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RESEARCH REPORT

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Change of substance-related hospitalisation in adolescents after cannabis legalisation in Thailand in 2022

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Abstract

Background and aims: On 9 June 2022, Thailand changed its cannabis legislation, expanding access to individuals aged >18 years. Evidence suggests that such changes could increase the risk of cannabis use and related harms, and could influence patterns of use of other substances among adolescents. This study measured the potential impact of these legislative changes on adolescent substance-related hospital admissions.

Design: An interrupted time-series study to assess the impact of cannabis legalisation on substance-related hospitalisations using anonymised admission records from the Thai Health Information Portal.

Setting: Nationwide study in Thailand spanning from 1 October 2016 to 30 September 2023, with 9 June 2022 marking cannabis legalisation.

Participants/cases: Adolescents aged 10–19 years in Thailand.

Measurements: Based on International Classification of Diseases, 10th Revision diagnostic codes, hospitalisation records were classified as relevant or irrelevant to each of eight predefined substance categories: stimulants (excluding cocaine), alcohol, cannabis, sedatives (including opioids and narcotics), volatile solvents, nicotine, hallucinogens and cocaine.

Findings: There were an additional 25.5 weekly cannabis-related hospitalisations (95% prediction interval = 23.5–27.2) compared with counterfactual predictions, resulting in 1762 excess cases over the 68-week post-legalisation period. Statistically significant excess admissions were also observed for stimulants, nicotine, volatile solvents and hallucinogens, corresponding to additional admissions of 9.1, 1.4, 0.5 and 0.5 per week, respectively (95% prediction intervals = 0.3–15.4, 0.4–2.1, 0.3–0.7 and 0.2–0.7, respectively). No statistically significant changes were observed for alcohol-, sedative- or cocaine-related hospitalisations.

Conclusions: Cannabis legalisation in Thailand was followed by a marked rise in adolescent hospitalisations related to cannabis, alongside an increase in stimulant-, nicotine-, volatile solvent- and hallucinogen-related hospitalizations. These findings highlight the potential unintended consequences of cannabis legalisation in Thailand and underscore the need for preventive strategies to reduce adolescent exposure and related harm.

KEYWORDS
adolescents, cannabis legalisation, substance use trends, substance-related hospitalisation, Thailand, time-series analysis

INTRODUCTION

Over the past decade, more than 50 countries have legalised cannabis for medical use, and nearly 10 countries have legalised recreational use [1–3]. Medical-cannabis legislation aims to provide regulated therapeutic access, whereas the transition from prohibition to regulated recreational access seeks to reduce the harms associated with cannabis use. Reported benefits of these policy changes include reduced criminal-justice involvement, increased research and awareness of therapeutic applications and higher tax revenues from legal cannabis markets [4–7]. However, legalisation has also raised public-health concerns, particularly increased exposure among children and adolescents [8]. Since 2022, Thailand has become the first Asian country to legalise cannabis beyond medical use [1, 9], raising critical questions about the balance between the potential benefits and harms of this policy in this regional context [10, 11].

Although most legalisation frameworks restrict cannabis use to adults (typically ≥18–20 years old), younger populations may still be affected by its increased availability, easier access and growing social acceptance [12–16]. Children are most often exposed to cannabis through unintentional ingestion, whereas adolescents are more likely to engage in recreational use [17, 18]. Although evidence on adolescent cannabis use after legalisation is mixed, rigorous studies suggest increasing consumption [18–20], particularly among adolescents with lower perceived risk [15, 16, 21]. Initiating cannabis use at a younger age substantially increases the likelihood of dependence, with reported ORs ranging from 1.3 to 7.2 [18, 22–25]. Approximately 17.5% of individuals with cannabis-use disorder began using cannabis before age 18 years [26]. Regular adolescent cannabis use is associated with impaired cognitive performance, poor decision-making, reduced high-school completion, greater unemployment risk [27–29] and elevated rates of psychiatric disorders and injury [30–35]. Cannabis exposure can also exacerbate asthma and raise the risks of pneumonia, myocardial infarction, arrhythmia and stroke in young adults [36–39].

Emerging evidence indicates that cannabis legalisation may influence the use of other substances in diverse ways. A national survey in the United States reported decline in amphetamine misuse among 8th-grade students, with no significant changes among 10th- and 12th-grade students [40]. Although overall alcohol use among adolescents is stable or declining, the co-use of alcohol and cannabis is increasing [15, 40–43]. Findings on opioid use and cigarette smoking remain inconsistent [40, 41, 44, 45]. No significant change has been observed in cocaine use, and evidence on volatile solvents and hallucinogen use remains limited [41]. Although there is limited empirical consensus on how cannabis-policy changes may influence other substance usage, prior research has proposed possible explanations, including substitution and complementarity effects [43, 44]. Most existing studies originate from the United States and Canada, underscoring the need for research in Asian and lower-to-middle-income settings.

