $15 000 and then this association levels off [5,7]. This is due mainly to a much higher proportion of abstainers, mainly life-time abstainers, in middle- and especially in

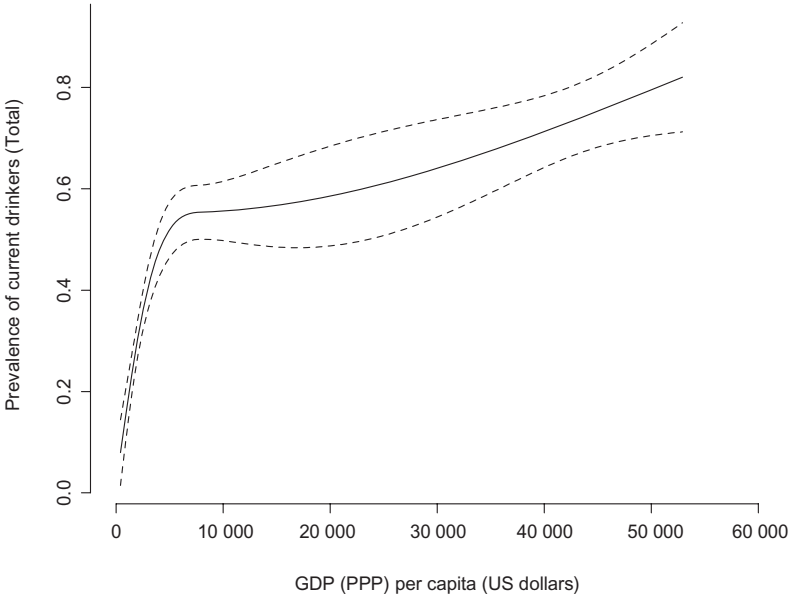

Figure 1 Association between prevalence of current drinkers (total) and gross domestic product (GDP–PPP) *per capita*. Our calculations are based on ongoing comparative risk assessment data (see also Global Information System on Alcohol and Health: http://apps.who.int/ghodata/?theme=GISAH)

low-income countries (LIC) [8]. Figure 1 describes the relationship between GDP–PPP and the prevalence of current drinkers in the adult population (based on 2005 rates of current drinkers from the ongoing comparative risk assessment).

As a result, the lowest-income countries tend to consume the least amount of alcohol on an adult per-capita basis [6]. In middle-income countries (MIC) adult per-capita consumption is higher than in LIC; however, consumption is still much lower than in high-income countries (HIC). While less alcohol is consumed in low- and middle-income countries (LMIC), the relative harm associated with each litre consumed per capita is much greater [9] due to alcohol being consumed in more harmful patterns [10], and there is a higher risk of mortality and morbidity from causes where alcohol plays a role (such as injuries) [11]. In addition, alcohol interacts with other risk factors such as poverty, crowding and malnutrition [5].

As a consequence of the above situation with the overwhelming majority of people drinking in HIC [8,12], the goal of preventing people from drinking at all (i.e. keeping a high proportion of life-time abstainers) is rarely formulated; most of the focus seems to be on delaying age of initiation and reducing harms associated with earlier initiation [2,3,13].

ALCOHOL CONSUMPTION AND ATTRIBUTABLE HARMS IN THAILAND

Thailand is considered an MIC with a GDP–PPP per capita of US$8643 in 2010 [14]. It had a low prevalence of current drinkers at approximately 30% (measured as having at least one drink in the past year) in 2007 [15], and a high prevalence of abstainers, especially among youth, with 75% of male and 86% of female secondary school students having abstained from alcohol in the past year [16]. Given Thailand's GDP–PPP and the relationship between GDP–PPP and total adult per-capita consumption (see above), we would expect the prevalence of current drinkers in Thailand to be around 50%.

From 2001 to 2007 Thailand had relatively stable or slightly decreasing prevalence rates of current or past year drinkers for both males and females and in all age groups: 55.9–52.3% for males, 9.8–9.1% for females, 21.6–22.2% for the age group 15–24 years, 40.4–36.3% for the age group 25–40 years, 38.1–34.5% for the age group 40–60 years and 20.0–16.4% for the age group 60 years and over [15]. In addition, Thailand's total per-capita consumption has remained relatively stable from 1990 to 2008, while GDP–PPP increased from $2900 to $8200 international dollars [7]. This trend is unexpected, given the previously observed association between GDP–PPP and total adult per-capita consumption [7]. As has been shown elsewhere, in LMIC adult per-capita consumption is correlated highly with level of abstention [8].

Despite a low prevalence of current drinkers, Thailand's alcohol-attributable harms are substantial. In the past 5 years there were more than 18 traffic accident deaths per 100 000 people per year [17]; among these deaths, 40–60% were attributable to drink-driving [18]. There has been a fourfold increase in the likelihood of domestic violence when alcohol is involved [19], and 40% of youth crimes are related to alcohol [20].

