



## Research Paper

# A composite index of provincial alcohol control policy implementation capacity in Thailand

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## ABSTRACT

**Background:** There is a well-published literature on the effectiveness and stringency of alcohol control policies, but not many studies focus on policy implementation, where policies transform into impact. The objective of this study is to create a composite index that measures the capacity for implementing effective alcohol control policies across all provinces in Thailand.

**Methods:** Based on the international literature, we developed a list of key indicators for tracking the implementation of alcohol policies at the subnational level. To ensure these indicators were relevant to the Thai context, we obtained feedback from Thai experts. We collected primary data according to the developed indicators using questionnaires filled in by key informants at the implementing agencies and gathered secondary data at the provincial level. On this basis, we developed indices that reflect the status of alcohol control policy implementation. We then investigated the association between the indices and the prevalence and pattern of alcohol consumption and alcohol-related harms while adjusting for potential confounders using multiple linear regression and negative binomial regression, respectively.

**Results:** Scores on the Provincial Alcohol Policy Implementation Capacity (PAPIC) Index ranged between 39 and 79. We found that each 1-point increase in PAPIC score was associated with a 1.98 % reduction in the quantity of alcohol consumed in grams per day (coefficient:  $-0.02$ ; 95 %CI:  $-0.03, -0.00$ ;  $p$ -value  $< 0.05$ ;  $e^{-0.02} = 0.9802$ ). We also found that for each 1-point increase in PAPIC score, the proportion of regular drinkers reduced by 0.30 per cent (coefficient:  $-0.30$ ; 95 %CI:  $-0.55, -0.05$ ;  $p$ -value  $< 0.05$ ). However, we did not find any association between the indices and alcohol-related harms.

**Conclusion:** The level of implementation of alcohol control policy at the sub-national level is associated with alcohol consumption levels. The findings suggest the value of allocating resources to the implementation of alcohol control policy.

## Introduction

Alcohol is a leading cause of death and disability globally, ranking seventh on both measures in 2016 (GBD 2016 Alcohol Collaborators, 2018). Reducing alcohol consumption is therefore one target of the United Nation's (UN) Sustainable Development Goals (SDGs) (United Nations, 2017). The UN had previously adopted the Political Declaration on Prevention and Control of NCDs, which includes alcohol control policies, among other measures (United Nations, 2011). Also seeking to reduce alcohol consumption and alcohol-related harms, in 2022, the

World Health Organization adopted the Global Alcohol Action Plan to Strengthen Implementation of the 2010 Global Strategy to Reduce the Harmful Use of Alcohol. The Global Action Plan recommends the implementation of effective alcohol control policies in countries to counter the harmful use of alcohol. At the country level, governments are facing the dual problem of inertia in adopting effective alcohol control laws (Allen et al., 2022) and challenges in translating effective policies into practice (World Health Organization, 2019).

Previous studies on the implementation of alcohol control policies have mostly used a qualitative approach to identify key barriers and

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facilitators to implementation (Jankhotkaew et al., 2022). Quantitative studies are also valuable for measuring progress in alcohol control policy implementation. In particular, a composite index is one method for comparing the progress of alcohol control policy implementation across countries. However, studies applying this method have mainly concentrated on the effectiveness and stringency of alcohol control policies (Brand et al., 2007; Ferreira-Borges et al., 2015; Joana & Sandro, 2018; Karlsson & Österberg, 2007; Leal-López et al., 2020). Only a few have integrated the potentially essential element of policy implementation, including in a composite index comparing countries in a specific region (Carragher et al., 2014), and more recently in impact measures reflecting implementation in a sample of countries (Casswell et al., 2022).

Implementation of alcohol control policies often happens at the subnational or local level. More importantly, alcohol control policy implementation is context-specific. Most studies measuring alcohol control policy implementation at the subnational level are set in high-income countries like the US (Blanchette et al., 2020; Naimi et al., 2014), Canada (Vallance et al., 2021), England (de Vocht et al., 2016), and Sweden (Nilsson et al., 2020). The focus of the North American studies is the stringency of local policies, while the latter two studies are concerned with implementation activities, policies and resources. However, indices of policy implementation are lacking for low- and middle-income countries, which differ in terms of their drinking culture, political climate, stage of economic development, as well as commitment to alcohol control policies among stakeholders. Therefore, this study attempts to create a composite index of provincial alcohol control policy implementation capacity in Thailand, an upper middle-income country where alcohol control laws are well established and already implemented in the form of four effective, best-buy policies (control of alcohol advertising, control of physical availability, drink-driving countermeasures, and alcohol taxation). The aim is to measure the status of alcohol policy implementation at the provincial level in Thailand.

### *Background to alcohol control policy in Thailand*

Thailand has a long history of alcohol control policy development. Currently, there are three main laws governing alcohol control policy in Thailand. First, the Alcoholic Beverage Control Act B.E. 2551 (2008) regulates alcohol advertising, physical availability, and alcohol treatment. After the adoption of the Act, various Ministerial Regulations were put in place to regulate alcohol advertising and control physical availability (e.g., limiting alcohol sales to certain hours, places and specific persons). Under the Act, there are three main committees: the National Alcohol Policy Committee, the Alcoholic Beverage Control Committee, and the Provincial Alcoholic Beverage Control Committee (the Provincial Committee). The Office of the Alcoholic Beverage Control Committee serves as the secretariat for the three committees. Operating across multiple government sectors, the Provincial Committee is the main agency responsible for implementing alcohol control policies at the provincial level. The second law is the Land Traffic Act B.E.2522 (1979), which regulates drink-driving behavior. The provisions of this Act are implemented by police officers under the command of the Chief of Provincial Office of the Royal Thai Police and Provincial Road Safety Committees (decision-making bodies at the provincial level). Third is the Excise Act B.E.2560 (2017), which regulates the taxation and licensing of alcohol sales and production (Waleewong et al., 2020). This Act is mainly implemented by officers of the Provincial Office of Excise Departments and its branches. Their main roles are collecting alcohol excise taxes (including earmarked taxes) and inspecting alcohol outlets and alcohol production factories to check for illicit sales and illicit alcohol production. They also check licenses for alcohol sales and alcohol production. These roles are authorized under the Excise Act B. E.2560 (2017).

This study is the first to create an index of alcohol control policy implementation at the subnational level in the low- and middle-income country context. Specifically, the aim is to create a composite index of

provincial alcohol control policy implementation capacity across all provinces in Thailand. The indices comprise the four best-buy alcohol policies, as mentioned earlier.