Thailand enacted the Narcotics Act (No. 7) on 19 February 2019, legalising medical cannabis, followed by the removal of cannabis and hemp from the narcotics list on 9 June 2022, allowing adults 20 years or older to cultivate, sell and use cannabis with minimal regulation [9, 46]. Although cannabis was initially legalised for medical purposes, most Thai adults use it recreationally [47–49]. Annual national surveys indicate that past-year cannabis use among adults 18 to 65 years increased from 2.2% in 2019 to 4.2% in 2022 [50]. Currently, data on how legalisation affects adolescent cannabis and other substance use in Thailand remain scarce.

Despite rapid policy changes, evidence on the effects of cannabis legalisation on adolescents in low- and middle-income countries remains limited. Thailand's status as the first Asian country to legalise adult cannabis use under minimal regulation highlights the need for contextualised evidence.

To address this gap, we used the Thai Health Information Portal (THIP), a nationwide database capturing most hospitalisations under the Universal Coverage Scheme. Because hospitalisation data reflect severe substance-related outcomes, they provide a robust basis for population-level assessments. We, therefore, aimed to evaluate the impact of cannabis legalisation on substance-related hospitalisations among Thai adolescents from 2017 to 2023.

METHODS

Design and data sources

We conducted an interrupted time-series study to assess the impact of cannabis legalisation on substance-related hospitalisations among adolescents in Thailand. We included individuals 10 to 19 years with substance-related hospitalisations identified using predefined International Classification of Diseases, 10th Revision (ICD-10) diagnostic codes. The study spanned from 1 October 2016 to 30 September 2023, with 9 June 2022 marking the legalisation date.

We analysed all eligible hospitalisation records from THIP, a collaborative data warehouse operated by the National Health Security Office of Thailand, Prince of Songkla University (PSU) and National Science and Technology Development Agency of Thailand. PSU serves as the data custodian and provides users with data access for educational and research purposes via the THIP gateway (http://thip.nbt.or.th). THIP includes all hospital admissions recorded in Thailand, for both residents and non-residents, and does not capture outpatient visits or emergency department presentations that do not result in admission. Restricting the numerator to residents only was not possible in the available dataset. All records were de-identified and made accessible after receiving approval from the ethics committee [51]. THIP provides anonymised information on patient age, sex assigned at birth, admission and discharge dates, diagnostic codes, procedures and clinical outcomes. According to coding practices in Thailand, all diagnoses (ICD-10) affecting patient care during hospitalisation are coded for reimbursement under Thailand's Diagnosis-Related Group–based payment system. Doctors may also code additional diagnoses to ensure that the medical record is comprehensive. These data are verified by the hospital's medical statisticians. The medical records are legally protected and maintained confidentially. These coding practices remained consistent following cannabis legalisation. Age- and sex-specific midyear population counts were obtained from the Bureau of the Registration Administration. The study protocol was approved by the Human Research Ethics Committee of the Faculty of Medicine, PSU (REC. 67–635–1-1).

Substance-related admissions were identified using the ICD-10 codes and grouped into eight categories: stimulants (excluding cocaine), alcohol, cannabis, sedatives (including opioids and narcotics), volatile solvents, nicotine, hallucinogens and cocaine. The specific ICD-10 codes for each category are listed in Table S1. To avoid duplication, multiple admissions occurring within a single day or involving hospital transfers were consolidated into a single hospitalisation event. Individual hospitalisations were then aggregated into weekly national-level counts for each substance group.

Statistical analysis

Pre- and post-legalisation weekly hospitalisation rates (per 1000,000 person-years) were calculated for adolescents by dividing the weekly counts by the age- and sex-specific midyear population counts stratified by sex assigned at birth, age group and substance category. To estimate the impact of cannabis legalisation on substance-related hospitalisations, we used a causal impact framework that compared observed admissions after legalisation (9 June 2022–30 September 2023, for a total duration of 68 weeks) with the counterfactual trends projected from models exclusively trained on the pre-legalisation data (1 October 2016–8 June 2022).

For each substance category, we chose the best-fitting counterfactual models using three-stage model selection. First, we specified candidate generalised linear models for count outcomes using the midyear population as an offset, considering alternative distributional families (Poisson, negative binomial, with/without zero-inflated variants). The predictor sets started with a linear time trend and lag-1 autoregressive term (set A). Seasonality (set B) and holidays (set C) were incrementally added. All sets were further separated into those with and without coronavirus disease (COVID-19) disruption terms included. COVID-19 was modelled as an intercept and slope change beginning on 18 July 2021, the date on which stricter COVID-19 lockdown regulations were issued in the Royal Thai Government Gazette [52]. Candidate models with fewer than five outcome events per estimated parameter were excluded to reduce the risk of overfitting.