Once Thai adolescents begin to drink, they tend to become regular drinkers (measured as drinking in the past month). Two-thirds of male and almost one-half of

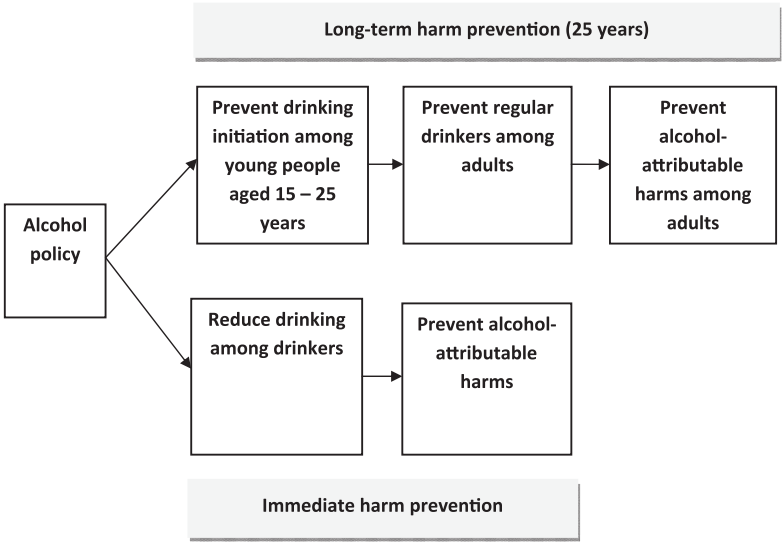

Figure 2 Diagram of the immediate and long-term alcohol-attributable harms addressed by alcohol policy in Thailand

female students who have had at least one alcoholic drink have also consumed alcohol in the last 30 days [16]. For Thailand and countries with a similar situation of overall low consumption and a high rate of abstention, alcohol policy should thus aim to reduce alcohol consumption among drinkers and to prevent drinking initiation to maintain a high proportion of abstainers, mainly lifetime abstainers. Combining these aims may reduce immediate, mid-term and long-term alcohol-attributable harms (see Fig. 2).

In most HIC, in contrast, it is accepted that the overwhelming majority of the general population will become drinkers, and alcohol policy tries primarily to reduce alcohol-attributable harms by reducing harm among drinkers or by postponing initiation of drinking [21].

BEVERAGES PREFERRED BY YOUTH IN THAILAND

Thai youth tend to consume low alcohol content beverages, specifically beer [15], alcohol mixed with fruit juice and ready-to-drink (RTD) beverages [22], and rarely consume white spirits, and other beverages with medium or high alcohol content [15]. Moreover, youth abstainers are most likely to first consume low alcohol content beverages [23]. A taxation method that would heavily tax beverages preferred by youth would potentially limit drinking initiation among youth.

ALCOHOL EXCISE TAXATION SYSTEMS

Excise taxation, a selective tax on a particular good, can be used by governments to increase prices on certain goods and/or services that produce externalities, i.e. costs to the public [24]. Specifically, alcohol excise taxation increases the price of alcohol to consumers who respond by decreasing their consumption, leading to a decrease in the resulting externalities attributable to alcohol consumption [24,25]. In comparison to other methods, taxation is one of the most effective interventions in terms of feasibility, implementation cost and cost-effectiveness [26,27].

There are two popular methods of excise taxation for alcoholic beverages: specific and *ad valorem* [24,28]. Specific taxation is based on the volume of pure alcohol in a beverage, while *ad valorem* taxation is a function of the price of a beverage. Specific taxation has proved to be appropriate for HIC with a high prevalence of current drinkers [29,30], as it favours low alcohol content beverages with lower overall intake of alcohol per occasion. However, it may encourage drinking initiation among youth in countries with a high prevalence of abstainers, as initiation is often via low alcohol content beverages [31]. However, for LMIC, it is imperative to prevent drinking initiation among youth as well as to reduce drinking levels among drinkers.

THAILAND'S ALCOHOL TAXATION SYSTEM

Thailand has six separate taxes which are charged on alcoholic beverages. The first tax is customs duty applied to imported beverages only. All other taxes are applied to imported and domestically produced beverages: excise tax, which is termed 'Two-Chosen-One' taxation (2C1), and municipality, health promotion and Thai television tax, which are equal to 10, 2 and 1.5% of the excise tax, respectively. Upon purchase, a value added tax, calculated as 7% of the retail price, is charged.

The customs taxation system is structured as a 2C1 taxation system with beverage-specific rates based on

price for *ad valorem* taxation, and a fixed sum per litre of pure alcohol for specific taxation. The higher of these two taxation methods is applied (see details below). The excise tax rate under 2C1 taxation in Thailand applies different tax rates to different alcoholic beverages as follows. The excise tax rates for beer and wine are 60% (inclusive rate) of ex-factory price (or producer price) for *ad valorem* taxation and 100 THB (Thai baht: $30 THB is about US$1) per litre of pure alcohol for specific taxation. For white spirits, mixed spirits and whisky, the *ad valorem* tax rate is 50% (inclusive rate) of ex-factory price for these distilled spirits, while the specific tax since 2009 has been calculated as 120, 300 and 400 THB per litre of pure alcohol, respectively.

TWO-CHOSEN-ONE TAXATION (2C1)

The 2C1 taxation method, outlined in the Alcohol Act 1950, calculates the excise tax of each alcoholic beverage using both primary taxation methods—specific and *ad valorem*; the excise tax on the beverage is then determined to be the higher of the two calculations. For example, the specific tax of a distilled spirit is 105 THB and the *ad valorem* tax is 58 THB; application of the 2C1 taxation system results in an excise tax of 105 THB. The specific tax of a beer is 3.15 THB and the *ad valorem* tax is 42.93 THB; application of the 2C1 taxation system results in an excise tax of 42.93 THB. Complete calculations for these examples are provided in Box 1.

