

# Patterns of Adolescent Substance Use: A Comparative Study among the United States, Canada, England, and South Korea from 2014-2021

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**Purpose:** This study aimed to identify the cross-national estimates of substance use, explore problematic substance use patterns among adolescents across countries and over time, and examine the relationship of individual characteristics on substance use patterns.

**Methods:** This study employed a time-series secondary data analysis spanning from 2014 to 2021 across four countries (United States, Canada, England, and South Korea). We analyzed the usage of five substances (alcohol, binge drinking, cigarettes, electronic cigarettes, and illicit drugs) alongside demographic characteristics. A descriptive analysis was performed to identify estimates of substance use across countries. Latent class analysis was employed to examine adolescents' substance use patterns across time and countries. A multinomial logistic regression model was fit to assess the relationship between latent class and demographic characteristics.

**Results:** Adolescents in the United States and Canada had the highest substance use, while Korean adolescents had the lowest, particularly concerning drugs. Latent class analysis revealed two classes (light-user and heavy-user), with the addition of a third class (moderate-user) in some instances. The substance use patterns, while differing significantly among nations, exhibited consistency over time. During COVID-19, a decrease in heavy-substance users was observed across countries. Male or older participants were more likely to belong to the heavy-user class.

**Conclusion:** This research offers valuable insights into the variations in substance use patterns between nations and over time. A tailored approach is essential to prevent adolescents from becoming heavy-substance users. This approach should consider country regulations and demographics for a targeted and comprehensive preventive strategy.

**Keywords:** Adolescent; Drug users; Substance use; Problem behavior

## Introduction

Adolescence is described as a risky period for initiating substance use; yet, any type of substance use can be harmful to adolescents [1,2]. Problem behavioral patterns in adolescence need to be noted as they are essential factors also affecting substance use later in adulthood [3]. Risks of substance use include immediate health threats, the potential to develop greater dependence than adults,

and poor academic performance [1,4,5]. Problem substance use behaviors are intensified by the co-occurrence of other problem behaviors [6].

Many highly risky behaviors of adolescents are attributed to alcohol and other drug use. Such behaviors include unwanted and unprotected sexual experiences, driving while intoxicated, and self-destructive behaviors such as self-harm or suicide attempts [7]. About 10% of adolescents pointed to alcohol and other drug

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use as the reason for their first sexual experience [8]. Adolescents' substance use is known to be influenced by peer, parental, and sociocultural factors [9,10]. Adolescents often anticipate that consuming substances like alcohol will help them be more social and feel relieved [11].

According to studies conducted in North America and Europe, cannabis use was higher among adolescents and young adults compared to other age groups [12-14]. In the United States (US), 22.3% of adolescents reported lifetime use of alcohol, 20.6% reported tobacco use, and 13.5% reported marijuana use [15]. Moreover, deaths from drug overdose among adolescents increased 2.3 times in 2021 compared to 2019 [16]. Given that adolescent use of these substances is illegal in the majority of contexts, these numbers are far from small.

- Previous studies have reported that demographic characteristics may be associated with substance use [17-21]. Gender, sexual identity, age, and race/ethnicity are recognized as social determinants of health that are associated with substance use. The relationship between each characteristic is reported differently depending on the study. For example, Duncan et al. (2006) have shown that female adolescents use more substances than male adolescents; however, other studies have reported the opposite [21]. Therefore, it is necessary to identify the association of demographic characteristics among various countries.
- Substance use behaviors are dynamic and can change over time due to various factors such as social influences and policy changes [22,23]. By identifying substance use patterns over time, it is possible to capture the temporal dynamics and fluctuations in patterns over time [24]. Understanding trends of substance use behavior is relevant to policymakers and education providers. For example, in US, current e-cigarette use rose from 1.5% to 13.4% between 2011 and 2014, while conventional cigarette use dropped from 11.6% to 8.2% [25]. Aggressive e-cigarette marketing in 2013 and relatively lax regulations may be speculated as contributing factors to this increasing trend [26]. Additionally, after the legalization of marijuana, there was an increase in marijuana use among adolescents in Canada [27].

Despite the importance of documenting trends in substance use, there has been limited data on patterns of substance use in a cross-national sample of adolescents. Understanding behavioral patterns is important to establish early detection strategies, treatments, and education. This study attempted to examine substance use problems in four countries, the United States, Canada, England, and South Korea. We chose these 3 countries to com-

pare with Korea because US, Canada, and England each rank in the top 10 by gross domestic product (GDP), and Asian countries often mirror Western trends [28]. Additionally, all four countries offer comparable data. It is crucial to understand the differences in regulations among these four countries to fully comprehend the nuances of substance use behaviors. Thanks to the comparison we can draw policy recommendations for regulations on various substances which differ from country to country.

In US, regulations are largely varied across states. The minimum legal age for tobacco and drinking at the federal level is age 21, (though there are some state-level exceptions), and in 21 states where cannabis is legal, the minimum age for use is 21 years old [29-31]. In Canada, where cannabis is legal, the minimum age to use tobacco, alcohol, or cannabis is set at 19 (age 18 in three states for alcohol) [32-34]. In England, one must be over the age of 18 to drink alcohol in public and buy tobacco. However, in a private home, alcohol can be consumed by those under the age 14. Cannabis is prohibited by law for all ages [35,36]. In South Korea, the legal age to drink or smoke is set at 19, and marijuana is illegal for all age groups [37,38]. Differences in legislation can also be seen in terms of accessibility. Increased access to substances increases the likelihood of substance use or addiction [39].

- We aimed to identify the cross-national estimates of substance use, examine problematic use patterns in substance use among adolescents across time and countries, and explore the association between demographic characteristics by substance user class.

## Methods

Within the framework of this secondary data analysis, time-series data collected by public administrative organizations (e.g., the United States, Canada, England and South Korea) were used (Table 1). The datasets consisted of adolescent behavior surveys using data from 2015 to 2021, with the population being school-based and aged between 10 and 19.

### Measurement

#### *Substance use*

The use or non-use of five substances were included in this study: 1) ever alcohol use, 2) current binge drinking, 3) ever cigarette use, 4) ever electronic cigarette (e-cigarette) use, and 5) ever cannabis or other drugs use. Details about the specific questions and response options are described in Table 2. For example, the variable "ever alcohol use" was determined by asking partici-

**Table 1.** Data Source and Sample

Country	Name of survey	Implementation period	Period used in this study	Population age	Sample size (approximately)
United States	Youth risk behavior surveillance system ( <a href="https://www.cdc.gov/healthyyouth/data/yrbs/index.htm">https://www.cdc.gov/healthyyouth/data/yrbs/index.htm</a> )	Every 2 years	2015 2017 2019 2021	12-18	14,000
Canada	Canadian student tobacco, alcohol, and drugs survey ( <a href="https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey.html">https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey.html</a> )	Every 2 years	2014 2016 2018	11-19	62,000
England	Smoking, drinking, and drug use (among young people in England) survey ( <a href="https://digital.nhs.uk/data-and-information/publications/statistical/smoking-drinking-and-drug-use-among-young-people-in-england/2021#data-sets">https://digital.nhs.uk/data-and-information/publications/statistical/smoking-drinking-and-drug-use-among-young-people-in-england/2021#data-sets</a> )	Every year	2014 2016 2018 2021	10-17	5,200
South Korea	Korean Youth risk behavior surveillance system ( <a href="https://www.kdca.go.kr/yhs/home.jsp">https://www.kdca.go.kr/yhs/home.jsp</a> )	Every year	2014 2016 2018 2021	12-17	54,000

pants if they have ever had a drink of alcohol that was more than just a sip. Similarly, "current binge drinking" was assessed by asking about the frequency of consuming multiple drinks within a short period in the past 30 days. For "ever cigarette use," participants were asked if they had ever tried cigarette smoking, even one or two puffs. For "ever electronic cigarette (e-cigarette) use," participants were asked if they had ever used an electronic vapor product.