Second, fitted models were screened using simulation-based residual diagnostics, including tests for uniformity, overdispersion, adequacy of zero-inflation and temporal autocorrelation. Models that failed the convergence criteria or diagnostic thresholds were excluded. Third, among diagnostically acceptable models, we ranked specifications using the corrected Akaike information criterion and retained those within 10 units of the minimum. These models were compared using rolling-origin cross-validation conducted exclusively within the pre-legalisation period. Predictive performance was assessed using mean out-of-sample negative log-likelihood (NLL), and the model with the lowest error was selected as the final counterfactual specification for each substance category. Full statistical details are provided in the Supporting information (Supporting information, Statistical analysis and Tables S2–S9).

From each final model, we simulated 1000 counterfactual weekly case trajectories using parametric bootstrap methods to account for uncertainty in model parameters and dispersion. For each substance, we plotted the observed hospitalisation trend against the central 50% and 95% prediction bands (ranges covered 50% and 95% of simulated counterfactual trajectories), which were statistically significant when the observed values lay outside these bands. For each simulated counterfactual line, we summarised the policy impact using three measures: (1) total excess cases, defined as the difference between the total observed and each total simulated counterfactual admissions across the post-legalisation periods; (2) average weekly excess cases, calculated by dividing the total excess cases by 68 post-legalisation weeks; and (3) the relative effect, expressed as a percentage change from total counterfactual levels. All estimates are presented with 95% prediction intervals (PIs) (2.5–97.5 percentiles), based on bootstrap simulations. Significance was inferred when the 95% PI did not include zero.

Additional analysis

We conducted three additional analyses to evaluate the robustness of the primary findings. First, we used adolescent acute appendicitis hospitalisations (ICD-10: K35–K37) as a negative-control outcome. Appendicitis is biologically unrelated to cannabis legalisation, but plausibly affected by COVID-19-related healthcare disruption. The identical model-selection and counterfactual estimation pipeline was applied. The absence of a post-legalisation effect would support the internal validity of the modelling framework. Full model specifications and diagnostics are presented in Table S10. Second, we replaced the linear time term in each substance's best-fitting pre-legalisation model with a natural spline with three degrees of freedom to examine potential misspecification of secular trends. Out-of-sample predictive performance was assessed using rolling-origin cross-validation, comparing NLL with the primary linear-trend model. We also examined whether substantive post-legalisation effect estimates changed under the spline specification. Third, we conducted additional analysis of stimulants, in which both COVID-19 terms were retained in the primary model, and observed a significant post-legalization change, assessing potential rebound following pandemic-related suppression. A counterfactual 'no COVID-19 and no legalization' scenario was generated by refitting the best-performing model specification using only pre-COVID data (1 October 2016–17 July 2021) and omitting COVID-related parameters. We, then, compared weekly admissions observed during the post-legalization period with those projected by this pre-COVID model.

All analyses, performed using R version 4.4.1, were not pre-registered and should be considered exploratory. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline for the observational studies [53], and the relevant checklist is available in the Supporting Information.

RESULTS

A comparison of substance-related hospitalisation counts, person-years at risk and incidence rates for Thai patients 10 to 19 years is presented in Table 1, stratified by sex and age, before and after cannabis legalisation. Following legalisation, the incidence rate increased for most substance-related admissions, including stimulants, sedatives, cannabis, nicotine, volatile solvents and hallucinogens. Cocaine-related incidents were minor and remained unchanged. Alcohol-related admissions declined overall, except for an increase among females and those 10 to 14 years. Across both periods and for all substances, males had consistently higher incidence rates, and adolescents 15 to 19 years experienced higher hospitalisation rates. The pre-legalisation trends are shown in Table 2.

TABLE 1 Crude comparison of substance-related admissions in adolescents in Thailand between pre- and post-cannabis legalisation periods.