Under 2C1 taxation, the excise tax on less expensive alcoholic beverages is equal to the calculated specific tax, while the excise tax on more expensive alcoholic beverages is the calculated *ad valorem* tax. The costs of producing low alcohol content, high image beverages result in these types of beverages generally being more expensive than low image but high alcohol content beverages [30,32]. In Thailand, low alcohol content beverages, such as alcohol mixed with fruit juice, RTD beverages, beers, wines and high image spirits are more expensive compared to domestic low image spirits. Figure 3 outlines the 2C1 tax rates and retail prices of 10 alcoholic beverages, arranged by alcoholic beverage type and by alcohol content. The sweet, low alcohol content beverages and beers on the left, and the high image, high alcohol content spirits on the right are expensive relative to their alcohol content and, thus, the 2C1 taxation system dictates that the applicable excise taxes are calculated as *ad valorem* taxes which are greater than their calculated specific taxes (see Table 1), whereas the applicable excise taxes on inexpensive spirits are calculated under the 2C1 taxation system as specific taxes. As a result, unlike specific taxation, which promotes low alcohol content beverages, 2C1 taxation favours medium strength alcoholic beverages. Consequently, under 2C1 taxation, the government can deter consumption of high alcohol content beverage consumption by adjusting the specific tax rate and also prevent drinking initiation by taxing highly advertised, high image alcoholic beverages and

Box 1 Excise tax calculation examples for the 'Two-Chosen-One' (2C1) tax method

Example 1: A distilled spirit (whisky #7 in Table 1) with an alcohol concentration of 40%, a volume of 700 cc and an ex-factory price of 116 Thai baht (THB) per bottle. The specific tax rate for distilled spirit is 400 THB* per litre of pure alcohol while the *ad valorem* tax rate is 50% of its ex-factory price

- Using the specific tax method, the tax revenue is $=0.40 \times 0.700 \times 400 = 112$ THB per bottle (equivalent to 6.08 THB per 12 g of alcohol)
- Using the *ad valorem* tax method, the tax revenue is $=50\% \times 116 = 58$ THB per bottle (equivalent to 3.15 THB per 12 g of alcohol)
- Using the 2C1 tax method, the excise tax is 105 THB per bottle (or 6.08 THB per 12 g of alcohol) because it is the higher of the calculated amounts

Example 2: A beer (beer #4 in Table 1) with an alcohol concentration of 5%, a volume of 630 cc and an ex-factory price of 42.93 THB per bottle. The specific tax rate for beer is 100 THB per litre of pure alcohol, whereas the *ad valorem* tax rate is 60% of its ex-factory price

- Using the specific tax method, the tax revenue is $=0.05 \times 0.630 \times 100 = 3.15$ THB per bottle (equivalent to 1.52 THB per 12 g of alcohol)
- Using the *ad valorem* tax method, the tax revenue is $=60\% \times 42.93 = 25.76$ THB per bottle (equivalent to 12.42 THB per 12 g of alcohol)
- Using the 2C1 tax method, this beer excise tax would be 25.76 THB per bottle (or 12.42 THB per 12 g of alcohol) because it is the higher of the calculated amounts

*1 US$ = 30 THB on 10 January 2011

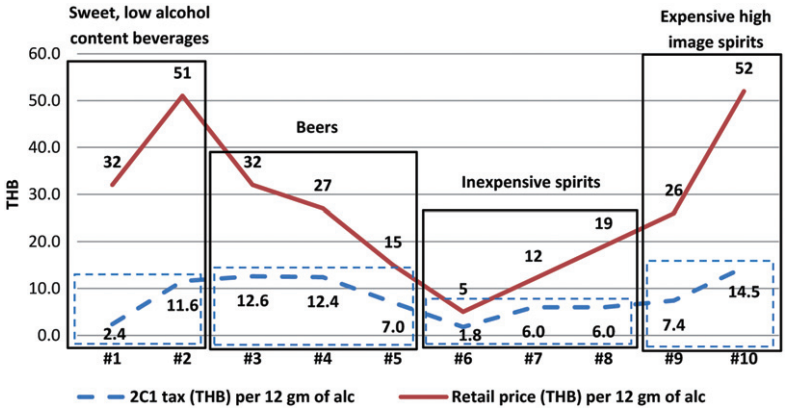

Figure 3 Graph of the 'Two-Chosen-One' (2C1) tax and retail prices per 12 g of alcohol of 10 alcoholic beverages, arranged by alcohol category and content (data in year 2010). Source: the values of the 2C1 tax per 12 g of alcohol of 10 alcoholic beverages are adopted from Table 1, while the values of retail prices per 12 g of alcohol of these beverages are calculated by the authors using data from alcohol producers for 2010; THB: Thai baht

Table 1 Ten examples of the excise tax calculation using the 'Two-Chosen-One' (2C1) taxation system.

Beverage	*Strength*	*Volume*	*Ex-factory price (THB/12 g of alcohol)*	*Specific tax (THB/12 g of alcohol)*	*Ad valorem tax (THB/12 g of alcohol)*	*Excise tax (THB/12 g of alcohol)*	*The tax method applied*
1. Wine cooler	5.0%	300 cc	9.44	1.52	2.36	2.36	AV
2. RTD (fruit flavour)	5.6%	275 cc	23.22	6.08	11.61	11.61	AV
3. Beer (imported)	5.0%	640 cc	20.93	1.52	12.56	12.56	AV
4. Beer (domestic)	5.0%	630 cc	20.7	1.52	12.42	12.42	AV
5. Beer (domestic)	6.4%	640 cc	11.72	1.52	7.03	7.03	AV
6. White spirit	40.0%	625 cc	2.93	1.82	1.47	1.82	Sp
7. Whisky (inexpensive—domestic)	40.0%	700 cc	6.29	6.08	3.15	6.08	Sp
8. Whisky (inexpensive—imported)	40.0%	700 cc	11.18	6.08	5.59	6.08	Sp
9. Brandy (expensive—domestic)	38.0%	700 cc	15.43	6.08	7.41	7.41	AV
10. Whisky (expensive—imported)	43.0%	750 cc	29.02	6.08	14.51	14.51	AV

Source: data of alcohol ex-factory prices, alcohol strengths, specific (Sp) excise tax rates and *ad valorem* excise tax rates were from the Excise Department; calculated into Sp, *ad valorem* (AV) and actual 'Two-Chosen-One' (2C1) tax rates per 12 g of alcohol by the authors. Note: wine cooler (beverage number 1) is in the wine category while ready-to-drink (RTD) (beverage number 2) is in the spirits category. Hence, they pay different tax rates. Note: the low tax rates of wine cooler (number 1) and white spirit (number 6) are not the result of 2C1 taxation. Instead, they are the result of a government differential tax rate determination among different alcoholic beverages; THB: Thai baht.

low alcohol content beverages, which reduces the affordability of these beverages.