Finally, "ever cannabis or other drugs use" was measured by asking participants how many times they had used marijuana, synthetic marijuana, prescription pain medicine without a doctor's prescription, cocaine, glue, gas, aerosols or sprays, heroin, methamphetamines, ecstasy, steroid pills, or injected illegal drugs. Based on previous studies, we dichotomized the responses into yes (i.e., people who have used at least once) or no [40-42].

*Participant characteristics*

To test the differences between latent classes, participant characteristics such as adolescents' age/grade and gender were included.

**Data Analysis**

To identify cross-national estimates of substance use, a descriptive analysis was performed. To examine problematic substance use behavior patterns among adolescents, latent class analysis (LCA) was employed using Mplus version 8 [43]. LCA is an analytic technique to identify subgroups or classes (i.e., clusters) of individuals with similar patterns [44], which is useful in our

study to investigate the substance use patterns based on substance use indicators. Following a stepwise approach, LCA was performed by iteratively increasing the number of classes, starting from a two-class model until no further statistical and theoretical improvements were observed. In order to determine the optimal model, entropy, the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT), Akaike information criterion (AIC), and Bayesian information criterion (BIC) were comprehensively considered. Entropy ranges between zero and one; higher entropy values indicate relatively greater distinctiveness among the classes [45]. AIC and BIC represent the goodness of fit and parsimony, with lower values indicating better model fit [46,47]. LMR-LRT compares the model fit improvement between the k and (k-1) classes. Values less than 0.05 indicate a statistically significant improvement for an increased number of classes [48].

Furthermore, a multinomial logistic regression model was fitted to assess the relationship between class membership and individual characteristics (i.e., age/grade and gender). Components with an odds ratio greater than 1.0 indicate that the odds of being a moderate/heavy user are higher than the reference group (light-user).

**Ethical Consideration**

Since this secondary data analysis study uses completely anonymous public data, we obtained an exemption from the Institutional Review Board of Chung-Ang University (No. 1041078-20240219-HR-029).

**Table 2.** Variables Used in This Study

Variables	United States	Canada	England	South Korea
Ever alcohol use	How old were you when you had your first drink of alcohol other than a few sips? <ul style="list-style-type: none"> <li>• No (I have never had a drink of alcohol other than a few sips)</li> <li>• Yes (8 years old or younger, 9 or 10 years old, 11 or 12 years old, 13 or 14 years old, 15 or 16 years old, 17 years old or older)</li> </ul>	Have you ever had a drink of alcohol that was more than just a sip? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Have you ever had an alcoholic drink – a whole drink, not just a sip? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Have you ever had a drink of alcohol that was more than just a glass? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>
Current binge drinking	During the past 30 days, on how many days did you have 4 or more drinks of alcohol in a row, that is, within a couple of hours (if you are female) or 5 or more drinks of alcohol in a row, that is, within a couple of hours (if you are male)? <ul style="list-style-type: none"> <li>• No (0 days)</li> <li>• Yes (1 day, 2 days, 3-5 days, 6-9 days, 10-19 days, 20 or more days)</li> </ul>	In the last 30 days, how often did you have 5 or more drinks of alcohol on one occasion? <ul style="list-style-type: none"> <li>• No (I have never done this in the last 30 days)</li> <li>• Yes (Once or twice, Once or twice a week, 3 or 4 times a week, 5 or 6 times a week, everyday)</li> </ul>	How many times have you been drunk in the last 4 weeks? <ul style="list-style-type: none"> <li>• No (0 time)</li> <li>• Yes (K times)</li> </ul>	In the last 30 days, what has been your average alcohol consumption? <ul style="list-style-type: none"> <li>• No (less than 4 drinks of alcohol)</li> <li>• Yes (5 or more drinks of alcohol)</li> </ul>
Ever cigarette use	Have you ever tried cigarette smoking, even one or two puffs? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Have you ever tried cigarette smoking, even just a few puffs? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Read the following statements carefully and tick the box next to the one which best describes you (cigarette smoking status) <ul style="list-style-type: none"> <li>• No (I have never tried smoking a cigarette, not even a puff or two)</li> <li>• Yes (I did once have a puff or two of a cigarette, I have only ever tried smoking once, I used to smoke sometimes but I never smoke a cigarette now, I sometimes smoke cigarettes now but I don't smoke as many as one a week, I usually smoke between one and six cigarettes a week, I usually smoke more than six cigarettes a week)</li> </ul>	Have you ever tried cigarette smoking, even one or two puffs? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>
Ever e-cigarette use	Have you ever used an electronic vapor product? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Which did you try first: a cigarette or an e-cigarette (vape, vape pen, tank & mod)? <ul style="list-style-type: none"> <li>• No (I have never tried a cigarette nor an e-cigarette, I have only tried a cigarette and never tried an e-cigarette)</li> <li>• Yes (I have only tried an e-cigarette and never tried a cigarette, I have tried both and tried a cigarette first, I have tried both and tried an e-cigarette first)</li> </ul>	Read the following statements carefully and tick the box next to the one which best describes you. Think about times when you may have had a puff or two as well as using whole electronic cigarettes. <ul style="list-style-type: none"> <li>• No (I have never tried electronic cigarettes)</li> <li>• Yes (I have used electronic cigarettes only once or twice, I used to use electronic cigarettes but I don't now, I sometimes use electronic cigarettes, but don't use them every week, I use electronic cigarettes regularly, once a week or more)</li> </ul>	Have you ever used an e-cigarette that contains nicotine? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>
Ever drug use	During your life, how many times have you used marijuana/ Synthetic marijuana/ prescription pain medicine without a doctor's prescription/ cocaine/ glue, gas, aerosols or sprays/ heroin/ methamphetamine/ ecstasy/ steroid pills/ inject illegal drugs? <ul style="list-style-type: none"> <li>• No (0 times)</li> <li>• Yes (1 or 2 times, 3 to 9 times, 10 to 19 times, 20 to 39 times, 40 to 99 times, 100 or more times)</li> </ul>	Have you ever used or tried marijuana or cannabis/ drug or substance/ amphetamines, mdma, hallucinogens, heroin, cocaine, synthetic cannabinoids, bzip, bath salts, 2c, tryptamines, glue, salvia? <ul style="list-style-type: none"> <li>• No (No, I have never used this)</li> <li>• Yes (Yes, I have used this in the last 12 months, Yes, I have used this, but not in the last 12 months)</li> </ul>	Have you ever tried cannabis/speed or other Amphetamines/ LSD/ ecstasy/ eemeron/ poppers/ tranquilisers/ heroin/magic mushrooms/ methadone/ crack/ cocaine/ ketamine/ mephedrone/gGlue, gas, aerosols or solvents/ nitrous oxide/ /legal highs/ other drugs(not from doctor)? <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>	Are there any drugs or substances you have used habitually other than for therapeutic purposes? Examples: stimulants, tranquilizers, butane gas, bond, etc. <ul style="list-style-type: none"> <li>• No</li> <li>• Yes</li> </ul>