	Demographic group									
			Sex				Age group			
	Total		Male		Female		10–14 years		15–19 years	
Substance category	Pre[a]	Post[a]	Pre[a]	Post[a]	Pre[a]	Post[a]	Pre[a]	Post[a]	Pre[a]	Post[a]
Total person-years (millions)	50.03	10.41	25.68	5.35	24.35	5.06	24.54	5.14	25.49	5.26
Any substance-related admissions (*n*)	17 062	5911	13 703	4692	3359	1219	2003	1014	15 059	4897
Any substance-related incidence rate[b]	341.0	567.9	533.6	877.6	137.9	240.8	81.6	197.1	590.7	930.2
Stimulants (except cocaine)										
Events (n)	9009	2374	7554	1965	1455	409	833	326	8176	2048
Incidence rate[b]	180.1	228.1	294.2	367.6	59.8	80.8	34.0	63.4	320.7	389.0
Alcohol										
Events (*n*)	4689	920	3490	611	1199	309	718	164	3971	756
Incidence rate[b]	93.7	88.4	135.9	114.3	49.2	61.0	29.3	31.9	155.8	143.6
Sedatives[c]										
Events (*n*)	1944	636	1411	409	533	227	230	93	1714	543
Incidence rate[b]	38.9	61.1	55.0	76.5	21.9	44.8	9.4	18.1	67.2	103.1
Cannabis										
Events (*n*)	1854	2343	1730	2080	124	263	190	456	1664	1887
Incidence rate[b]	37.1	225.1	67.4	389.1	5.1	51.9	7.7	88.6	65.3	358.4
Nicotine										
Events (*n*)	949	292	860	232	89	60	90	57	859	235
Incidence rate[b]	19.0	28.1	33.5	43.4	3.6	11.8	3.7	11.1	33.7	44.6
Volatile solvents										
Events (*n*)	296	66	235	41	61	25	65	17	231	49
Incidence rate[b]	5.9	6.3	9.2	7.7	2.5	4.9	2.6	3.3	9.1	9.3
Hallucinogen										
Events (*n*)	240	73	187	52	53	21	26	17	214	56
Incidence rate[b]	4.8	7	7.3	9.7	2.2	4.2	1.1	3.3	8.4	10.6
Cocaine										
Events (*n*)	34	7	29	6	5	1	3	0	31	7
Incidence rate[b]	0.7	0.7	1.1	1.1	0.2	0.2	0.1	0	1.2	1.3

[a]Pre, pre-legalisation periods (1 October 2016 to 8 June 2022); Post, post-legalisation periods (9 June 2022–30 September 2023).
[b]Incidence rate per 1 000 000 person-years.
[c]Including opioids, sedatives and narcotics.

TABLE 2 Best-fit pre-legalisation models and trend estimate of substance-related hospitalisation rates for subsequent counterfactual projection.

	Selected model specification[a]		Annualised incidence rate changes % [95% CI][b]	
Substance category	Family	Variables	Baseline	Post-COVID[c]
Cannabis	NB	A	+8.3* [+4.6 to +12.1]	–
Stimulant	NB	A + COVID	+13.3* [+10.6 to +16.0]	−9.7 [−29.6 to +15.9]
Alcohol	NB	C + COVID	+4.6* [+1.2–+8.1]	+2.9 [−37.3 to +69.1]
Sedatives	NB	A	+4.1* [+1.0–+7.2]	–
Volatile solvents	Poisson	A	−17.8* [−23.8 to −11.3]	–
Nicotine	NB	A	−1.8 [−6.6 to +3.2]	–
Hallucinogens	Poisson	A	−7.8* [−14.7 to −0.3]	–
Cocaine	NB	A	−12.9 [−31.4 to +10.5]	–

Abbreviations: COVID-19, coronavirus disease 2019; NB, negative binomial;
[a]Full model specifications and diagnostics are presented in Tables S2–S9. Variable sets: A = time trend + lag-1 autoregressive term; B = A + seasonality; C = B + holidays; COVID, Intercept and slope change terms after the COVID-19 disruption (18 July 2021).
[b]Adjusted for covariates in the selected model specification.
[c]Post-COVID trends were calculated from linearly combining baseline slope with the post-COVID slope change.
*Statistical significance where 95% confidence intervals exclude zero.

Table 2 presents the best-fit pre-legalisation models used for the subsequent counterfactual projections of each substance. The negative binomial models best fit most categories, whereas the Poisson models were optimal for volatile solvents and hallucinogens. For nearly all substances, the most parsimonious predictor set (set A: linear time trend plus lag-1 autoregressive term) was sufficient; alcohol required a more complex specification (set C), which additionally incorporated seasonality and holiday effects. COVID-19 variables were only included in the models for stimulant- and alcohol-related admissions. Details of the model selection processes are provided in Tables S2–S9.

Table 2 also presents the estimated annualised incidence rate change, and the 95% CI was significant. From these pre-legalisation models, we observed significant increases in baseline annualised trends for cannabis, stimulants, alcohol and sedative admissions, with no evidence of changes for nicotine and cocaine. Conversely, volatile-solvent and hallucinogen admissions showed significant declines. Following the COVID-19 pandemic onset, previously increasing trends in stimulant- and alcohol-related admissions flattened and became non-significant.