2C1 TAXATION'S THREE MECHANISMS

Ad valorem tax on alcoholic beverages is calculated based on price. In response to *ad valorem* taxation, alcohol producers tend to downgrade the perceived quality of their product (such as by removing non-alcoholic mixtures used in beverages, changing packaging and reducing advertising) in order to lower the costs associated with their product and the resulting tax; this response is referred to commonly as a 'downgrading effect' [28,33–35]. As a result, *ad valorem* tax promotes less expensive, but higher alcohol content beverages, and may increase overall alcohol consumption [28,33–35].

Specific tax is calculated based on alcohol content of the beverage. Because this method taxes alcohol content irrespective of price or perceived quality, alcohol producers tend to decrease alcohol content in order to minimize the tax burden on alcohol products, referred to commonly as an 'upgrading effect' [28,33–35]. As a result, specific taxation promotes relatively high-priced, low alcohol content beverages of higher perceived quality [28,33–35]. Specific taxation has been shown to be effective for countries with a high prevalence of current drinkers, as it can reduce per-capita alcohol consumption and deter harmful alcohol consumption levels [29]. It may have a negative effect in promoting the low alcohol content beverages which lead to drinking initiation.

Even though 2C1 taxation applies both basic taxation methods, it possesses unique attributes. 2C1 taxation causes an 'upgrading effect' for inexpensive beverages (as with specific taxation); however, unlike *ad valorem* taxation, it does not have a pronounced 'downgrading effect'

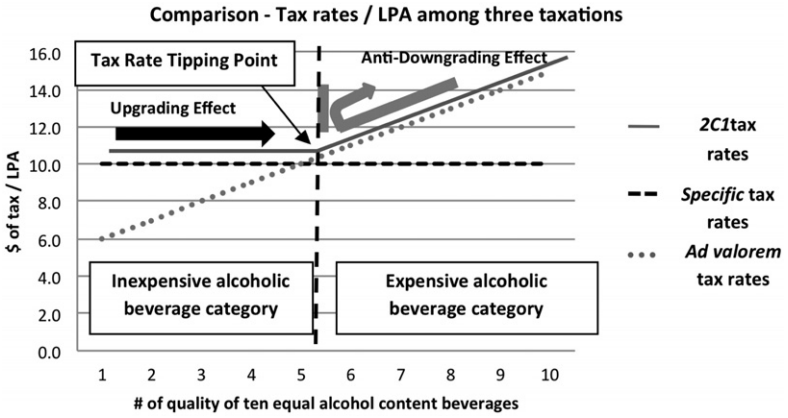

Figure 4 Graphic representation of hypothetical alcoholic beverages' specific and *ad valorem* taxes using 'Two-Chosen-One' (2C1) taxation; LPA: litres of pure alcohol

for expensive alcoholic beverages, even though 2C1 taxes such beverages under the *ad valorem* taxation method. Because of the combination of specific and *ad valorem* taxation methods, 2C1 taxation has two unique features: a 'tax rate tipping point' and an 'anti-downgrading effect'. Outlined in Table 1 are four spirits which have the same specific tax rates of 6.08 THB per standard drink (defined in this paper as 12 g of pure alcohol [36]), but which have different ex-factory prices and, thus, different *ad valorem* tax rates of 3.11, 5.59, 7.41 and 14.51 THB per standard drink, respectively. The excise tax rates under 2C1 taxation for these beverages are 6.08, 6.08, 7.41 and 14.51 THB per drink, respectively. None of these spirits has an excise tax lower than 6.08 THB per drink. If alcohol producers decrease the price of their products such that the *ad valorem* tax is no longer higher than the specific tax, then the specific tax rate will apply. This is referred to as the 'tax rate tipping point', namely the price where the tax rate to be applied changes from the *ad valorem* tax to the specific tax if the price of the product goes down, and changes from specific to *ad valorem* if the price of the product goes up. As a result, due to the 'tax rate tipping point' alcohol producers have no tax-based incentive to downgrade their products below this point which, in turn, deters producers from decreasing the price of expensive alcoholic beverages and discourages consumption of expensive beverages. This mechanism can be referred to as an 'anti-downgrading effect'. In conclusion, 2C1 taxation has three mechanisms (i) the 'tax rate tipping point', which leads to (ii) an 'upgrading effect' for inexpensive alcoholic beverages and (iii) an 'anti-downgrading effect' for expensive alcoholic beverages.

Figure 4 illustrates the attributes of 2C1 taxation using an example of 10 hypothetical beverages with equal alcohol content, arranged in price from low to high. The 'tax rate tipping point' divides alcoholic beverages into two categories: inexpensive and expensive. Inexpensive beverages are taxed under the specific taxation method, whereas expensive beverages are taxed under the *ad valorem* taxation method.