## Results

### Prevalence of substance use among adolescents in four countries

Table 3 presents cross-national prevalence of substance use over time among adolescents. For all substances, adolescents in US and Canada had the highest use while Korean adolescents showed the least use, especially in relation to drugs. Alcohol was found to be the most used substance in all four countries (32.7-61.8%). In US and Canada, alcohol use was reported by about half or more respondents (45.1-61.8% in the US, 50.6-52.8% in Canada). In the case of current binge drinking, US and Canada also showed relatively high levels over 10% (8.2-17.4% in US, 14.8-16.5% in Canada), followed by England (7.9-10.6%) and Korea (4.0-6.0%). In terms of ever cigarette use, all four countries showed values approaching or exceeding 20%. E-cigarettes were used the most in US (35.1-47.9%) and the least in Korea (6.9-8.6%). As for drugs, US reported the highest rates (31.2-45.2%), followed by Canada (24.8-31.1%), England (15.0-22.4%), and Korea, with much lower rates than the comparison countries (0.7-1.0%).

Considering the societal changes due to the COVID-19 pandemic, it can be observed that cigarette and e-cigarette use, as well as drug consumption, decreased in US, England, and South Korea in 2021 compared to previous years. Additionally, alcohol consumption and binge drinking decreased in US and South Korea.

### Model selection and description of the latent classes

Table 4 presents the model fit statistics for LCA models of two-

to four-class solutions among adolescents in four countries; the United States, Canada, England, and South Korea. In case of US in 2015, the LMR-LRT values were significant in all models. Although the four-class model showed the lowest AIC and BIC value, the two-class model showed the highest entropy value. This suggests that the best overall model fit was the parsimonious identification of two or three latent classes.

Figure 1 provides a graphical representation of the latent classes of adolescents in four countries. The x-axis represents substance use and the y-axis shows the probability of having substance use behaviors within each class. We assigned labels to the class based on substance use probabilities ( $\lambda$ ) and identified substance use profiles for each country. The first profile was the “light-user” (Figure 1, solid blue line), comprising about 52-90% of the population (e.g., 52.3% of US adolescents in 2015, 84.2% of Korean adolescents in 2021). Exceptionally in Canada (2016 and 2018) and South Korea, there was one additional class, which was labeled as “moderate-user” (Figure 1, solid yellow line), representing approximately 10.2-24.6% of the population. The last profile of all four countries was named as “heavy-user” (Figure 1, dotted red line), accounting for 5.5-47.7% of the population. Members in the heavy-user group reported high probabilities for substance use behaviors.

### Profiles of substance use among adolescents in US, Canada, England, and South Korea

Each country had its own unique pattern with many fluctuations within substances, however the pattern did not change signifi-

Table 3. Prevalence of Substance Use among Adolescents in US, Canada, England and South Korea (% of use)

Country	Year	N	Alcohol	Binge drinking	Cigarette	E-cigarette	Drug
United States	2015	15,624	61.8	17.4	29.8	45.4	45.2
	2017	14,765	55.9	12.0	22.5	40.0	41.2
	2019	13,677	54.0	12.1	16.9	47.9	41.9
	2021	17,232	45.1	8.2	13.9	35.1	31.2
Canada	2014	36,665	50.6	16.5	22.6	21.4	24.8
	2016	52,103	50.1	14.6	20.4	26.5	28.3
	2018	62,850	52.8	14.8	21.2	35.0	31.1
England	2014	6,173	36.8	7.9	16.0	20.9	15.0
	2016	12,051	46.4	10.1	17.3	25.3	21.0
	2018	13,664	43.3	8.8	14.5	24.2	22.4
	2021	9,288	43.6	10.6	12.2	23.9	18.1
South Korea	2014	72,060	42.4	6.4	19.4	8.6	1.0
	2016	65,528	37.9	6.3	14.5	8.2	0.8
	2018	60,040	41.1	7.2	14.2	7.3	1.0
	2021	54,848	32.7	4.0	9.7	6.9	0.7



**Table 4.** Model Fit Statistics for 2- To 4-Class Models

Model Fit Indexes		2015				2016				2017				2018				2019				2021			
Year		2	3	4	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4
United States																									
Entropy		.79	.64	.61	.78	.78	.59	.77	.62	.60	.80	.68	.76												
LMR-LRT <sup>†</sup>		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00												
AIC <sup>‡</sup>		77099.29	76219.25	75890.55	67704.57	66995.10	66833.09	61459.75	60925.36	60731.46	69265.44	68773.14	68469.88												
BIC <sup>§</sup>		77183.51	76349.40	76066.64	67788.16	67124.29	67007.88	61542.50	61053.25	60904.47	69350.73	68904.95	68648.22												
Canada																									
Year		2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018												
Entropy		.86	.75	.74	.86	.78	.75	.84	.73	.73	.84	.78	.81												
LMR-LRT <sup>†</sup>		.00	.00	.00	.33	.00	.00	.33	.00	.00	.00	.00	.00												
AIC <sup>‡</sup>		152790.70	150319.60	149436.90	223506.60	219699.30	218672.10	281325.50	276671.90	275212.70	34289.09	33986.55	33991.29												
BIC <sup>§</sup>		152884.30	150464.20	149632.60	223604.00	219849.90	218875.90	281425.00	276825.70	275420.80	34367.56	34107.83	34155.37												
England																									
Year		2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018												
Entropy		.86	.79	.81	.80	.69	.72	.82	.71	.53	.84	.78	.81												
LMR-LRT <sup>†</sup>		.00	.00	.01	.00	.00	.03	.00	.00	.00	.00	.00	.13												
AIC <sup>‡</sup>		23533.34	23343.66	23197.07	38909.79	47333.48	47336.50	52707.22	52389.93	52378.51	34289.09	33986.55	33991.29												
BIC <sup>§</sup>		23607.35	23458.03	23351.81	38976.34	47459.19	47506.58	52789.95	52517.78	52551.48	34367.56	34107.83	34155.37												
South Korea																									
Year		2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2018	2018												
Entropy		.85	.84	.78	.87	.85	.83	.86	.84	.81	.92	.87	.89												
LMR-LRT <sup>†</sup>		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00												
AIC <sup>‡</sup>		216124.27	214071.65	205423.09	181190.84	178972.43	178355.92	170074.91	167792.13	167397.13	127663.27	126121.36	125850.74												
BIC <sup>§</sup>		216225.31	214227.80	205634.35	181290.83	179126.96	178564.99	170173.94	167945.17	167604.20	127761.31	126272.87	126055.72												

<sup>†</sup>Lo-Mendell-Rubin likelihood ratio test; <sup>‡</sup>Akaike information criterion; <sup>§</sup>Bayesian information criterion.