## **Methods**

### *Study design*

We applied mixed methods across six phases to develop a composite index of provincial alcohol control policy implementation capacity in Thailand. First, we undertook a scoping review to gather tools and indicators from the international literature. Second, we employed a qualitative approach using key informant interviews to develop the conceptual framework, indicators and tools used in the study. Third, we validated the framework, indicators, and tools through an expert consultative workshop. Next, we piloted questionnaires among key informants in two selected provinces to ensure they were understandable and readable. Fifth, we applied a quantitative approach by conducting a self-administered survey among key informants across all provinces in Thailand, and we also gathered secondary data from the relevant organizations. Last, we conducted data analysis to generate the index (see the flowchart illustrating the methods of the study in the supplement, Fig. 1A). We followed the recommended steps from the OECD handbook on constructing composite indicators (OECD, 2008). We focused on effective policies that are mainly regulatory (see a summary of effective alcohol control policies in Thailand in the supplement, Table 1A). Below, we outline the phases of developing the composite index, describing the participants and procedure for each step.

#### *Phase 1: Theoretical framework and indicator development: Mapping tools and indicators from the international literature*

We conducted a scoping review to map tools and indicators for assessing policy implementation by searching two main databases: SCOPUS and Web of Science. Further detail on the review method is provided elsewhere (Jankhotkaew et al., 2023). We also conducted a scoping review of barriers and facilitators for the implementation of effective policies to ensure we captured important indicators for measuring alcohol control policy implementation (Jankhotkaew et al., 2022).

#### *Phase 2: Theoretical framework and indicator development: Adaptation of the indicators and tools for the Thai context*

##### a) Participants

The key informants for the semi-structured interviews were purposefully selected to conceptualize and suggest possible indicators. Snowball sampling was also applied. The key informants included governmental officers and members of academia and civil society who had been involved in supporting policy implementation at the national level, and those involved in policy implementation at the provincial level. We conducted interviews with ten people (four government officers at the national level, two civil society organization (CSO) members at the national level, two CSO members at the regional level, one academic at the national level, and one government officer at the provincial level).

##### b) Procedures

Three steps were involved in developing the theoretical framework so that the indicators and tools fit the Thai context. First, to ensure the tools and indicators collated from the international literature were relevant to the Thai context, we conducted a narrative review of the existing regulations to understand the content, context, and policy processes around the four effective alcohol policies in Thailand, both at



**Table 1**  
Indicators of indices for each policy measure.

| No. | Indicators  | Advertisement | Physical availability | Drink-driving | Taxation |
|-----|---|---------------|-----------------------|---------------|----------|
|     | <b>Policy capacity at provincial level</b>  |               |                       |               |          |
|     | <b>Political capacity</b>   |               |                       |               |          |
| 1   | Establishment of written policy   | ✓             | ✓                     | ✓             | ✓        |
| 2   | Number of policy champions  | ✓             | ✓                     | ✓             | ✓        |
| 3   | Establishment of Sub-committee of the Provincial Alcoholic Beverage Control Committee (Provincial Committee) with engagement of civil society members | ✓             | ✓                     | NA            | NA       |
| 4   | Establishment of Sub-Committee on Provincial Road Safety Committee on Law enforcement   | NA            | NA                    | ✓             | NA       |
|     | <b>Analytical capacity or technical capacity</b>  |               |                       |               |          |
| 5   | Number of technical support persons   | ✓             | ✓                     | ✓             | NA       |
| 6   | Number of lawyers who provide legal support   | ✓             | ✓                     | NA            | NA       |
|     | <b>Operational capacity</b>   |               |                       |               |          |
| 7   | Establishment of communication channel  | ✓             | ✓                     | ✓             | NA       |
| 8   | Number of officers who enforce specific laws per 1,000 alcohol outlets  | ✓             | ✓                     | NA            | ✓        |
| 9   | Number of officers who support implementation of specific laws per 1,000 alcohol outlets  | ✓             | ✓                     | NA            | ✓        |
| 10  | Budget for law enforcement per capita   | ✓             | ✓                     | ✓             | NA       |
| 11  | Number of officers who enforce drink-driving measures per 100,000 driving licenses  | NA            | NA                    | ✓             | NA       |
| 12  | Number of officers who support implementation of drink-driving measures per 100,000 driving licenses  | NA            | NA                    | ✓             | NA       |
| 13  | Sufficiency of alcohol breathalyzers  | NA            | NA                    | ✓             | NA       |
| 14  | Number of alcohol breathalyzers per 100,000 driving licenses  | NA            | NA                    | ✓             | NA       |
|     | <b>Implementation process for</b>   |               |                       |               |          |

**Table 1 (continued)**

| No. | Indicators  | Advertisement | Physical availability | Drink-driving | Taxation |
|-----|---|---------------|-----------------------|---------------|----------|
|     | <b>strengthening law enforcement</b>  |               |                       |               |          |
| 15  | Using evidence-based action, using evidence for decision making, planning, and action   | ✓             | ✓                     | ✓             | ✓        |
| 16  | Frequency of meetings of the Provincial Committee   | ✓             | ✓                     | NA            | NA       |
| 17  | Frequency of meeting of sub-committee of the Provincial Committee   | ✓             | ✓                     | NA            | NA       |
| 18  | Frequency of having agenda on drink-driving during meetings of the Provincial Road Safety Committee or Sub-Committee of the Provincial Road Safety Committee on Law Enforcement | NA            | NA                    | ✓             | NA       |
| 19  | Number of staff trained on law content and law enforcement  | ✓             | ✓                     | ✓             | ✓        |
| 20  | Number of activities around providing education/raising awareness for the public and alcohol outlets  | ✓             | ✓                     | ✓             | ✓        |
|     | <b>Implementation processes: Law enforcement</b>  |               |                       |               |          |
| 21  | Intensity: Frequency of law enforcement at social events or festivals at provincial level   | ✓             | NA                    | NA            | NA       |
| 22  | Intensity: Frequency of online monitoring of alcohol advertising violation  | ✓             | NA                    | NA            | NA       |
| 23  | Intensity: Frequency of outlet inspection regarding alcohol advertising control   | ✓             | NA                    | NA            | NA       |
| 24  | Coverage: Percentage of alcohol outlets that have been inspected regarding alcohol advertising control  | ✓             | NA                    | NA            | NA       |
| 25  | Intensity: Percentage of reported cases that have been prosecuted regarding alcohol advertising control   | ✓             | NA                    | NA            | NA       |

(continued on next page)