SPECIFIC EFFECTS OF 2C1 TAXATION

2C1 taxation generates a higher average tax rate resulting in lower total alcohol consumption, compared to the specific system or the *ad valorem* system individually. This can be proved using mathematical derivations (Box 2). 2C1 taxation can be seen as a specific 'plus' taxation system, as all beverages are taxed at least at a specific taxation rate, with expensive beverages being taxed at an *ad valorem* taxation rate. Higher tax rates act to lower alcohol consumption [29,30,37]; thus, 2C1 taxation lowers alcohol consumption more than if either the specific or the *ad valorem* taxation systems were applied (Box 3).

Table 2a,b demonstrates hypothetical taxation and substitution effects on alcohol consumption among three taxation methods: specific, *ad valorem* and 2C1. In these examples, all beverages have the same specific and *ad valorem* tax rates. Table 2a outlines an example of four beverages with equal alcohol content, but with different prices. Table 2b outlines an example of four beverages with equal quality (indicated by years of brew), but with different alcohol contents. For these examples, we assumed that consumers spend a fixed amount of money on alcohol. For each example, we considered two scenarios: (i) no substitution; and (ii) 10% cross-category substitution.

We observed that (i) price per unit of alcohol (regardless of taxation method) is higher in beverages with higher perceived quality (see line 6 of Table 2a) and in beverages with lower alcohol content (see line 6 of Table 2b); (ii) the range of post-tax prices of alcoholic beverages is narrower under specific taxation (see line 10 of Table 2a,b), which results in relatively greater consumption of more expensive and lower alcohol content

Box 2 Comparisons of specific and *ad valorem* taxation methods to 'Two-Chosen-One' (2C1) in terms of average tax rates

	Variable/equation			Explanation
	T_{2C1}	=		The average tax rate of the 2C1 method
	T_S	=		The average tax rate of the specific tax method
	T_V	=		The average tax rate of the *ad valorem* tax method
	t_S	=		The specific tax rate of an alcoholic beverage
	t_V	=		The *ad valorem* tax rate of an alcoholic beverage
	A	=		The alcohol content of an alcoholic beverage
	P	=		The price of an alcoholic beverage
	In the 2C1			
1.	T_{2C1}	=	$T_s = t_s(A)$, if $T_s > T_v$	This would happen in the inexpensive beverage category
			$T_v = t_v(P)$, if $T_v > T_s$	This would happen in the expensive beverage category
2.	In case, T_s	>	T_v, In cheap beverage	
3.	T_s	=	$T_v + T_{sov\text{-in cheap bev}}$	$T_{sov\text{-in cheap bev}}$ is the extra tax that the specific taxation generates over the *ad valorem* taxation
4.	In case, T_v	>	T_s, In expensive beverage	
5.	T_v	=	$T_s + T_{vos\text{-in expensive bev}}$	$T_{vos\text{-in expensive bev}}$ is the extra tax that the *ad valorem* taxation generates over the specific taxation
	Compare 2C1 to the specific tax method			
6.	X	=	$X_C + X_E$	Suppose there are X units of alcohol in the whole alcohol market consisting of X_C units of inexpensive beverage category and X_E units of expensive beverage category
7.	$T_{2C1}(X)$	=	$T_sX_C + T_vX_E$	The total tax revenue generation of the 2C1 is equal to the combination of the tax revenue generation in the inexpensive and expensive beverage categories. The revenue from the cheap beverage category is equal to the specific tax rate multiplied by X_C units of pure alcohol in the inexpensive beverage category, whereas the revenue from the expensive beverage category is equal to the *ad valorem* tax rate times X_E units of pure alcohol in the expensive beverage category
8.		=	$T_sX_C + (T_s + T_{vos})X_E$	From 5: $T_v = T_s + T_{vos\text{-in expensive bev}}$
9.		=	$T_sX_C + T_sX_E + T_{vos}X_E$	
10.		=	$(T_sX_C + T_sX_E) + T_{vos}X_E$	
11.		=	$T_s(X_C + X_E) + T_{vos}X_E$	
12.		=	$T_s(X) + T_{vos}X_E$	Since $X = X_C + X_E$
13.		=	$(T_s + \Delta)(X)$	Since $T_{vos}X_E > 0$; Δ = any positive number
14.	T_{2C1}	=	$(T_s + \Delta)$	The 2C1 taxation can be called the specific plus
15.	T_{2C1}	>	T_s	Tax rate using 2C1 is higher than the tax rate using specific taxation
	Compare *2C1* to the *ad valorem* tax method			
16.	$T_{2C1}(X)$	=	$T_sX_C + T_vX_E$	
17.		=	$(T_v + T_{sov})X_C + T_vX_E$	From 3
18.		=	$T_vX_C + T_{sov}X_C + T_vX_E$	
19.		=	$(T_vX_C + T_vX_E) + T_{sov}X_C$	
20.		=	$T_v(X_C + X_E) + T_{sov}X_C$	
21.		=	$T_v(X) + T_{sov}X_C$	Since $X = X_C + X_E$
22.		=	$(T_v + \Delta)(X)$	Since $T_{vos}X_E > 0$; Δ = any positive number
23.	T_{2C1}	=	$(T_v + \Delta)$	The 2C1 taxation can be called the *ad valorem* plus
24.	T_{2C1}	>	T_v	Tax rate using 2C1 is higher than the tax rate using *ad valorem* taxation
				Conclusion: 2C1 provides the highest tax rate, given the same tax revenue, compared to the specific and the *ad valorem* methods of taxation

Box 3 Comparison of overall alcohol consumption for specific, *ad valorem* and 'Two-Chosen-One' (2C1) taxation methods