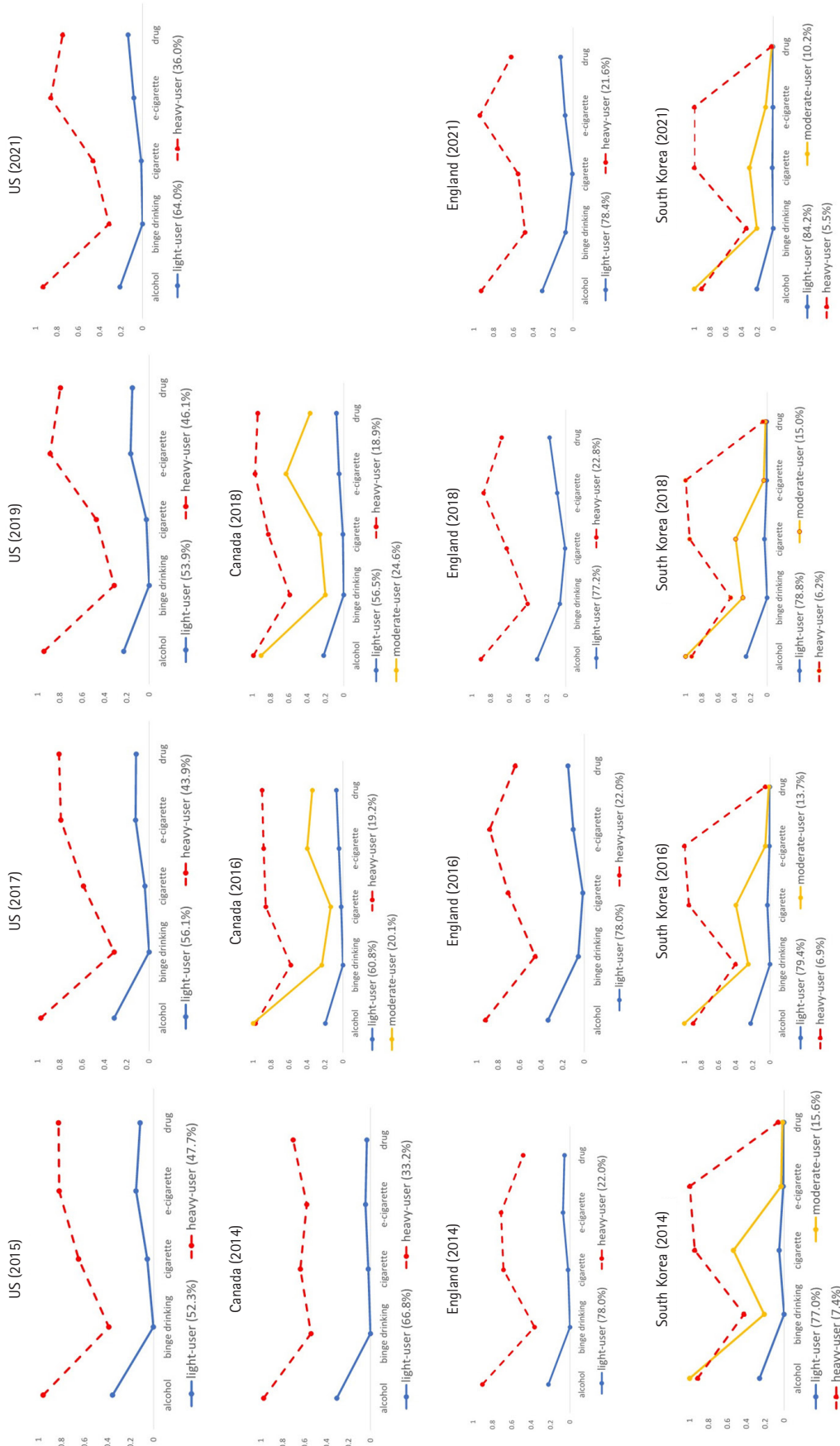


Figure 1. Substance use behaviors for each latent class in the United States, Canada, England, and South Korea.

cantly from year to year. In US, the *heavy-user* group constituted a substantial portion relative to other nations (36-48% in US, 19-33% in Canada, 22% in England, 6-7% in South Korea). Drug use probability was higher in US and Canada ( $\lambda > 0.7$ ) than in other countries ( $\lambda = 0.48-0.68$  in England,  $\lambda = 0.02-0.07$  in South Korea).

In US and Canada, e-cigarette and drug use were found to be impactful in group classification. In US, the *heavy-user* class, comprising 36-48% of the respondents, exhibited markedly high probabilities of using substances including alcohol (93-97%), binge drinking (31-39%), cigarette (46-65%), e-cigarette (79-89%), and drug (75-83%). In Canada, the *heavy-user* class exhibited high probabilities of using substances that included alcohol (97-99%), binge drinking (54-59%), cigarette (64-86%), e-cigarette (58-97%), and drug (71-94%). The *moderate-user* class in Canada exhibited higher probabilities of using five substances than *light-user* class, with alcohol as high as *heavy-user* class (90-100%), but other substances not as high.

In England and South Korea, the usage of alcohol and e-cigarette played a significant role in determining group classification. The *heavy-user* class in England, which comprised of 36-48% of the respondents, demonstrated notably high probabilities of using substances including alcohol (90-93%), binge drinking (37-48%), cigarette (55-71%), e-cigarette (71-94%), and drug (48-68%). In South Korea, while the probability of drug usage was significantly lower compared to other countries, the drug usage probability in the *heavy-user* class was 5-22 times higher than that in the *light-user* class. The *moderate-user* class in South Korea exhibited higher alcohol use than in *heavy-user* class, but other substances were lower.

Regarding the COVID-19 situation, the proportion of *heavy-users* in US, England, and South Korea has decreased compared to before (from 46.1 to 36.0 in US, from 22.8 to 21.6 in England, and from 6.2 to 5.5 in South Korea). In terms of drug usage, the probability decreased in all three countries.

### Relationship between class membership and individual characteristics

The multinomial logistic regression indicated that adolescents in the *heavy-user* class were expected to be significantly older than those in *light-user* class in all four countries (e.g., Canada in 2018, OR = 1.82, 95% CI = 1.80, 1.85) (Table 5). The analysis also revealed that males had a greater probability of belonging to the *heavy-user* class as opposed to the *light-user* class than females in both Canada (OR = 1.13, 95% CI = 1.08, 1.18) and South Korea (OR = 5.06, 95% CI = 4.73, 5.41).

## Discussion

Our study identified several notable patterns and trends in adolescents' substance use across four countries: the United States, Canada, England, and South Korea. The prevalence and patterns of substance use among adolescents varies across the four countries. In US and England, two classes of users: light and heavy were identified, while in Canada and South Korea three classes were identified, including a *moderate-user* class between light and heavy users. The proportion of *heavy-user* class was predominant in the US (over 40%) and Canada (over 30%), followed by England (around 20%) and South Korea, which stood at approximately 6%.

Drug use prevalence was highest in US (31.2-45.2%) and Canada (24.8-31.1%), followed by England (15-22.4%) and South Korea, with the lowest prevalence ranging from 0.7% to 1.0%. Notably, in US (varies by state) and Canada, where cannabis has been legalized, increased accessibility to such substances may encourage adolescent usage compared to other countries [49,50]. Our findings suggest that different regulations on substance use across countries could have a significant impact on patterns of substance use among adolescents. Although the prevalence of drug use in South Korea may be low, it is essential to remain vigilant due to the tendency of Eastern countries to frequently mirror Western cultural trends [28]. Moreover, there's a concern that the criminal justice approach to narcotics in Asia might inadvertently drive illicit drug use underground and consequently underestimate its prevalence [51,52].