Table 1 (continued)

| No. | Indicators  | Advertisement | Physical availability | Drink-driving | Taxation |
|-----|---|---------------|-----------------------|---------------|----------|
| 26  | Intensity: Frequency of outlet inspection regarding alcohol sales in certain places   | NA            | ✓                     | NA            | NA       |
| 27  | Intensity: Frequency of outlet inspection regarding control of alcohol sales on certain days  | NA            | ✓                     | NA            | NA       |
| 28  | Intensity: Frequency of outlet inspection regarding control of alcohol sales at certain times   | NA            | ✓                     | NA            | NA       |
| 29  | Intensity: Frequency of outlet inspection regarding control of alcohol sales to underage drinkers                                       | NA            | ✓                     | NA            | NA       |
| 30  | Coverage: Percentage of outlets that have been inspected by officers regarding restriction of alcohol sales on certain days             | NA            | ✓                     | NA            | NA       |
| 31  | Coverage: Percentage of outlets that have been inspected by officers regarding restriction of alcohol sales at certain times            | NA            | ✓                     | NA            | NA       |
| 32  | Coverage: Percentage of outlets that have been inspected by officers regarding restriction of alcohol sales to underage drinkers        | NA            | ✓                     | NA            | NA       |
| 33  | Intensity: Percentage of reported cases that have been prosecuted regarding physical availability control                               | NA            | ✓                     | NA            | NA       |
| 34  | Intensity: Frequency of law enforcement by setting up sobriety check points   | NA            | NA                    | ✓             | NA       |
| 35  | Coverage: Percentage of drivers who have experienced alcohol breath testing   | NA            | NA                    | ✓             | NA       |
| 36  | Intensity: Frequency of law enforcement among alcohol outlets regarding Excise Act B. E.2560 (2017) and related ministerial regulations | NA            | NA                    | NA            | ✓        |

Table 1 (continued)

| No. | Indicators   | Advertisement | Physical availability | Drink-driving | Taxation |
|-----|--|---------------|-----------------------|---------------|----------|
| 37  | Coverage: Percentage of outlets that have been inspected by officers regarding Excise Act B. E.2560 (2017) and related ministerial regulations | NA            | NA                    | NA            | ✓        |
|     | <b>Total numbers of indicators</b>   | <b>19</b>     | <b>22</b>             | <b>16</b>     | <b>9</b> |

NA: Not applicable

goals (Wu et al., 2015). We also integrated the Implementation Model to Increase the Effectiveness of Alcohol Control Policies, thereby incorporating implementation processes not covered in the Framework. These were processes for implementing the law (e.g., frequency of committee meetings), educating the public and staff, enforcement, and monitoring and evaluation (Jones-Webb et al., 2014).

*Phase 3: Theoretical framework and indicator development: Validation of the indicators and tools with the Thai experts*

a) Participants

We conducted a workshop with experts from both the national and provincial levels. We purposively selected experts at the national level based on the list of organizations mentioned in the joint assessment report by Waleewong et al. (2020). At the provincial level, we purposively selected two provinces (i.e., with the most and the least implemented policies) for each of the four regions (north, northeast, south, and central) and Bangkok. We decided to focus on those with the most and least implemented alcohol policies because we wanted to identify indicators that reflected levels of implementation across all regions. The criteria for provinces with higher levels of implementation were regular, at least yearly meetings of the Provincial Committee over the past three years; reporting of prosecuted cases; and regular law enforcement through setting up regular monitoring of law compliance among alcohol retailers (at least twice a year) over the last three years. Conversely, the provinces deemed to have low implementation levels did not meet these criteria. The provincial experts had to be involved in policy implementation at the provincial level. These experts included governmental officers and civil society members. One civil society member at the provincial level, one civil society member at the national level, one academic at the national level and three governmental officers at the provincial level were unable to attend the workshop. In total, 21 participants participated in the workshop: 11 from the government sector (3 national level, and 8 provincial or regional level), five academics (all national level), and five civil society members (3 national level, and 2 regional level).

b) Procedures

We conducted the expert consultative workshop online, with the Thai experts commenting on the conceptual framework, draft indicators, and the tool. The workshop was organized as follows: 1) presentation of the overall project; 2) the experts comment on the conceptual framework; 3) the experts comment on the indicators for assessing policy implementation; and 4) the experts comment on the draft tool. However, we were only able to cover the first three issues during the workshop. We therefore asked participants to provide written comments on the tool via e-mail. After the workshop, we revised the indicators in accordance with the experts' comments. We then confirmed the deletion or insertion of indicators using two methods. First, we sent an e-mail to the experts who

attended the workshop to inform them of the changes, allowing two weeks for comment and feedback. Second, to ensure the indicators' relevancy to policy implementation, we also confirmed deletions and insertions with governmental officers at the provincial level.

#### Phase 4: Piloting the tool

##### a) Participants

We selected members of the Provincial Alcoholic Beverage Control Committee (Provincial Committee) in two provinces to test the questionnaire. These key stakeholders are responsible for the implementation of alcohol control policy at the provincial level. The testing involved 29 key informants across the two provinces (one person was not available). We tightened the selection criteria for the best and worst provinces in terms of implementation compared with phase 3. The three main criteria were: 1) the Provincial Committee meeting at least four times within three years; 2) having regular law enforcement (i.e., at least 1,000 alcohol outlets inspected over the past three years); and 3) reporting more than 20 prosecuted cases over the last three years.

##### b) Procedures

The main purpose of the pilot was to test understanding of the questionnaire. We tested the questionnaire using an online form, also asking participants about the availability of data for the indicators gathered from secondary sources. We asked key informants to reflect on their understanding of the questionnaire and the availability of the data. After piloting, we revised the questionnaire and indicators in line with suggestions from the key informants.

#### Phase 5: data collection

##### a) Participants

In total, five key informants per province were invited to participate. They represented the following five organizations: the Provincial Office of the Ministry of Public Health, the Provincial Office of the Excise Department, the Provincial Office of Mitigation and Disaster Relief, the Provincial Office of the Royal Thai Police, and CSOs. These organizations are key to implementing alcohol policies. Seven provinces have more than one branch of the Provincial Office of the Excise Department, so we randomly selected one branch.