Figure 1 illustrates the observed weekly hospitalisations (black lines) along with counterfactual predictions (coloured bands) for the eight substance categories among adolescents 10 to 19 years. Following legalisation, cannabis-related admissions substantially increased to >95% PIs throughout the post-legalisation period. Stimulant- and nicotine-related admissions also gradually increased, exceeding the upper prediction bands in the latter half of the post-legalisation period. Volatile solvent- and hallucinogen-related admissions showed trends along the upper bounds of the 95% CIs, whereas alcohol, sedative and cocaine admissions generally remained within the prediction bands.

Table 3 shows the estimated excess substance-related hospitalisations among adolescents, comparing the observed admissions with the counterfactual predictions. Significant excess hospitalisations were observed for five substance categories: cannabis, stimulants, nicotine, volatile solvents and hallucinogens. Cannabis showed the largest impact, with a median of 1762 excess admissions (95% PI = 1621–1877), corresponding to 25.5 additional weekly admissions (95% PI = 23.5–27.2) and 303% increase relative to counterfactual levels. These accounted for 63.8% of the total excess substance-related admissions. Stimulants also showed a significant increase, with 631 excess admissions (95% PI = 20–1061), or 9.1 additional weekly admissions (95% PI = 0.3–15.4), representing a relative increase of 36%. Nicotine, volatile solvent and hallucinogen admissions showed significant but smaller excesses. Conversely, alcohol-, sedative- and cocaine-related admissions did not differ significantly from the counterfactual predictions.

Three additional analyses were conducted. First, the negative-control outcome (appendicitis) showed no significant post-legalisation change (median excess weekly admissions −64.3 cases, 95% PI = −164.6 to 4.3) (Table S11). Second, we deliberately evaluated potential non-linear trends using a natural spline with three degrees of freedom. Across all substance categories, the non-linear models showed higher NLL values, suggesting that the linear trend model was more appropriate (Table S12). Third, refitting the stimulant model on pre-COVID-19 data only revealed that post-legalisation admissions remained below the pre-pandemic projected trajectory (median excess weekly admissions −14.3 cases, 95% PI =−20.1 to −9.8) (Table S13 and Figure S1).

DISCUSSION

We observed higher rates of cannabis-, stimulant-, sedative-, nicotine-, volatile solvent- and hallucinogen-related hospitalisations in the post-legalisation period, while alcohol-related admissions slightly