				Explanation
25.	R_{2C1}	=	R_s	Compare alcohol consumption between two tax systems given the same tax revenue
26.	$T_{2C1}X_{2C1}$	=	T_sX_s	
27.	Since, T_{2C1}	>	T_s	From 15
28.	Then, X_{2C1}	<	X_s	Meaning the 2C1 taxation encourages lower alcohol consumption than does specific taxation
29.	R_{2C1}	=	R_v	Compare alcohol consumption between two tax systems given the same tax revenue
30.	$T_{2C1}X_{2C1}$	=	T_vX_v	
31.	Since, T_{2C1}	>	T_v	From 24
32.	Then, X_{2C1}	<	X_v	Meaning 2C1 taxation results in overall lower consumption than specific taxation
33.				Conclusion: 2C1 encourages lower alcohol consumption compared to both the specific and the *ad valorum* taxation methods, given neutral revenue

beverages (see lines 15 and 18 of Table 2a,b) compared to *ad valorem* taxation (see lines 11, 16 and 19 of Table 2a,b); (iii) 2C1 taxation favours medium alcohol content beverages (regardless of substitution effect) leading to relatively lower overall alcohol consumption compared to either specific and *ad valorem* taxation (see lines 15–20 of Table 2a,b); and (iv) because youth prefer low alcohol content beverages upon drinking initiation [23], 2C1 taxation, compared to specific taxation, leads to a barrier for drinking initiation among youth by heavily taxing the youth preferred beverages (compare line 12 to line 10 in each of Table 2a,b).

EMPIRICAL EVIDENCE

In addition to our theoretical analyses and simulation, there is also empirical evidence from Thailand that the 2C1 method has been effective. For the general relationship see [37]. The empirical evidence is as follows:

1. The overall level of abstention is higher than expected for a MIC with the GDP–PPP of Thailand (see above), and has remained stable for some years. In addition, drinking initiation of youth has not increased as expected, as evidenced by the high abstention rates in this age category (see above).
2. Adult *per-capita* consumption has stabilized in recent years (1997–2008) after a marked increase in consumption [8].
3. Time–series analyses indicated that tax increases in Thailand were associated with a decrease in alcohol consumption [38,39]. By studying the excise tax increases in Thailand in 2007 and 2009, Sornpaisarn and colleagues observed through bivariate time–series analyses that the price elasticity was −2.4 for beer and −0.8 for white spirits [39]. Additionally, Poapongsakorn and colleagues observed that alcohol consumption was associated with price changes of alcoholic beverages using data from 1978 to 2003. In their study, the price elasticity of beer was −2.7, the price elasticity of domestic brown spirits was −1.6 and the price elasticity of imported spirits was −0.6, controlling for the effects of *per-capita* income and annual alcohol advertising budgets [38].

DISCUSSION

Specific taxation has been shown to be appropriate for countries with a high prevalence of current drinker, as it discourages harmful patterns of alcohol consumption by promoting relatively inexpensive low alcohol content beverages; in countries with a high proportion of abstainers this system may encourage drinking initiation. 2C1 taxation may be more appropriate for countries with a high prevalence of abstainers, as it may prevent drinking initiation in addition to discouraging harmful patterns of alcohol consumption. However, more and better-controlled research to test the theoretical attributes of 2C1 is necessary.

Thailand has a high prevalence of life-time abstainers potentially vulnerable to persuasion, especially at young ages. In Thailand, those beverages which are most popular with, or desired by, youth are taxed using an *ad valorem* tax method, making them more expensive than under a specific tax method. We hypothesize that the stable percentage of current drinkers among Thai people aged 15–24 years between 2001 and 2007 (see above) can be seen as a consequence of high price due to 2C1 taxation despite the expected increase due to economic factors [8]. If Thailand were to shift from 2C1 taxation to specific taxation, the price of these beverages would decrease, probably resulting in an increase in drinking initiation. Under 2C1 taxation it is counterintuitive that wine coolers (low content beverage) and white spirits (see Table 1) are taxed at a lower rate than other beverages

Table 2a Hypothetical taxation and substitution effects on alcohol consumption of four alcoholic beverages with the same alcohol content, comparison among three taxation methods: specific (Sp), *ad valorem* (AV) and 'Two-Chosen-One' (2C1) taxation.

		Perceived quality				
		Very low	*Low*	*High*	*Very high*	
Line	*Alcohol beverage price*	*Very cheap*	*Cheap*	*Expensive*	*Very expensive*	
	Hypothetical example: four 1-litre spirits with similar 40 degree but different years of brew which are 2, 3, 4 and 5 years, respectively					
1	Alcohol content (litre of pure alcohol—LPA) (=1 × 40%)	0.4	0.4	0.4	0.4	
2	Year of brew (year)	2	3	4	5	
3	Pure alcohol price ($/litre of beverage—LOB) (=litre × $125/LPA)	50	50	50	50	
4	Cost of perceived quality ($) (=year × $10/year)	20	30	40	50	
5	Pre-tax price of alcoholic beverage ($/LOB) (=3 + 4)	70	80	90	100	
6	Pre-tax price of alcoholic beverage ($/LPA) (=5/1)	175	200	225	250	
	Taxes and prices after tax					
7	Specific tax ($/LPA) (=$125/LPA)	125	125	125	125	
8	*Ad valorem* tax ($/LPA) (=60% (exclusive) of pre-tax alcoholic beverage)	103	118	133	147	
9	2C1 tax ($/LPA) (=higher tax between Sp and AV)	125	125	133	147	
10	Post-tax price—Sp ($/LPA)	300	325	350	375	
11	Post-tax price—AV ($/LPA)	278	318	358	397	
12	Post-tax price—2C1 ($/LPA)	300	325	358	397	
	Alcohol consumption supposed equal market share, 25% for each beverage category; total consumer money used for alcohol consumption is constant at $21 250					Total
13	Amount of pre-tax alcohol consumption (LPA)	25	25	25	25	100
14	Money used for pre-tax alcohol consumption ($)	4375	5000	5625	6250	21 250
	Consumption after tax under a scenario of no substitution					Total
15	Amount of post-tax alcohol consumption—under Sp (LPA)	14.6	15.4	16.1	16.7	62.7
16	Amount of post-tax alcohol consumption—under AV (LPA)	15.7	15.7	15.7	15.7	62.9
17	Amount of post-tax alcohol consumption—under 2C1 (LPA)	14.6	15.4	15.7	15.7	61.4
	Consumption after tax under a scenario of 10% substitution					Total
18	Amount of post-tax alcohol consumption—under Sp (LPA)	13.5	15.4	16.1	17.5	62.5
19	Amount of post-tax alcohol consumption—under AV (LPA)	16.8	15.8	15.8	14.8	63.2
20	Amount of post-tax alcohol consumption—under 2C1 (LPA)	13.5	16.4	16.7	14.8	61.4