##### b) Procedures

We sent questionnaires to key informants at the provincial level, asking them to fill these in online. The response rate for the survey was 81 per cent (312/385). For some indicators, data were available at the national level of the organizations. We therefore obtained data such as the number of reported cases prosecuted and the percentage of drivers who experienced alcohol breath testing at the national level to reduce the burden on our key informants. We collected data from August to October 2022. However, due to issues with the availability of key informants, we extended the data collection period to January 2023. We made up to three follow-up phone calls after the initial contact. Researchers from the project also joined regional meetings attended by key informants at the provincial level to encourage their participation. If key informants had already provided data but there were unclear answers, we later contacted them for clarification. We invited key informants working under the Ministry of Public Health to an online Zoom meeting to request their cooperation. During the meeting, we explained the questionnaire and provided supporting documents. Unfortunately, 22 provinces were unable to attend the online meeting. However, we made individual calls to explain the details instead.

We asked key informants to recall the implementation of alcohol

control policy at the provincial level in 2019, prior to the disruptions to policy implementation caused by COVID-19. We also asked key informants to provide supporting information or documents where available.

#### Phase 6: Analysis methods

##### a) Dealing with missing data

There was on average 13 percent missing data for the various indicators. We applied two main methods to address this, namely using data from the nearest-neighboring province and median replacement. We applied data from the nearest-neighboring provinces because neighboring provinces have similar drinking cultures (Assanangkornchai, 2019). We excluded one province due to it having no available data for any indicators.

##### b) Normalization of data

We applied the tertile approach to normalize the data (OECD, 2008). Specifically, for the continuous variables, we categorized the provinces into three groups using the tertile method. Provinces that fell into group 1 received a score of 1, and those falling into group 3 received a score of 3. For those provinces that reported 0, we replaced the score with 0 instead. Then, we rescaled the scores from 0 to 1 by dividing by 3. While the OECD suggests using percentiles, due to the limited number of provinces we applied tertiles instead.

##### c) Weight and aggregation

We applied expert opinion using Delphi techniques to weight the implementation indicators (see list of indicators in Table 1) (Nelson et al., 2013). We set up a workshop with experts based on the list provided in the Joint Assessment Report by Waleewong et al. (2020). Twelve experts attended the meeting and completed the survey (11 experts had experience in the implementation of alcohol control policies across all policies and one for drink-driving countermeasures alone). This phase of the research involved three stages. First, we sent questionnaires to the experts to fill in before the meeting. We then circulated the findings to the experts via email, followed by the workshop where the experts were able to clarify unclear indicators. After the workshop, we asked the experts to fill in the questionnaire again (see weighted scores in supplementary Table 2A and Table 2B).

To obtain the overall index, we multiplied the index of each policy measure by the weighted scores and later estimated the sum of the indices of the different policy measures: alcohol advertising control, control of physical availability, drink-driving control, and alcohol taxation policies. After weighting, we rescaled the scores on a 0–100 scale by dividing the scores by the maximum scores and multiplying by 100. To obtain the specific indices of different policy measures, we divided the specific policy scores with maximum scores and multiplied by 100.

##### d) Associations between the indices and alcohol consumption patterns and alcohol-related harms

We tested the validity of the index by investigating the associations between the indices and the quantity of alcohol consumed, alcohol consumption patterns, rates of alcohol-related road traffic injuries, and alcoholic liver cirrhosis – both inpatient and deaths. Alcohol-related road traffic injuries and deaths in 2019 were determined through injury surveillance at emergency departments collected by the Ministry of Public Health, Thailand. The measures were based on the observations of medical officers, inquiries made by medical officers to patients, and alcohol breath or blood tests, depending on the specific circumstances of each case. We also gathered secondary data on alcoholic liver

**Table 2**  
Overall index and rank on overall index by province.

| Province            | Overall index | Rank on overall index |
|---------------------|---------------|-----------------------|
| Nan                 | 79.3          | 1                     |
| Phitsanulok         | 79.1          | 2                     |
| Amnat Charoen       | 76.7          | 3                     |
| Sing buri           | 75.7          | 4                     |
| Ranong              | 75.6          | 5                     |
| Surin               | 75.4          | 6                     |
| Mae Hong Son        | 75.0          | 7                     |
| Sukhothai           | 74.5          | 8                     |
| Chumphon            | 73.6          | 9                     |
| Maha Sarakham       | 72.6          | 10                    |
| Sakon Nakhon        | 71.6          | 11                    |
| Satun               | 69.8          | 12                    |
| Nakhon Ratchasima   | 69.4          | 13                    |
| Chai Nat            | 68.8          | 14                    |
| Phayao              | 68.7          | 15                    |
| Udon Thani          | 68.5          | 16                    |
| Tak                 | 68.5          | 17                    |
| Krabi               | 67.8          | 18                    |
| Nong Bua Lamphu     | 67.5          | 19                    |
| Lamphun             | 66.5          | 20                    |
| Ang Thong           | 66.3          | 21                    |
| Loei                | 66.2          | 22                    |
| Phetchaburi         | 66.1          | 23                    |
| Khonkaen            | 65.5          | 24                    |
| Sa Kaeo             | 65.1          | 25                    |
| Pattani             | 64.2          | 26                    |
| Mukdahan            | 63.7          | 27                    |
| Trang               | 63.4          | 28                    |
| Roi Et              | 63.1          | 29                    |
| Yala                | 62.5          | 30                    |
| Ratchaburi          | 62.5          | 31                    |
| Sisaket             | 62.1          | 32                    |
| Bangkok             | 61.6          | 33                    |
| Nong Khai           | 61.5          | 34                    |
| Chachoengsao        | 60.7          | 35                    |
| Samut Prakan        | 60.4          | 36                    |
| Prachuap Khiri Khan | 60.4          | 37                    |
| Kanchanaburi        | 60.0          | 38                    |
| Buri ram            | 60.0          | 39                    |
| Trat                | 59.8          | 40                    |
| Ayutthaya           | 59.6          | 41                    |
| Phetchabun          | 59.6          | 42                    |
| Phatthalung         | 59.3          | 43                    |
| Phara               | 59.1          | 44                    |
| Nakhom Sawan        | 58.8          | 45                    |
| Chonburi            | 58.5          | 46                    |
| Kalasin             | 58.3          | 47                    |
| Rayong              | 58.1          | 48                    |
| Samut Sakhon        | 57.9          | 49                    |
| Chiang Rai          | 57.5          | 50                    |
| Phichit             | 57.4          | 51                    |
| Chiang Mai          | 56.1          | 52                    |
| Lampang             | 56.0          | 53                    |
| Chaiyaphum          | 55.8          | 54                    |
| Surat Thani         | 55.7          | 55                    |
| Bueng Kan           | 55.7          | 56                    |
| Lop Buri            | 55.4          | 57                    |
| Phang Nga           | 55.3          | 58                    |
| Phuket              | 55.2          | 59                    |
| Nakhon Phanom       | 54.8          | 60                    |
| Saraburi            | 54.7          | 61                    |
| Uttaradit           | 54.5          | 62                    |
| Kamphaengphet       | 53.4          | 63                    |
| Nakhon Pathom       | 53.4          | 64                    |
| Suphan Buri         | 53.1          | 65                    |
| Uthai Thani         | 53.0          | 66                    |
| Prachin Buri        | 51.8          | 67                    |
| Samut Songkhram     | 50.0          | 68                    |
| Nakhon Si Thammarat | 49.9          | 69                    |
| Ubon Ratchathani    | 49.7          | 70                    |
| Pathum Thani        | 47.2          | 71                    |
| Nonthaburi          | 46.6          | 72                    |
| Narathiwat          | 46.4          | 73                    |
| Chanthaburi         | 46.2          | 74                    |
| Nakhon Nayok        | 40.3          | 75                    |
| Songkhla            | 38.6          | 76                    |