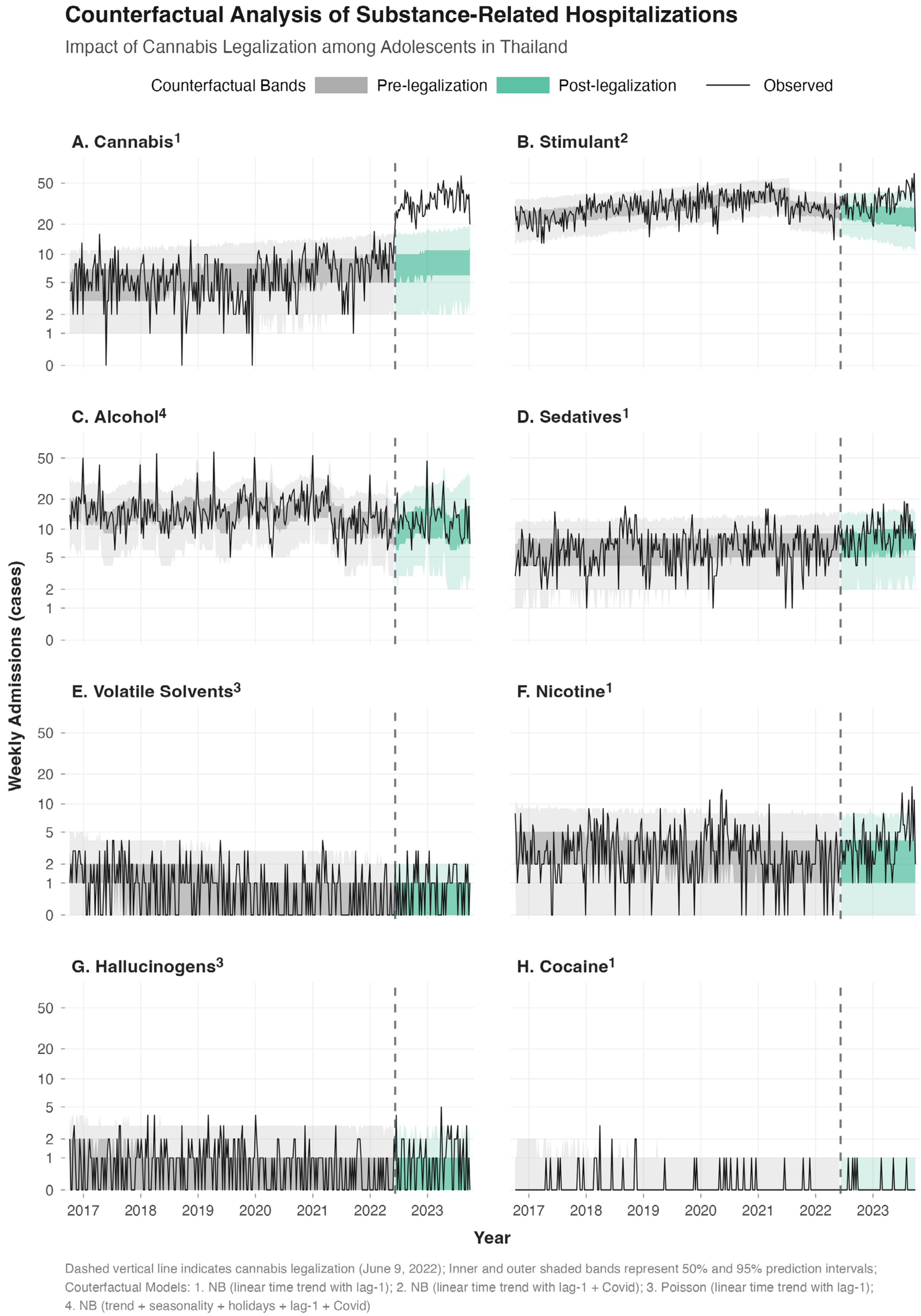

FIGURE 1 Counterfactual analysis of substance-related hospitalisations following cannabis legalisation. The vertical dashed line indicates the legalisation of cannabis (9 June 2022). The shaded bands represent the 50% and 95% prediction intervals from 1000 counterfactual simulations based on pre-legalisation data.

TABLE 3 Estimated excess substance-related hospitalisations among adolescents 10 to 19 years in the post-legalisation period, comparing observed and counterfactual scenarios.

Substance category	Observed admissions A	Counterfactual admissions B, median [95% PI]	Excess admissions A–B, median [95% PI]	Excess weekly admissions (A–B) per week, median [95% PI]	Relative change (A–B)/B × 100%, % [95% PI]
Cannabis	2343	581 [466–722]	1762 [1621–1877]*	25.5 [23.5–27.2]*	303.3% [224.4%–402.8%]*
Stimulants	2374	1743 [1313–2354]	631 [20–1061]*	9.1 [0.3–15.4]*	36.2% [0.8%–80.8%]*
Alcohol	920	824 [464–1480]	96 [−560 to 456]	1.4 [−8.1 to 6.6]	11.7% [−37.8% to 98.3%]
Sedatives	636	531 [425–660]	105 [−24 to 211]	1.5 [−0.3 to 3.1]	19.8% [−3.6% to 49.6%]
Nicotine	292	194 [144–265]	98 [27–148]*	1.4 [0.4–2.1]*	50.5% [10.2%–102.8%]*
Volatile solvents	66	31 [18–48]	35 [18–48]*	0.5 [0.3–0.7]*	112.9% [37.5%–266.7%]*
Hallucinogen	73	40 [24–60]	33 [13–9]*	0.5 [0.2–0.7]*	82.5% [21.6%–204.2%]*
Cocaine	7	4 [0–15]	3 [−8 to 7]	0.0 [−0.1 to 0.1]	NA[a]

Abbreviation: PI, prediction interval from 1000 bootstrap draws of counterfactual simulations.
[a]Relative change for cocaine not calculated as the majority of counterfactual predicted weekly cases were zero, making percentage calculations unreliable.
*Indicates statistical significance where 95% prediction intervals exclude zero.

declined and cocaine admissions remained stable. Across all eight substance groups, admission rates were consistently higher for males and older adolescents. Pre-legalisation models confirmed that trends for cannabis and sedative admissions had already increased before legalisation, volatile solvent and hallucinogen admissions declined and the change in nicotine- and cocaine-related admissions remained non-significant. Stimulant- and alcohol-related admissions also showed upward trends early on, although they flattened in the later years following the COVID-19 disruption. On extrapolating these pre-legalisation trends to generate counterfactual trajectories, we found that, for most substances, the actual post-legalisation admissions rose significantly above the levels expected had legalisation not been implemented, except for alcohol, sedatives and cocaine.

We observed a significant and immediate increase in cannabis-related hospitalisations following legalisation, averaging 25.5 additional admissions per week or more than 1700 excess cases in the first 15 months. Similar surges in adolescent cannabis-related hospital visits have been reported in the United States and Canada following adult-use legalisation, suggesting that our findings in Thailand are consistent with broader international patterns [12, 14, 18, 54, 55]. A national survey also found increased prevalence of cannabis use among adults during the legalisation period [50]. Potential contributors include easier access to cannabis, reduced risk perception and limited supervision in households where caregivers also use cannabis [15, 16, 21, 56, 57]. Such exposure during adolescence is particularly concerning, as cannabis can decrease functional connectivity of the prefrontal network, disrupt adolescent brain maturation, predict lower full-scale IQ, decrease academic achievement, decrease life satisfaction and induce psychopathology, especially psychosis [58–61]. These findings suggest that cannabis-related harms among adolescents may have increased in Thailand during the post-legalisation period and could represent an important emerging public health concern.