Table 2b Hypothetical taxation and substitution effects on alcohol consumption of four alcoholic beverages with the same perceived quality, comparison among three taxation methods: specific (Sp), *ad valorem* (AV) and 'Two-Chosen-One' (2C1) taxation.

		Alcohol content				
	Degree of alcoholic beverage	*5%*	*10%*	*25%*	*40%*	
Line	*Alcohol beverage type*	*Regular beer*	*Strong beer*	*Light spirit*	*Usual spirit*	
	Hypothetical example: four 1-litre alcoholic beverages with similar perceived quality but different alcohol content which are 5%, 10%, 25% and 40%, respectively					Average
1	Alcohol content (litres of pure alcohol—LPA) (=1 × degree)	0.05	0.10	0.25	0.40	0.2
2	Year of brew (year)	2	2	2	2	
3	Pure alcohol price ($/litres of beverage—LOB) (=litre × $125/LPA)	6.2	12.5	31.5	50.0	
4	Cost of perceived quality ($) (=year × $10/year)	20	20	20	20	
5	Pre-tax price of alcoholic beverage ($/LOB) (=3 + 4)	26.2	32.5	51.5	70.0	
6	Pre-tax price of alcoholic beverage ($/LPA) (=5/1)	525	325	205	175	
	Taxes and prices after tax					
7	Sp ($/LPA) (=$125/LPA)	125	125	125	125	
8	AV tax ($/LPA) (=60% (exclusive) of pre-tax alcoholic beverage)	310	192	121	103	
9	2C1 tax ($/LPA) (=higher tax between Sp and AV)	310	192	125	125	
10	Post-tax price—Sp ($/LPA)	650	450	330	300	
11	Post-tax price—AV ($/LPA)	835	517	326	278	
12	Post-tax price—*2C1* ($/LPA)	835	517	330	300	
	Alcohol consumption supposed equal market share, 25% for each beverage category; total consumer money used for alcohol consumption is constant at $30 750					Total
13	Amount of pre-tax alcohol consumption (LPA)	25	25	25	25	100
14	Money used for pre-tax alcohol consumption ($)	13 125	8125	5125	4375	30 750
	Consumption after tax under a scenario of no substitution					Total
15	Amount of post-tax alcohol consumption—under Sp (LPA)	20.2	18.1	15.5	14.6	68.4
16	Amount of post-tax alcohol consumption—under AV (LPA)	15.7	15.7	15.7	15.7	62.9
17	Amount of post-tax alcohol consumption—under 2C1 (LPA)	15.7	15.7	15.5	14.5	61.6
	Consumption after tax under a scenario of 10% substitution					Total
18	Amount of post-tax alcohol consumption—under Sp (LPA)	21.2	19.1	16.1	13.5	69.89
19	Amount of post-tax alcohol consumption—under AV (LPA)	14.80	15.54	15.38	16.40	62.13
20	Amount of post-tax alcohol consumption—under 2C1 (LPA)	14.80	17.06	16.68	13.54	62.07

with a similar price and alcohol content. These relatively low tax rates are the result of a government decision influenced by the political process and not inherent to the 2C1 taxation system itself.

Most countries consider alcohol taxation as a revenue generating tool rather than as a policy tool to reduce alcohol-related harms and thus to achieve public health goals. However, with increasing knowledge that the social costs of alcohol-attributable harms to an economy by far outweigh the taxation income (for Thailand, see [40]), this may change. Other LMIC with a high prevalence of abstainers and increasing alcohol consumption may benefit from the 2C1 taxation system, as it may reduce and control harmful patterns of alcohol consumption and help to prevent drinking initiation among youth. It may be difficult to implement such systems in LMIC without explicit societal consensus on treating alcohol policy mainly as a public health issue, but the current World Health Organization (WHO) global strategy [1] offers a change to achieve such a consensus in other countries and regions.

Economic analyses have recommended a combination of specific and *ad valorem* taxation systems under different circumstances [24,28,33–35]. The WHO *Technical Manual on Tobacco Tax Administration* [41] compared 2C1 taxation's theoretical properties, such as tax base and its impact on prices and health benefits with those of specific, *ad valorem*, mixed specific and *ad valorem* taxation, and minimum price taxation. It concluded that 2C1 has the potential to yield health benefits as it reduces downgrading, namely the reduction in the quality of a product, for example, by keeping filters on cigarettes.

An alternative solution to deterring initiation of drinking among youth in a country is to employ a minimum pricing policy. There are two main disadvantages to using a minimum pricing system compared to 2C1 taxation. First, minimum pricing increases the income of alcohol producers, which can be used to market alcohol, i.e. resulting in a consequence not necessarily advantageous for public health. Secondly, minimum pricing has no set taxation structure and, thus, could promote initiation of alcohol consumption by setting a low minimum price for low alcohol content high image beverages.