cirrhosis from the Ministry of Public Health. The alcoholic liver cirrhosis measures in 2019 were based on inpatients diagnosed with alcoholic liver cirrhosis (ICD-10: K70) and deaths from alcoholic liver cirrhosis. Deaths from alcoholic liver cirrhosis were identified using data from death registries, which were cross-checked with hospital records to ensure accuracy and completeness by the staff of Ministry of Public Health. We calculated age-standardized morbidity and mortality rates for alcoholic liver cirrhosis. For alcohol-related road traffic injuries, we received data on total case numbers in each province for age groups below 20 years and 20 years and above. Consequently, we calculated the rates of alcohol-related road traffic injuries by dividing the numbers of such injuries by the total population within those age groups.

Alcohol consumption data was derived from a national survey conducted by the National Statistical Office in 2017, which utilized provincially representative samples. The 2017 survey was chosen because it is the only survey data available. Three key measures were employed to investigate alcohol consumption patterns. Firstly, alcohol consumption was calculated based on beverage-specific questionnaires completed by drinkers. Respondents were asked to list the three beverages they most frequently consumed in the past 12 months. Subsequently, their drinking frequency, the type and quantity of drinking containers used, and the number of units consumed were assessed. This information allowed for the estimation of overall alcohol consumption, which was then converted into a daily consumption figure by dividing by 365 days. Mean consumption per day (grams of pure alcohol per day) was chosen over the median, as median values across all provinces were found to be consistently zero. We transformed the quantity of alcohol consumption among drinkers into log form because it was not normally distributed. Secondly, binge drinking was determined through specific survey questions, identifying individuals who consumed more than five standard drinks or 50 grams in one occasion within the past 12 months. Thirdly, regular drinkers were defined as those who consumed alcohol on a weekly basis in the same time frame. Weighted analysis was employed to ensure the provincial representativeness of the samples.

We applied multiple linear regression to investigate the associations between the indices and the quantity of alcohol consumed and alcohol consumption patterns. We tested the main assumptions of linear regression, including normality of the outcomes (using Shapiro-wilk test), linear association (using scatterplots), homoscedasticity (using Breusch-Pagan /Cook-Weisberg test for heteroskedasticity), and multicollinearity (using the correlation coefficient). All assumptions were met.

We adjusted for potential confounders, including Gross Provincial Products (GPP) (Thai baht), (Cohen et al., 2002), regions (Central, North, Northeast, and South) (Chaiyasong & Thamarangsi, 2016), population percentage of Muslims (Jankhotkaew et al., 2023), and location of provinces in relation to tourist areas.

We applied negative binomial regression to investigate the association between the indices and rates of alcohol-related road traffic injuries and age-standardized alcoholic liver cirrhosis, both inpatient and deaths. We applied negative binomial regression rather than poisson regression due to the data not fitting a poisson distribution. We adjusted for region and population percentage of Muslims in calculating the association between the indices and age standardization of alcoholic liver cirrhosis. The region reflects different drinking cultures. People from the northern and northeastern regions reported a higher prevalence of alcohol consumption compared to the south and central regions (Chaiyasong & Thamarangsi, 2016). We adjusted for percentage of Muslim population because provinces with higher numbers of Muslims will have a lower prevalence of alcohol consumption, reflecting religious restrictions (Khamis et al., 2022). Region and percentage of Muslim population are associated with drinking prevalence, and in turn alcoholic liver cirrhosis and alcohol-related road traffic injuries. We did not adjust for GPP and areas of tourism in the models because we did not find associations between these two factors and age standardization of alcoholic liver cirrhosis. In addition, we did not find any statistically

significant association between the percentage of Muslims, GPP, and areas of tourism and alcohol-related road traffic injuries; therefore, we only adjusted for region to calculate the association between the indices and alcohol-related road traffic injuries. Moreover, we analyzed the association between the indices and alcohol-related road traffic injuries for two separate age groups, the population aged below 20 years and those aged 20 years and above. However, the differences were not statistically significant between the two age groups and therefore we reported the association between the indices and alcohol-related road traffic injuries for the overall population.

e) Conducting sensitivity analysis

We applied two methods to investigate the variability of the index. First, to deal with missing data from the provinces that provided no data, we applied median replacement because the continuous variables were skewed, comparing the findings with the nearest-province replacement. We also investigated both weighted and unweighted scores of the index. We employed unweighted scores to investigate the variability of the index, comparing the findings with weighted scores. In applying weighted and unweighted scores, we also employed two methods of dealing with missing data: nearest-neighboring provinces and median replacement.

**Ethical issues**

The study was approved by the Mahasarakham University Ethics Committee for Research Involving Human Subjects in Thailand (Approval number: 166-100/2022). In the participant information sheet, we provided information about the project and participants' right to terminate their involvement in the study at any time.

**Results**

*The provincial alcohol control policy implementation capacity index (PAPIC) in Thailand*

The mean of the overall index was 61.0 (Standard Deviation: 8.8), spanning a range from 79.3 to 38.6. The five provinces with the highest PAPIC scores, indicating strong implementation, were Nan (northern region), Phitsanulok (lower northern region), Amnat Charoen (north-eastern region), Singburi (central region), and Ranong (southern region). The lowest PAPIC scores were received by Songkhla (southern region), Nakhon Nayok (central region), Chantaburi (eastern region), Narathiwat (southern region), and Nonthaburi (central region) (Table 2 & Fig. 1). We also determined the variation in the indices for different policy measures across provinces in Thailand (Supplementary Fig. 2A-2D and Table 3A-D).