Stimulants remain the leading cause of substance-related admissions among Thai adolescents across most periods and demographic groups. This pattern reflects Thailand's long-standing methamphetamine epidemic. Thailand has served as a central hub for the production and distribution of methamphetamine in Southeast Asia for over two decades, with 172 771 registered users and 84.8 tonnes seized in 2023, which is nearly half of all regional seizures [62, 63]. Our substance-related hospitalisation data differed from those of previous school-based studies and online surveys. Previous studies have reported alcohol, cigarettes and e-cigarettes as the most commonly used substances among adolescents [64–68]. The discrepancy likely reflects differences in the populations captured. Surveys measure any use, whereas our in-patient data reflect severe episodes requiring admission. Stimulant intoxication also necessitates hospitalisation more often than smoking- or vaping-related harm, explaining its dominance in the inpatient setting [69].

Despite the dampening of their pre-legalisation upward trend following the COVID-19 disruption, our counterfactual analysis revealed a renewed surge in stimulant-related hospitalisation following cannabis legalisation, over 600 excess admissions and a 36% increase above the expected levels. Contrasting reports from the United States, adolescent amphetamine misuse declined after the enactment of the medical marijuana laws [40]. This change in youth stimulant use after cannabis legalisation in Thailand and the United States highlights how substance-use patterns are strongly shaped by culture, legislation, economics, geopolitics and drug markets [70–72]. In Bangkok, Thailand, more than 66% of youths who misuse amphetamines initiate use before the age of 15 years, whereas adolescents in the United States typically begin using methamphetamines and other stimulants at a mean age of 17 years [73, 74]. Given that polysubstance use is common among adolescents [75], Thai youths misusing amphetamines may be more likely to co-use cannabis following its legalisation. Another plausible explanation, suggested by our third additional analysis, is that the observed increase represents a partial rebound of pre-COVID-19 trends temporarily disrupted during the COVID-19 lockdowns. Therefore, the findings should be interpreted with caution, as multiple mechanisms may have contributed to the observed trend. Further research is needed to disentangle the potential effects of cannabis legalisation from those of the COVID-19 pandemic on stimulant-related hospitalisations.

Our findings indicate that alcohol-related hospitalisation among adolescents continues to follow a counterfactual trend following cannabis legalisation. This pattern is consistent with those of previous studies of adolescent populations, which have also demonstrated stable or declining trends in alcohol use following cannabis legalisation [(40–42, 76]. Conversely, studies of adult populations have shown heterogeneous results [76–81]. Alcohol and cannabis may function as substitutes or complements, and this relationship is mediated by the strictness of substance laws, user age and sex [76, 82–84]. The non-significant change in the alcohol-related hospitalisation trends during cannabis legalisation could be a combination of the substitution effect, complementary effect of polysubstance users under the regulation of the Alcohol Beverage Control Act, B.E. 2551, 2008, which set minimum legal purchase age as 20 years, and Excise Act, B.E. 2560, 2017, which regulated taxation and licensed alcohol production [15, 43, 85].

Our analysis also showed significant surges compared with the counterfactual values of nicotine-, volatile solvent- and hallucinogen-related hospitalisations. The observed increases in e-cigarette use are consistent with previous results, whereas findings regarding cigarette use remain mixed, and those for volatile solvent and hallucinogen use are sparse [40, 44, 86]. Findings from the 2017 Youth Risk Behavior Surveillance Survey suggest that students residing in states that legalised recreational cannabis were more likely to report vaping, whereas those residing in states that legalised medical cannabis were less likely to report cigarette smoking in the past 30 days [44]. Analyses of the national Monitoring the Future annual surveys (1991–2015) show declining cigarette use among 8th-grade students, but increasing prevalence among 12th-grade students [40]. Because most cigarette smokers and vapers are not hospitalised for nicotine-related causes, further studies examining the prevalence of adolescent nicotine use in community settings may provide a more comprehensive understanding of its impact [87, 88]. Although polysubstance use is beyond the scope of our study, according to the common liability explanation, vulnerable adolescents prone to substance use may have easier access to cannabis and other substances following the legalisation period [89].