When comparing South Korea to three other nations, it was evident that these countries' populations had higher probability of being *heavy-user*, and the prevalence of drug use as well as other substance use was higher. Given the growing concern about youth drug use in Korea, as highlighted in studies [53,54], policies adopted in countries with high prevalence rates should be closely examined. South Korea faces significant challenges in addressing youth drug addiction due to a scarcity of specialized treatment facilities and a system that prioritizes punishment over rehabilitation [55,56]. Despite the Youth Protection Act mandating treatment and rehabilitation for substance addiction, its implementation is skewed towards punitive measures [57,58]. This is evident in the limited availability of specialized treatment centers for youth and the emphasis on legal penalties over therapeutic interventions [57,58]. Rehabilitation programs in Korea, including those for adolescents, are not adequately funded or supported, leading to an inability to provide comprehensive treatment and recovery strategies [57,58]. In contrast, Western coun-



**Table 5.** Relationship between Class Membership and Individual Characteristics (Odds Ratio, 95% Confidence Interval)

United States	Latent Class	2015			2017			2019			2021		
		Light user	Heavy user		Light user	Heavy user		Light user	Heavy user		Light user	Heavy user	
Gender, male (vs. female)	Ref	1.02 (0.95-1.08)	1.03 (0.97-1.10)	Ref	Ref	0.97 (0.90-1.13)	Ref	0.99 (0.93-1.06)	Ref	Ref	Ref	0.99 (0.93-1.06)	
	Ref	1.10 (1.07-1.12)	1.17 (1.14-1.20)	Ref	Ref	1.12 (1.09-1.15)	Ref	1.15 (1.12-1.18)	Ref	Ref	Ref	1.15 (1.12-1.18)	
Age													
Canada	Year	2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2018	
Latent Class	Light user	Light user	Moderate user	Light user	Light user	Moderate user	Light user	Moderate user	Light user	Moderate user	Light user	Heavy user	
	Ref	1.13 (1.08-1.18)	1.08 (1.03-1.14)	Ref	Ref	1.12 (1.07-1.17)	Ref	1.07 (1.03-1.12)	Ref	1.05 (1.01-1.10)	Ref	1.82 (1.80-1.85)	
Gender, male (vs. female)	Ref	1.57 (1.55-1.59)	1.48 (1.46-1.51)	Ref	Ref	1.71 (1.69-1.74)	Ref	1.44 (1.43-1.46)	Ref	1.82 (1.80-1.85)	Ref	1.82 (1.80-1.85)	
	Ref			Ref			Ref		Ref		Ref		
Age													
England	Year	2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2021	
Latent Class	Light user	Light user	Heavy user	Light user	Light user	Heavy user	Light user	Heavy user	Light user	Heavy user	Light user	Heavy user	
	Ref	1.08 (0.96-1.22)	1.00 (0.91-1.09)	Ref	Ref	1.01 (0.93-1.10)	Ref	1.01 (0.93-1.10)	Ref	1.01 (0.93-1.10)	Ref	0.96 (0.88-1.06)	
Gender, male (vs. female)	Ref	1.11 (1.06-1.15)	1.08 (1.05-1.12)	Ref	Ref	1.00 (0.98-1.03)	Ref	1.00 (0.98-1.03)	Ref	1.00 (0.98-1.03)	Ref	1.00 (0.96-1.03)	
	Ref			Ref			Ref		Ref		Ref		
Age													
South Korea	Year	2014	2016	2018	2018	2018	2018	2018	2018	2018	2018	2021	
Latent Class	Light user	Light user	Moderate user	Light user	Light user	Moderate user	Light user	Moderate user	Light user	Moderate user	Light user	Moderate user	
	Ref	1.95 (1.85-2.05)	1.87 (1.76-1.98)	Ref	Ref	3.58 (3.34-3.84)	Ref	1.59 (1.50-1.68)	Ref	4.03 (3.72-4.36)	Ref	1.48 (1.37-1.60)	
Gender, male (vs. female)	Ref	1.40 (1.38-1.42)	1.51 (1.49-1.54)	Ref	Ref	1.52 (1.49-1.55)	Ref	1.45 (1.42-1.47)	Ref	1.54 (1.51-1.57)	Ref	1.48 (1.45-1.52)	
	Ref			Ref			Ref		Ref		Ref		
Age													

tries prioritize public health perspectives, offering various programs to address substance use issues. For example, the UK's ten-year drug strategy promises significant funding for treatment services and focuses on education and support for at-risk families [59]. Canada invests in community-led programs and addresses social determinants of health and drug use through federal programs [60]. In US, programs such as the SAFER university program for preventing harm from binge drinking [61], and SBIRT (Screening, Brief Intervention, and Referral to Treatment) for preventing drug-related harm, are being implemented [62]. The Korean government should consider adopting similar approaches in policy development by referencing such foreign examples. There is a need for more specialized programs that cater to the unique needs of adolescents, integrating educational support and family therapy to address the broader impact of addiction on young lives.

The prevalence and patterns of substance use among adolescents varies across four countries. The *light-user* class, which comprised 53-84% of the population in each country, showed relatively lower probability of substance use. However, alcohol use was still high in this class, suggesting that drinking is widespread among adolescents. The overall prevalence of alcohol use was found to be the highest among all substances in four countries. Underage drinking poses significant risks across various developmental domains, including academic, social, physical, and psychological aspects [63]. Research indicates that early alcohol consumption increases the likelihood of developing mental health problems, such as depression, anxiety, and suicidal tendencies later in adulthood [64]. Moreover, alcohol use during adolescence can interfere with brain development, causing long-term cognitive impairments and emotional instability [64]. Furthermore, underage drinking may potentially lead to the use of other substances [63]. Interventions should be provided to prevent alcohol use among adolescents. For example, one Australian research finding showed that relevant education provided to both students and parents was effective in reducing alcohol use and preventing alcohol abuse in adolescents [65].

The adolescents in the *heavy-user* class were found to have a significantly high probability of using not only alcohol but also substances such as e-cigarettes, cigarettes, and drugs. E-cigarette use played an important role in determining the class between *light-user* and *heavy-user*. According to a US study [66], the use of regular cigarettes is decreasing and the use of e-cigarettes is increasing among adolescents, which is consistent with our results. It is said that the use of e-cigarettes leads to later use of cigarettes and other dangerous substances such as marijuana [66]. Govern-

ment-level measures should be taken to prevent adolescents from being exposed to advertisements for e-cigarettes [67]. Additionally, rather than blaming adolescents who smoke, education and services should be provided to smokers to help them quit. In Canada and South Korea, adolescents in the *moderate-user class* used other substances less frequently than *heavy-users*, but had higher probabilities of alcohol, cigarettes, and e-cigarettes use. Implementing focused prevention strategies to deter them from progressing into *heavy users* could be a priority.

The findings indicate that the COVID-19 pandemic has caused notable alterations in the behavior of substance use among adolescents, aligning with previous studies [23]. Adolescents' substance use is influenced by peer pressure and emotional detachment from parents [68]. The decline in substance use during the COVID-19 pandemic can be ascribed to more time spent within residential areas, less peer influence due to various restrictions, less social use, and less accessibility [23]. Understanding the factors that influenced changes in substance use behaviors during the pandemic can inform the development of more effective and targeted strategies to address adolescent substance use in the future.

Individual characteristics such as gender and age played significant roles in determining substance use classes among adolescents. Older adolescents were more likely to engage in moderate or heavy substance use compared to younger adolescents. As noted in certain studies, this tendency in older adolescents may be related to their perception of greater access to substances compared to younger adolescents [69]. Gender disparities were also observed, with males exhibiting higher odds of belonging to the *heavy-user* class compared to females in certain countries (i.e., Canada and South Korea). Recognizing these demographic variations can offer valuable insights for creating focused interventions customized for particular populations.