**Table 3**

The associations between the provincial alcohol control policy implementation capacity index and alcohol consumption patterns.

| Variables                    | Quantity consumed     | Prevalence of alcohol consumption | Proportion of binge drinkers | Proportion of regular drinkers | Prevalence of youth drinkers |
|------------------------------|-----------------------|-----------------------------------|------------------------------|--------------------------------|------------------------------|
| PAPIC                        | -0.02 (-0.03, -0.00)* | 0.05 (-0.11, 0.21)                | -0.05 (-0.32, 0.22)          | -0.30 (-0.55, -0.05)*          | -0.02 (-0.18, 0.14)          |
| Gross Provincial Products    | 0.00 (-0.01, 0.01)    | -0.01 (-0.12, 0.09)               | 0.31 (0.13, 0.49)*           | -0.13 (-0.30, 0.04)            | -0.05 (-0.16, 0.05)          |
| Areas of tourism (No vs Yes) | -0.10 (-0.37, 0.18)   | 4.19 (0.87, 7.38)*                | -4.74 (-10.27, 0.78)         | -1.78 (-6.95, 3.39)            | 4.50 (1.23, 7.76)*           |
| Regions (Central-reference)  |                       |                                   |                              |                                |                              |
| North                        | -0.26 (-0.61, 0.09)   | 8.00 (3.86, 12.13)*               | 8.93 (1.90, 15.96)*          | -4.72 (-11.30, 1.86)           | 6.18 (2.03, 10.34)*          |
| Northeast                    | -0.65 (-1.00, 0.30)   | 4.64 (0.42, 8.86)                 | 10.93 (3.77, 18.10)*         | -11.70 (-18.41, -5.00)*        | 4.29 (0.06, 8.53)*           |
| South                        | -0.16 (-0.60, 0.27)   | -6.13 (-11.31, -0.96)*            | 9.77 (0.98, 18.56)*          | -3.26 (-11.49, 4.96)           | -3.90 (-9.10, 1.29)          |
| Percent of Muslims           | -0.00 (-0.01, 0.01)   | -0.19 (-0.29, -0.09)*             | -0.05 (-0.23, 0.12)          | 0.06 (-0.10, 0.22)             | -0.08 (-0.19, 0.02)          |
| Constant                     | 2.52 (1.67, 3.37)     | 20.71 (10.59, 30.84)              | 36.25 (19.06, 53.45)         | 70.19 (54.10, 86.28)           | 9.92 (-0.25, 20.08)          |
| Adjusted-R square            | 0.28                  | 0.62                              | 0.11                         | 0.22                           | 0.38                         |

\*p-value<0.05; PAPIC: index of the provincial alcohol control policy implementation capacity

*Associations between the provincial alcohol control policy implementation capacity index (PAPIC) and alcohol consumption patterns*

We found an association between the PAPIC and alcohol consumption per drinker and by proportion of regular drinkers. Each 1-point increase in PAPIC score was associated with a 1.98 % reduction in alcohol consumption in grams per day (coefficient: -0.02; 95 %CI: -0.03, -0.00; p-value<0.05;  $e^{-0.02} = 0.9802$ ). Also, every 1-point increase in PAPIC score was associated with a 0.30 reduction in the proportion of regular drinkers (coefficient: -0.30; 95 %CI: -0.55, -0.05; p-value<0.05) (Table 3).

When we investigated associations between indices for more specific measures, we found that the index of implementation of alcohol advertising control was negatively associated with quantity consumed among drinkers. We also found that for every 1-point increase in the score for alcohol advertising control, the quantity of alcohol consumed decreased by 1.98 % (coefficient: -0.02; 95 %CI: -0.03, -0.00; p-value <0.05;  $e^{-0.02} = 0.9802$ ). We also found a negative association between the indices of alcohol advertising control and physical availability and the proportion of regular drinkers. We found that for every 1-point increase in the score for alcohol advertising control, the proportion of regular drinkers decreased by 0.30 per cent (coefficient: -0.30; 95 %CI: -0.50, -0.09; p-value <0.05). We also found that for every 1-point increase in the score for physical availability control, the proportion of regular drinkers decreased by 0.31 per cent (coefficient: -0.31; 95 %CI: -0.50, -0.11; p-value <0.05). However, we did not find any association between the indices of drink-driving measures and alcohol taxation policy and patterns of alcohol consumption (Table 4).

*The association between the provincial alcohol control policy implementation capacity index and alcohol-related harms*

We found no statistically significant results for the association between the PAPIC and alcohol-related harms (Table 5), nor did we find any association between the indices of implementation for different policy measures and alcohol-related harms (Table 6).

*Sensitivity analysis*

When we compared the scores and ranking of provinces using sensitivity analysis, median replacement of missing data, and unweighted scores, we found the scores and ranking were not that different. For example, Nan province ranked number one on the overall PAPIC, with province rankings ranging between 1 and 2. Nan received a score of 79.3, with province scores ranging between 76.8 and 79.3 (see supplementary Table 4A).

We conducted a sensitivity analysis using the median replacement of missing data. We found the same association between the indices and

**Table 4**

The associations between the provincial alcohol control policy implementation capacity index, considering different policy measures, and alcohol consumption patterns

| Variables             | Quantity consumed         | Prevalence of alcohol consumption | Proportion of binge drinkers | Proportion of regular drinkers | Prevalence of youth drinkers |
|-----------------------|---------------------------|-----------------------------------|------------------------------|--------------------------------|------------------------------|
| Alcohol advertising   | -0.02 (-0.03, -0.00)<br>* | 0.03 (-0.10, 0.16)                | -0.02 (-0.24, 0.21)          | -0.30 (-0.50, -0.09)*          | -0.01 (-0.14, 0.12)          |
| Physical availability | -0.01 (-0.01, 0.00)       | 0.04 (-0.09, 0.17)                | 0.01 (-0.20, 0.23)           | -0.31 (-0.50, -0.11)*          | 0.05 (-0.07, 0.18)           |
| Drink-driving         | -0.01 (-0.02, 0.00)       | 0.06 (-0.08, 0.20)                | -0.11 (-0.35, 0.12)          | -0.10 (-0.33, 0.12)            | -0.04 (-0.17, 0.10)          |
| Alcohol taxation      | -0.01 (-0.02, 0.00)       | -0.00 (-0.10, 0.10)               | -0.01 (-0.18, 0.17)          | -0.06 (-0.23, 0.11)            | -0.04 (-0.14, 0.06)          |

\*\**p*-value<0.05; The models were adjusted for Gross Provincial Products, areas of tourism, regions, and percent of Muslim population

alcohol consumption patterns (Table 4B) and alcohol-related harms (Table 4C). We also conducted a sensitivity analysis using unweighted methods and found that the association between the indices and alcohol consumption patterns and alcohol-related harms were similar to those using weighted methods (Table 4D-4E).