There are some limitations to the 2C1 tax method as currently applied in Thailand. First, for the specific taxation method, excise taxes are fixed unless they are calculated taking into account changes in the Consumer Price Index. Secondly, 2C1 requires more supporting information than does either of the specific or *ad valorem* taxation systems alone, as 2C1 requires information pertaining to beverage strengths and pricing. Additionally, more research is required to determine if taxation increases on low alcohol content beverages in LMIC will result in people switching from low alcohol content to medium alcohol content beverages. Similarly, the relationship between 2C1 taxation and unrecorded consumption [42] will have to be studied. However, until now, Thailand is estimated to have proportionally less unrecorded consumption than other LMIC [8].

Although taxation is one of the most effective measures to reduce alcohol consumption and the resulting harms, countries should formulate explicit and comprehensive alcohol policies on a national level (where appropriate, local and/or regional strategies may also be required) [1,43]. These strategies should not only rely on taxation but should include other measures, such as controlling the availability of alcohol, implementation and enforcement of advertising bans, and deterring alcohol-attributable harms through measures such as drink-driving programmes [43]. Additional research is required on the impact of a variety of factors, including the religious and/or cultural make-up of a country, to determine the potential effectiveness of different alcohol control measures.

CONCLUSION

Neither the *ad valorem* nor the specific taxation systems alone have the desired effects of decreasing harmful consumption of alcohol and deterring drinking initiation. 2C1 taxation targets both objectives simultaneously by applying the lowest tax to medium alcohol content beverages. The 2C1 taxation method may be an effective way of reducing alcohol-attributable harms in the short- and middle-term in LMIC with a high prevalence of abstainers, often life-time abstainers. Better-controlled research on the effectiveness of 2C1 taxation in various settings is necessary.

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Of course, the United States differs from Thailand in myriad respects, including income level and drinking patterns, but these national contexts are perhaps not so different that they cannot learn from each other.

Declarations of interest

None.

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TWO-CHOSEN-ONE TAXATION: EXAMINING ITS POTENTIAL EFFECTIVENESS TO REDUCE DRINKING INITIATION AND HEAVY ALCOHOL CONSUMPTION IN LOW- TO MIDDLE-INCOME COUNTRIES

We would like to thank the commentators for their thoughtful comments in response to our for debate contribution [1]. All commentators were in agreement that 'two-chosen-one' (2C1) taxation may have the potential to reduce alcohol consumption and drinking initiation in low- and middle-income countries (LMIC) which have a high prevalence of abstainers [1–5]. However, as noted in the paper and by the commentators, 2C1 taxation may have limitations in terms of unrecorded consumption, tax rate implementation and potential changes in beverage preferences.

Medina-Mora raises the concern of a potential shift in alcohol consumption towards unrecorded alcoholic beverages as taxation increases [5]. Such a shift may be associated with all taxation increases [6,7], and is not specific to 2C1 taxation. Our evidence base for control of unrecorded alcohol consumption is limited, but some measures exist and should be the subject of further study [7].

Sarntisart notes that *specific* taxation rates should be linked to an inflation index [3,8]; otherwise, the relative cost of the tax will decrease with inflation. 2C1 taxation has an advantage over specific (only) taxation in that the *ad valorem* component of 2C1 taxation will act as a taxation floor, which creates inflation-binding taxation. None the less, 2C1's specific tax rate should be linked with inflation. Sarntisart also raises the issue of companies reporting abnormally low ex-factory prices to reduce the *ad valorem* tax rate [9]. To resolve this problem, governments should implement measures to verify the accuracy of the ex-factory prices reported by the manufacturing companies and/or base *ad valorem* taxation on the retail price.

We agree with Österberg regarding the need for consistent taxation rates for similar beverages [4]; otherwise, the effectiveness of taxation will be less due to substitution effects [10]. In Thailand, differential tax rates have been the result of the political influence of alcohol companies [11], and such influences in general often hinder the implementation of best practices around the world. Österberg also raises the concern that changes in beverage preferences will decrease the effectiveness of the 2C1 taxation system. As 2C1 taxation levies a specific tax based on alcohol content on the cheapest alcoholic beverages which heavy consumers of alcohol purchase, 2C1 taxation will be effective in decreasing alcohol consumption among heavy drinkers.

We disagree with Cook's conclusion that age restrictions may be better than taxation in reducing drinking initiation in Thailand, as the US data upon which this conclusion was based examined the effects of taxation on 30-day abstinence, which is different from life-time abstention. Life-time abstention is an embedded value in the culture of Thailand and other LMIC countries, and half of drinkers in Thailand do not consume alcohol before the age of 20 years [12]. Although higher tax rates on beverages preferred by youth and on high-alcohol content beverages can be achieved through methods such as minimum pricing [13], this may lead to fair trade violations [14] and has the potential downside of increased profits going to the alcohol industry.

In summary, because LMICs typically have a high prevalence of life-time abstainers, an alternative view of alcohol control policies may be required which addresses simultaneously the issues of drinking initiation prevention among youths and of harmful alcohol consumption among heavy drinkers [15]. 2C1 taxation is a system which may accomplish both objectives. However, to implement 2C1 taxation effectively, governments need to implement equal tax rates among similar beverages, bind specific taxation rates to inflation, and either verify the accuracy of ex-factory price declarations or tie *ad valorem* taxation to alcohol retail prices.

Declarations of interest

None.

Keywords 2C1, *ad valorem*, alcohol, drinking initiation, heavy consumption, low-income country, middle-income country, specific, taxation.

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