A key strength of this study lies in its innovative extension of Latent Class Analysis (LCA) to classify substance users, followed by an exploration of the association between substance user classes and individual characteristics. Additionally, the study's comprehensive examination of time trends spanning from 2014 to 2021 across four countries provides valuable insights into the evolving landscape of substance use. However, the current study has several limitations to consider. All data were reliant on self-report measures from adolescents, which may be susceptible to social desirability bias [70]. Moreover, the original data of the four countries were collected from adolescents attending school and this may restrict the generalizability of findings to the broader adolescent population. Canadian data for 2022 are not yet avail-

able to the public and are therefore not included in this study, which may raise concerns about the completeness and accuracy of the observed time trends. Incorporating and analyzing this data once it becomes available will provide a more comprehensive understanding of recent trends. While we considered lifetime use of various substances, it would be beneficial for future studies to include additional indicators in the analysis to take into account the extent or severity of substance use and better delineate substance user classes. Furthermore, the study's exclusive focus on four countries might hinder the applicability of its findings to a broader context. Therefore, it is advisable to incorporate data from diverse Asian countries or other continents' representative nations to gain a more comprehensive understanding of regional variations.

## Conclusions

This study provides important perspectives on the differences in substance use trends among various countries and across time periods. Despite South Korea's low probability of drug use, careful attention is needed due to Eastern countries' tendencies to emulate Western cultural trends [28]. A customized approach is crucial to effectively dealing with and preventing adolescents from becoming severe substance users, and to helping those who are heavier users to reduce or avoid substance use. This approach should take into account the unique regulations in each country, the time dynamics, and the demographic traits to ensure a focused and thorough preventive strategy.

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## Authors' contributions

Chaehee Kim contributed to conceptualization, data curation, formal analysis, visualization, writing-original draft, review & editing, investigation, resources, and software. Kihye Han contributed to methodology, project administration, writing-original draft, review & editing, resources, supervision, and validation. Jieun Kim contributed to conceptualization, methodology, and writing-review & editing. Alison M. Trinkoff contributed to writing-review & editing and supervision. Sihyun Park contributed to conceptualization, methodology, and writing-review & editing. Hyejin Kim contributed to conceptualization, and writing-review & editing.

## Data availability

Public data was used, and the URL is presented in [Table 1](#).

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## References

1. American Academy of Pediatrics. Substance use screening and intervention implementation guide [Internet]. Burlington: Vermont Department of Health. 2016 [cited 2024 Jan 10]. Available from: [https://www.healthvermont.gov/sites/default/files/documents/pdf/ADAP\\_Adolescent-PC-SU-Screening-Guide.pdf](https://www.healthvermont.gov/sites/default/files/documents/pdf/ADAP_Adolescent-PC-SU-Screening-Guide.pdf)
2. Carpentier C, Me A, Carvacho P, Crean C, Davis P, et al. World Drug Report 2018. Research Report. Vienna: United Nations Office on Drugs and Crime;2018 June. Report No.: E.18.XL9.
3. Thorisdottir IE, Asgeirsdottir BB, Sigurvinsdottir R, Allegrante JP, Sigfusdottir ID. The increase in symptoms of anxiety and depressed mood among Icelandic adolescents: Time trend between 2006 and 2016. *The European Journal of Public Health*. 2017;27(5):856–861. <https://doi.org/10.1093/eurpub/ckx111>
4. Chen CY, Storr CL, Anthony JC. Early-onset drug use and risk for drug dependence problems. *Addictive Behaviors*. 2009;34(3):319–322. <https://doi.org/10.1016/j.addbeh.2008.10.021>
5. Macleod J, Oakes R, Copello A, Crome I, Egger M, Hickman M, et al. Psychological and social sequelae of cannabis and

- other illicit drug use by young people: A systematic review of longitudinal, general population studies. *The Lancet*. 2004;363(9421):1579–1588. [https://doi.org/10.1016/S0140-6736\(04\)16200-4](https://doi.org/10.1016/S0140-6736(04)16200-4)
6. Jessor R. Problem-behavior theory, psychosocial development, and adolescent problem drinking. *British Journal of Addiction*. 1987;82(4):331–342. <https://doi.org/10.1111/j.1360-0443.1987.tb01490.x>
  7. Patton GC, Olsson CA, Skirbekk V, Saffery R, Wlodek ME, Azzopardi PS, et al. Adolescence and the next generation. *Nature*. 2018;554(7693):458–466. <https://doi.org/10.1038/nature25759>
  8. Leslie K. Youth substance use and abuse: Challenges and strategies for identification and intervention. *CMAJ*. 2008;178(2):145–148. <https://doi.org/10.1503/cmaj.071410>
  9. Brown SA, Christiansen BA, Goldman MS. The alcohol expectancy questionnaire: An instrument for the assessment of adolescent and adult alcohol expectancies. *Journal of Studies on Alcohol*. 1987;48(5):483–491. <https://doi.org/10.15288/jsa.1987.48.483>
  10. Christiansen BA, Goldman MS, Inn A. Development of alcohol-related expectancies in adolescents: Separating pharmacological from social-learning influences. *Journal of Consulting and Clinical Psychology*. 1982;50(3):336–334. <https://doi.org/10.1037/0022-006X.50.3.336>
  11. Wagner EF, Myers MG, Brown SA. Adolescent substance abuse treatment. In: Creek LV, Knapp S, Jackson TL, editors. *Innovations in Clinical Practice: A Source Book*. Vol. 13. Professional Resource Press/Professional Resource Exchange; Sarasota, FL: 1994. p. 97–121.
  12. Health Canada. Canadian cannabis use survey 2019 - summary [Internet]. Ottawa: Health Canada. 2019 [cited 2023 Nov 15]. Available from: <https://doi.org/10.25318/1310039401-eng>
  13. Substance Abuse and Mental Health Services Administration. National Survey on Drug Use and Health 2019 (NSDUH-2019-DS0001) [Internet]. Rockville: Substance Abuse and Mental Health Services Administration. 2020 [cited 2023 Nov 16]. Available from: <https://datafiles.samhsa.gov/>
  14. Carpentier C, Me A, Astoul J, Barrera J, Davalos L, et al. World Drug Report 2022. Research Report. Vienna: United Nations Office on Drugs and Crime; 2022 June. Report No.: 22.XI.8.
  15. Substance Abuse and Mental Health Services Administration. 2022 National Survey on Drug Use and Health (NSDUH): Tables 1.2B, 2.1B [Internet]. Rockville: Substance Abuse and Mental Health Services Administration. 2022 [cited 2024 Mar 20]. Available from: <https://www.samhsa.gov/data/sites/default/files/reports/rpt42728/NSDUHDetailedTabs2022/NSDUHDetailedTabs2022/2022-nsduh-detailed-tables-toc.htm#toc>
  16. Friedman J, Godvin M, Shover CL, Gone JP, Hansen H, Schriger DL. Trends in drug overdose deaths among US adolescents, January 2010 to June 2021. *Jama*. 2022;327(14): <https://doi.org/10.1001/jama.2022.2847>
  17. Barnes GM, Welte JW, Hoffman JH. Relationship of alcohol use to delinquency and illicit drug use in adolescents: Gender, age, and racial/ethnic differences. *Journal of Drug Issues*. 2002;32(1):153–178. <https://doi.org/10.1177/002204260203200107>
  18. Wang J, Simons-Morton BG, Farhart T, Luk JW. Socio-demographic variability in adolescent substance use: Mediation by parents and peers. *Prevention Science*. 2009;10:387–396. <https://doi.org/10.1007/s11121-009-0141-1>
  19. Musher-Eizenman DR, Holub SC, Arnett M. Attitude and peer influences on adolescent substance use: The moderating effect of age, sex, and substance. *Journal of Drug Education*. 2003;33(1):1–23. <https://doi.org/10.2190/yed0-bqa8-5rvx-95jb>
  20. Duncan SC, Duncan TE, Strycker LA. Alcohol use from ages 9 to 16: A cohort-sequential latent growth model. *Drug and Alcohol Dependence*. 2006;81(1):71–81. <https://doi.org/10.1016/j.drugalcdep.2005.06.001>
  21. Johnston LD, O'Malley PM, Bachman JG. Monitoring the future: National results on adolescent drug use: Overview of key findings. *Focus*. 2003;1(2):213–234. <https://doi.org/10.1176/foc.1.2.213>
  22. Dave D, Feng B, Pesko MF. The effects of e-cigarette minimum legal sale age laws on youth substance use. *Health Economics*. 2019;28(3):419–436. <https://doi.org/10.1002/hec.3854>
  23. Layman HM, Thorisdottir IE, Halldorsdottir T, Sigfusdottir ID, Allegrante JP, Kristjansson AL. Substance use among youth during the COVID-19 pandemic: A systematic review. *Current Psychiatry Reports*. 2022;24(6):307–324. <https://doi.org/10.1007/s11920-022-01338-z>
  24. Cuadros DF, Branscum AJ, Moreno CM, MacKinnon NJ. Narrative minireview of the spatial epidemiology of substance use disorder in the United States: Who is at risk and where? *World Journal of Clinical Cases*. 2023;11(11):2374–2385. <https://doi.org/10.12998/wjcc.v11.i11.2374>
  25. Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, et al. Tobacco use among middle and high school stu-