## Discussion

Our study is the first to create an index of alcohol control policy implementation for the four most effective policies at the sub-national level in the low- and middle-income country context. The findings show that the overall index and the index for the implementation of alcohol advertising control are associated with the quantity of alcohol consumption and the proportion of regular drinkers. We also found an association between the index for physical availability control and the proportion of regular drinkers. However, the indices show no association with alcohol-related harms.

When we compared our findings with a Swedish study that developed indices based on implementation components (i.e., resources, policies, cooperation, supervisions and licenses, activities), we found similar results associating an increase in the indices with alcohol consumption (Nilsson et al., 2020). When we compared the findings of our study with previous research using indices based on the stringency of alcohol control policies at the state level and patterns of alcohol consumption, such as in the US, we found notable differences. The previous study showed that these indices were associated with binge drinking (Naimi et al., 2014), whereas our study did not find a significant association in this regard. Instead, our study found that the PAPIC index was associated with the proportion of regular drinkers. It might be that this association is due to the low prevalence of alcohol consumption in Thailand: Nationally, one-third of Thai are drinkers (National Statistical Office, 2017). The reason for the lack of a relationship between the PAPIC index and binge drinking is not known.

In addition, we report similar findings compared to previous studies that have investigated the association between the indices of policy stringency across countries and alcohol consumption per capita (Carragher et al., 2014; Casswell et al., 2022). However, the PAPIC index further contributes a detailed focus on policy implementation. This is very important because policies do not automatically translate into action, which requires resources and the commitment of policymakers and operational staff at all levels. Furthermore, we also controlled for potential confounding factors, whereas other studies have created indices based on effectiveness by applying correlation coefficients (Brand et al., 2007; Casswell et al., 2022). This study, therefore, has a stronger design in terms of taking into account factors that affect the indices and outcomes.

The study findings show that the indices for implementation of two policy measures, control of alcohol advertising and control of physical availability, were associated with the proportion of regular drinkers. These policy domains were measured by the extent to which the provincial authorities conducted inspections of outlets and social events to monitor compliance with the laws controlling physical availability (e.g., selling alcohol to minors) and alcohol advertising. The findings are

similar to a previous study showing that an increased index of control of alcohol advertising is significantly associated with lower alcohol consumption (Casswell et al., 2022).

We did not find any association between the indices for drink-driving measures and alcohol taxation policy and alcohol consumption among drinkers. Alcohol taxation policy is set at the national level, and is consistent across provinces (Excise Department, 2017a). The main tasks of the provincial authorities are collecting alcohol excise taxes and inspecting alcohol outlets and alcohol production factories for illicit alcohol sales and production (Excise Department, 2017a, 2017b, 2017c). They have no role in influencing alcohol taxation rates, which are set at the national level (Excise Department, 2017a). For drink-driving countermeasures, there is no evidence of a relationship between the level of implementation and alcohol consumption patterns. Unlike taxation, the provincial authorities have a role in implementing drink-driving control (National Road Safety Center, 2020). However, it may be the case that setting up sobriety checkpoints does not affect the levels of alcohol consumption and patterns of drinking.

We did not find any association between the PAPIC indices and alcoholic liver cirrhosis. Previous studies report inconsistent findings. Similarly to our study, a study conducted in Sweden found that the association between their implementation index and alcoholic liver cirrhosis was not significant (Nilsson et al., 2020). However, US study found a significant association between an index of the stringency of policy at the state level and alcoholic liver cirrhosis among females (Hadland et al., 2015). One possible reason we did not find a significant association between the PAPIC index and alcoholic liver cirrhosis is that our study did not reveal a significant association between the index and binge drinking, and alcoholic liver cirrhosis is typically caused by heavier alcohol consumption (Norström & Skog, 2001). Consequently, we did not find an association between rates of alcoholic liver cirrhosis and the index.

We did not find any association between the PAPIC and alcohol-related road traffic injuries. This is inconsistent with findings from a previous study conducted in Sweden (Nilsson et al., 2020). There are several possible explanations for why we did not find a significant association between the index and alcohol-related road traffic injuries. First is the quality of the data. We used data from the Ministry of Public Health, but not all hospitals report alcohol-related road traffic injuries as this is done on a voluntary basis. Additionally, the majority of reporting hospitals are provincial, where they receive referrals for most severe injuries from district hospitals. Approximately 23 % of the reporting hospitals providing this information are at the district level. Next, the data on alcohol-related road traffic injuries were based on people who came to a hospital emergency department. Therefore, people who do not present to hospitals with such injuries will not be included in the study. Our study also focused on the frequency of sobriety checkpoints to examine police practices around drink-driving countermeasures in Thailand. However, according to current evidence, there are limitations to employing sobriety checkpoints, as individuals can potentially more easily avoid detection compared to random breath testing (Babor et al., 2022).

**Table 5**  
The associations between the provincial alcohol control policy implementation capacity index and alcohol-related harms

| Variables             | IRR (95 %CI) Age standardization of morbidity of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of morbidity of alcoholic liver cirrhosis among females | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among females | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among females | IRR (95 % CI) RTI rates | IRR (95 %CI) RTI death rates |
|-----------------------|--|--|--|--|--|--|-------------------------|------------------------------|
| Overall index         | 1.00(0.99, 1.02)   | 1.01 (0.99, 1.02)  | 0.99 (0.98, 1.01)  | 0.99 (0.97, 1.02)  | 0.99 (0.98, 1.01)  | 0.99 (0.97, 1.02)  | 1.01 (0.98, 1.04)       | 1.01(0.98, 1.03)             |
| Region (Ref. Central) |  |  |  |  |  |  |                         |                              |
| North                 | 1.22 (0.94, 1.58)  | 0.83 (0.54, 1.26)  | 1.24 (0.93, 1.66)  | 0.86 (0.51, 1.43)  | 1.24 (0.93, 1.66)  | 0.86 (0.51, 1.43)  | 2.46 (1.21, 5.02)*      | 2.86 (1.60, 5.13)*           |
| Northeast             | 1.31 (1.02, 1.69)*   | 0.86 (0.56, 1.31)  | 0.63 (0.46, 0.88)*   | 0.48 (0.27, 0.86)*   | 0.63 (0.46, 0.88)*   | 0.48 (0.27, 0.86)*   | 1.03 (0.50, 2.12)       | 1.13 (0.57, 2.25)            |
| South                 | 0.79 (0.56, 1.12)  | 0.33 (0.18, 0.60)*   | 0.88 (0.56, 1.36)*   | 0.29 (0.10, 0.87)*   | 0.88 (0.56, 1.36)*   | 0.29 (0.10, 0.87)*   | 1.04 (0.33, 1.44)       | 1.04 (0.49, 2.22)            |
| Percent of Muslim     | 0.99 (0.98, 0.99)*   | 0.98 (0.96, 0.99)*   | 0.99 (0.98, 1.00)*   | 0.99 (0.95, 1.02)  | 0.99 (0.98, 1.00)*   | 0.99 (0.95, 1.02)  | -                       | -                            |