Post-legalisation admissions related to sedative and cocaine use showed no significant change, contrasting the findings of a United States study reporting increased non-medical prescription opioid use among 12th-grade students following the implementation of medical marijuana laws [40]. Consistent with a previous study, no significant change was observed in cocaine use [41]. These substances are illegal and regulated under the Narcotic Drugs Code Act B.E. 2564 (2021) and Psychotropic Substances Act B.E. 2559 (2016) [90, 91]. Their limited accessibility, perceived harm, under-reporting owing to stigmatisation and lack of laboratory confirmation in resource-limited hospitals may have contributed to the non-significant change in the admission trend related to sedatives and cocaine after cannabis legalisation.

Across all eight substances, admission rates were higher in males and in 15 to 19 year-olds, mirroring prior studies [92–94]. Early adolescents (10–14 years) may have been generally protected from exposure to substances. Conversely, older adolescents have easier access to substances and are more likely to experiment with them owing to risk-taking behaviours associated with heightened activity in the brain's reward circuitry [90, 93]. The influence of sex differences on substance-use patterns among adolescents may be affected by biological and sociocultural factors and warrants further study [94].

The strength of our study lies in its use of national hospitalisation reimbursement data from the Universal Health Coverage scheme, which covers approximately 75% of healthcare services. This dataset represents severe health consequences of substance use. This comprehensive 6-year dataset (2017–2023), analysed using interrupted time-series analysis, provides a robust representation of substance-related harm among adolescents.

Our study had some limitations. First, the accuracy of ICD-10 diagnoses depends on the clinical judgement of healthcare professionals and the limited availability of confirmatory laboratory tests in smaller hospitals, potentially leading to inaccurate or incomplete diagnoses. Because of this limitation, we classified certain substances into eight categories to mitigate potential misclassifications. Second, hospital admission data included both residents and non-residents, whereas population estimates were restricted to residents. This discrepancy may have led to a minor overestimation of incidence rates. Third, hospitalisation data serve as surrogate markers for the severe consequences of substance exposure and do not capture the full scope of its impact on this vulnerable population. Moreover, data from emergency department visits and private hospitals were not included. Fourth, the admission data did not capture the patterns, intensity or intention of substance use among adolescents. Fifth, it is possible that the legalisation may have partially influenced clinical attention to cannabis-related presentations and patients' willingness to disclose cannabis use, which could in turn affect detection and reporting practice. Sixth, although the interrupted time-series design allows us to estimate deviations from pre-legalisation trends, it cannot definitively establish causality. The observed changes occurring after the legalisation date may reflect the policy shift, but also broader socio-economic and policy influences occurring around the same period. Therefore, interpretations should be cautious. Further research should integrate hospitalisation data with community- and school-based surveillance to better capture the full spectrum of adolescent substance use and explore how cannabis policies interact with those for other substances.

Despite these limitations, our results demonstrated an apparent increase in adolescent admissions related to cannabis, stimulants, nicotine, volatile solvents and hallucinogens following cannabis legalisation, with no significant change in alcohol-, sedative- or cocaine-related admissions. This finding is particularly troubling because early exposure to cannabis and other substances increases the risk of subsequent health and psychiatric morbidities, cognitive impairment and poor educational attainment [23–25, 27–29, 36–39]. Policymakers and public-health actors should increase investment in effective, evidence-based prevention and harm-reduction strategies, including restricting youth access to minimize unintended harms related to young people's particular vulnerabilities.

CONCLUSION

There has been a significant increase in hospital admissions related to cannabis, stimulants, nicotine, volatile solvents and hallucinogens among adolescents following the legalisation of cannabis in Thailand. These findings highlight the need to carefully consider the potentially harmful effects of substance legalisation and decriminalisation on adolescents in future policy decisions. Unintended adverse outcomes of drug policies should always be anticipated, examined, identified, addressed and responded to prevent substance exposure among at-risk youths and ensure adequate care for those affected.

AUTHOR CONTRIBUTIONS

Sirada Puetpaiboon: Conceptualization; writing—original draft; methodology; writing—review and editing; investigation; formal analysis; validation. **Songyos Rajborirug:** Conceptualization; writing—review and editing; visualization; validation; methodology; formal analysis; investigation; writing—original draft. **Vorthunju Nakhonsri:** Software; data curation; resources; project administration. **Chumpol Ngamphiw:** Software; data curation; resources; project administration. **Peerapat Khunkham:** Software; data curation; resources; project administration. **Sissades Tongsima:** Software; data curation; resources; project administration. **Watcharapot Janpoung:** Software; data curation; resources; project administration. **Virasakdi Chongsuvivatwong:** Supervision; conceptualization; methodology; writing—review and editing; validation; formal analysis; writing—original draft.

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DECLARATION OF INTERESTS

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from https://thip.nbt.or.th/ upon request, subject to ethics committee approval.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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