- dents—United States, 2011–2014. *MMWR. Morbidity and Mortality Weekly Report*. 2015;64(14):381–385.
26. Wasowicz A, Feleszko W, Goniewicz ML. E-Cigarette use among children and young people: The need for regulation. *Expert Review of Respiratory Medicine*. 2015;9(5):507–509. <https://doi.org/10.1586/17476348.2015.1077120>
  27. Sandhu HS, Anderson LN, Busse JW. Characteristics of Canadians likely to try or increase cannabis use following legalization for nonmedical purposes: A cross-sectional study. *Canadian Medical Association Open Access Journal*. 2019;7(2):E399–E404. <https://doi.org/10.9778/cmajo.20190008>
  28. Cohen WI. Americanization of East Asia. *Education about Asia*. 2006;11(2):26–29.
  29. United States Alcohol Policy Information System. The 1984 National Minimum Drinking Age Act [Internet]. Rockville: National Institute on Alcohol Abuse and Alcoholism. 1984 [cited 2024 Feb 5]. Available from: <https://alcoholpolicy.niaaa.nih.gov/the-1984-national-minimum-drinking-age-act#:~:text=The%201984%20National%20Minimum%20Drinking%20Age%20Act%2C%20%5B23%20U.S.C.,of%20receiving%20State%20highway%20funds>
  30. United States Food and Drug Administration. Tobacco 21 [Internet]. Silver Spring: United States Food and Drug Administration. 2019 [cited 2023 Dec 20]. Available from: [https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/tobacco-21#:~:text=This%20legislation%20\(known%20as%20%E2%80%9CTobacco,and%20persons%20with%20no%20exceptions](https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/tobacco-21#:~:text=This%20legislation%20(known%20as%20%E2%80%9CTobacco,and%20persons%20with%20no%20exceptions)
  31. United States Congressional Research Service. Recent Developments in Marijuana Law, 2022 [Internet]. Washington: United States Congressional Research Service. 2022 [cited 2023 Dec 20]. Available from: <https://crsreports.congress.gov/product/pdf/LSB/LSB10859>
  32. Government of Canada Justice Laws Website. Tobacco Act 1997 [Internet]. Ottawa: Government of Canada. 1997 [cited 2023 Dec 20]. Available from: <https://laws.justice.gc.ca/eng/acts/T-11.5/page-1.html>
  33. Government of Canada Justice Laws Website. Cannabis Act 2018 [Internet]. Ottawa: Government of Canada. 2018 [cited 2023 Dec 20]. Available from: <https://laws-lois.justice.gc.ca/eng/acts/C-24.5/>
  34. Canadian Centre on Substance Abuse. The impact and effectiveness of minimum legal drinking age legislation in Canada [Internet]. Ottawa: Canadian Centre on Substance Abuse. 2017 [cited 2023 Dec 20]. Available from: <https://ccsa.ca/sites/default/files/2019-04/CCSA-Impact-Effectiveness-ML-DA-Legislation-2017-en.pdf>
  35. United Kingdom Legislation Center. Children and Young Persons Act 1963 [Internet]. London: United Kingdom Legislation Center. 1963 [cited 2023 Dec 21]. Available from: <https://www.legislation.gov.uk/ukpga/1963/37>
  36. United Kingdom Legislation Center. Misuse of Drugs Act 1971 [Internet]. London: United Kingdom Legislation Center. 1971 [cited 2023 Dec 21]. Available from: <https://www.legislation.gov.uk/uksi/2018/1055/contents/made>
  37. United Kingdom Legislation Center. Youth Protection Law [Internet]. London: United Kingdom Legislation Center. 2011 [cited 2023 Dec 21]. Available from: <http://www.law.go.kr/lsInfoP.do?lsiSeq=121990&efYd=20120916#0000>
  38. Korea National Legislation Information Center. Narcotics Control Law [Internet]. Seoul: Korea National Legislation Information Center. 2022 [cited 2023 Dec 21]. Available from: [https://law.go.kr/%EB%B2%95%EB%A0%B9/%EB%A7%88%EC%95%BD%EB%A5%98%EA%B4%80%EB%A6%AC%EB%B2%95#:~:text=%EC%A0%9C1%EC%A1%B0\(%EB%AA%A9%EC%A0%81\)%20%EC%9D%B4,7.5D](https://law.go.kr/%EB%B2%95%EB%A0%B9/%EB%A7%88%EC%95%BD%EB%A5%98%EA%B4%80%EB%A6%AC%EB%B2%95#:~:text=%EC%A0%9C1%EC%A1%B0(%EB%AA%A9%EC%A0%81)%20%EC%9D%B4,7.5D)
  39. Tam CL, Foo YC. Contributory factors of drug abuse and the accessibility of drugs. *International Journal of Collaborative Research on Internal Medicine & Public Health*. 2012;4(9):1621–1625.
  40. McAloney-Kocaman K, Rogon PJS, Ireland L. Clustering of lifetime substance use and sexual intercourse among young people: Analysis of two school-based surveys. *Journal of Child & Adolescent Substance Abuse*. 2019;28(2):99–104. <https://doi.org/10.1080/1067828X.2019.1602090>
  41. Tam CC, Qiao S, Garrett C, Zhang R, Aghaei A, Aggarwal A, et al. Substance use, psychiatric symptoms, personal mastery, and social support among COVID-19 long haulers: A compensatory model. *Plos One*. 2023;18(8):e0289413. <https://doi.org/10.1371/journal.pone.0289413>
  42. Kristjansson SD, Agrawal A, Lynskey MT, Chassin LA. Marijuana expectancies and relationships with adolescent and adult marijuana use. *Drug and Alcohol Dependence*. 2012;126(1-2):102–110. <https://doi.org/10.1016/j.drugalcdep.2012.04.024>
  43. Muthén LK, Muthén B. *Mplus user's guide: Statistical analysis with latent variables*. 7th ed. Los Angeles: Muthén & Muthén; 2017. 812 p.
  44. Collins LM, Lanza ST. *Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences*. Chichester WS: John Wiley & Sons; 2009. 285 p.
  45. Ng CW, Luo N, Heng BH. *Health status profiles in communi-*