\*p-value<0.05; IRR: incident rate ratio; RTI: alcohol-related road traffic injury rates

**Table 6**  
The association between the provincial alcohol control policy implementation capacity index, considering different policy measures, and alcohol-related harms

| Variables             | IRR (95 %CI) Age standardization of morbidity of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of morbidity of alcoholic liver cirrhosis among females | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among females | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among males | IRR (95 %CI) Age standardization of mortality of alcoholic liver cirrhosis among females | IRR (95 % CI) RTI rates | IRR (95 %CI) RTI death rates |
|-----------------------|--|--|--|--|--|--|-------------------------|------------------------------|
| Alcohol advertising   | 1.00 (1.00, 1.01)  | 1.00 (0.99, 1.02)  | 0.99 (0.98, 1.01)  | 0.99 (0.97, 1.01)  | 0.99 (0.98, 1.01)  | 0.99 (0.97, 1.01)  | 1.01 (0.99, 1.03)       | 1.01 (0.99, 1.03)            |
| Physical availability | 1.00 (0.99, 1.01)  | 1.00 (0.98, 1.01)  | 0.99 (0.98, 1.00)  | 1.00 (0.98, 1.02)  | 0.99 (0.98, 1.00)  | 1.00 (0.98, 1.02)  | 1.01 (0.98, 1.03)       | 1.01 (0.99, 1.03)            |
| Drink-driving         | 1.01 (1.00, 1.02)  | 1.01 (0.99, 1.03)  | 1.00 (0.99, 1.01)  | 1.01 (0.99, 1.03)  | 1.00 (0.99, 1.01)  | 1.01 (0.99, 1.03)  | 1.01 (0.99, 1.04)       | 1.01 (0.99, 1.03)            |
| Alcohol taxation      | 1.00 (1.00, 1.01)  | 1.00 (0.99, 1.01)  | 1.00 (0.99, 1.00)  | 0.99 (0.98, 1.01)  | 1.00 (0.99, 1.00)  | 0.99 (0.98, 1.01)  | 0.99 (0.98, 1.01)       | 0.99 (0.98, 1.01)            |

The models of aged standardization of alcoholic liver cirrhosis were adjusted for region and percentage of Muslims; The models of rates of alcohol-related road traffic injuries were adjusted for region; \*p-value<0.05; IRR: incident rate ratio; RTI: alcohol-related road traffic injury rates.

### Policy implication

The innovation introduced by our study is identifying indicators of policy implementation capacity. These indicators reflect the capacity of provinces to implement alcohol control policy and cover policy infrastructure and resources at the provincial level, and the policy implementation process. The resulting PAPIC can be used to help assess progress with policy implementation at the sub-national level in Thailand. Furthermore, other low- and middle-income countries can adapt the index to their own country contexts.

The findings show a negative association between the index of implementation of alcohol advertising and quantity of alcohol consumption and proportion of regular drinkers. It is therefore recommended that policymakers at the provincial level effectively implement this policy measure.

To reduce alcohol consumption and help meet the UN's SDGs, Thailand needs to effectively implement alcohol control policies at the sub-national level. Based on this study, the stronger the implementation, the greater the reduction in alcohol consumption and number of regular drinkers.

### Strengths and limitations of the study

Our study achieved high response rates of more than 80 per cent. It is also based on a national scale survey among key informants and, therefore able to explore policy implementation at the provincial level in Thailand. However, the study has some limitations that need to be taken into consideration. First, because it is a cross-sectional survey, reverse causality could have occurred, and therefore causality cannot be confirmed. Second, social desirability bias could be a factor. However, we tried to minimize this by requesting existing documents, such as annual reports, to verify key informants' answers. Third, because we asked key informants to think back to 2019 before COVID-19, recall bias could be an issue. Fourth, we applied alcohol consumption data from a 2017 survey due to the unavailability of 2019 survey data. Last, the alcohol consumption data is based on survey data; therefore, under-reporting of alcohol consumption could be a factor, potentially leading to underestimation of the effect of the association between the index and alcohol consumption.

### Conclusion

The index of provincial alcohol control policy implementation capacity (PAPIC) was found to be significantly associated with the quantity consumed by drinkers, particularly for the implementation of alcohol advertising control. Increased levels of overall implementation and the two policy measures of alcohol advertising and availability control were also associated with a reduction in the proportion of regular drinkers. Based on this study, to achieve SDG 3.5, Thailand needs to increase levels of implementation at the sub-national level. Also, repeated monitoring is needed to measure the progress of policy implementation at the sub-national level. This research can also be adapted by other low- and middle-income countries to measure their progress with policy implementation at the sub-national level where alcohol policy is largely implemented.

### CRedit authorship contribution statement

**Jintana Jankhotkaew:** Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sally Casswell:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Taisia Huckle:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Surasak Chaayasong:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Romtawan Kalapat:** Writing – review & editing, Project administration, Investigation, Data curation. **Orratai Waleewong:** Writing –

review & editing, Resources, Funding acquisition. **Karl Parker:** Writing – review & editing, Formal analysis.

### Declaration of competing interest

The authors declare they have no known competing financial interests or personal relationships that could appear to have influenced the work reported in this paper.

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### Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT 3.5 to revise some of the sentences to increase readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

### Ethics approval

The authors declare that they have obtained ethics approval from an appropriately constituted ethics committee/institutional review board where the research entailed animal or human participation.

The study is approved by Mahasarakham University Ethics Committee for Research Involving Human Subjects in Thailand. The number of ethical approval is 166-100/2022.

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### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.drugpo.2024.104504](https://doi.org/10.1016/j.drugpo.2024.104504).

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