- ty-dwelling elderly using self-reported health indicators: A latent class analysis. *Quality of Life Research*. 2014;23(10):2889–2898. <https://doi.org/10.1007/s11136-014-0723-7>
46. Jung T, Wickrama KAS. An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass*. 2007;2(1):302–317. <https://doi.org/10.1111/j.1751-9004.2007.00054.x>
47. Muthén B. Statistical and substantive checking in growth mixture modeling: comment on Bauer and Curran. Los Angeles: Muthén & Muthén; 2003. 25 p.
48. Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. *Biometrika*. 2001;88(3):767–778. <https://doi.org/10.1093/biomet/88.3.767>
49. Walker M, Carpino M, Lightfoot D, Rossi E, Tang M, Mann R, et al. The effect of recreational cannabis legalization and commercialization on substance use, mental health, and injury: A systematic review. *Public Health*. 2023;221:87–96. <https://doi.org/10.1016/j.puhe.2023.06.012>
50. Rubin-Kahana DS, Crépault JF, Matheson J, Le Foll B. The impact of cannabis legalization for recreational purposes on youth: A narrative review of the Canadian experience. *Frontiers in Psychiatry*. 2022;13:984485. <https://doi.org/10.3389/fpsy.2022.984485>
51. Jia Z, Jin Y, Zhang L, Wang Z, Lu Z. Prevalence of drug use among students in mainland China: A systematic review and meta-analysis for 2003–2013. *Drug and Alcohol Dependence*. 2018;186:201–206. <https://doi.org/10.1016/j.drugalcdep.2017.12.047>
52. Hardon A, Hymans TD. Ethnographies of youth drug use in Asia. *International Journal on Drug Policy*. 2014;25(4):749–754. <https://doi.org/10.1016/j.drugpo.2014.06.009>
53. Yim YJ, An SW. A study on the actual condition analysis of adolescents inhaling hallucinogenic substances. *Korean Association of Addiction Crime Review*. 2020;10(4):141–159. <http://doi.org/10.26606/kaac.2020.10.4.7>
54. Park SS. Youth substance addiction prevention strategy. *Korean Association of Addiction Crime Review*. 2017;7(4):43–62. <http://doi.org/10.26606/kaac.2017.7.4.3>
55. Kim BS. Korean drug courts a bridge between correction and social welfare. *Law Review*. 2018;59(1):297–325. <https://doi.org/10.35275/pnulaw.2018.59.1.010>
56. Park SS. A study on the revitalization of drug addiction prevention project. *Korean Association of Addiction Crime Review*. 2022;12(4):71–100. <https://doi.org/10.26606/kaac.2022.12.4.4>
57. Koreapro. Why more young South Koreans are grappling with drug abuse and addiction [Internet]. Seoul: Koreapro. 2023 [cited 2024 Jun 10]. Available from: <https://koreapro.org/2023/05/why-more-young-south-koreans-are-grappling-with-drug-abuse-and-addiction/>
58. Asian Pacific Foundation of Canada. Rising drug use in South Korea forces government to respond, adapt [Internet]. Vancouver: Asian Pacific Foundation of Canada. 2023 [cited 2024 Jun 10]. Available from: <https://www.asiapacific.ca/publication/rising-drug-use-south-korea-forces-government-respond-adapt>
59. Holland A, Stevens A, Harris M, Lewer D, Sumnall H, Stewart D, et al. Analysis of the UK government’s 10-year drugs strategy—a resource for practitioners and policymakers. *Journal of Public Health*. 2023;45(2):e215–e224. <https://doi.org/10.1093/pubmed/fdac114>
60. Government of Canada. Canadian Drugs and Substances Strategy: Prevention and education [Internet]. Ottawa: Government of Canada. 2023 [cited 2024 Mar 20]. Available from: <https://www.canada.ca/en/health-canada/services/substance-use/canadian-drugs-substances-strategy/prevention-education.html>
61. Saltz RE, Paschall MJ, McGaffigan RP, Nygaard PMO. Alcohol risk management in college settings: The safer California universities randomized trial. *American Journal of Preventive Medicine*. 2010;39(6):491–499. <https://doi.org/10.1016/j.amepre.2010.08.020>
62. Substance Abuse and Mental Health Services Administration. Screening, Brief Intervention, and Referral to Treatment (SBIRT) Grantees [Internet]. Rockville: Substance Abuse and Mental Health Services Administration. 2024 [cited 2024 Mar 20]. Available from: <https://www.samhsa.gov/sbirt/grantees>
63. Centers for Disease Control and Prevention. Underage drinking [Internet]. Atlanta: Centers for Disease Control and Prevention. 2024 [cited 2024 Mar 20]. Available from: <https://www.cdc.gov/alcohol/fact-sheets/underage-drinking.htm#:~:text=Increased%20risk%20of%20suicide%20and,Misuse%20of%20other%20substances>
64. National Institute on Alcohol Abuse and Alcoholism. Mental health issues, alcohol use disorder, and common co-occurring conditions [Internet]. Bethesda: National Institute on Alcohol Abuse and Alcoholism. 2024 [cited 2024 Jun 10]. Available from: <https://www.niaaa.nih.gov/health-professionals-communities/core-resource-on-alcohol/mental-health-issues-alcohol-use-disorder-and-common-co-occurring-conditions>
65. Toumbourou JW, Gregg MED, Shortt AL, Hutchinson DM, Slaviero TM. Reduction of adolescent alcohol use through

- family-school intervention: A randomized trial. *Journal of Adolescent Health*. 2013;53(6):778–784. <https://doi.org/10.1016/j.jadohealth.2013.07.005>
66. Jones K, Salzman GA. The vaping epidemic in adolescents. *Missouri Medicine*. 2020;117(1):56–58.
67. Pettigrew S, Santos JA, Pinho-Gomes AC, Li Y, Jones A. Exposure to e-cigarette advertising and young people's use of e-cigarettes: A four-country study. *Tobacco Induced Diseases*. 2023;21:141. <https://doi.org/10.18332/tid/172414>
68. Gallegos MI, Zaring-Hinkle B, Wang N, Bray JH. Detachment, peer pressure, and age of first substance use as gateways to later substance use. *Drug and Alcohol Dependence*. 2021;218:108352. <https://doi.org/10.1016/j.drugalcdep.2020.108352>
69. Broman CL. The availability of substances in adolescence: Influences in emerging adulthood. *Journal of Child & Adolescent Substance Abuse*. 2016;25(5):487–495. <https://doi.org/10.1080/1067828x.2015.1103346>
70. Paulhus DL, Vazire S. The self-report method. In: Robins RW, Fraley RC, Krueger RF, editors. *Handbook of research methods in personality psychology*. New York: Guilford; 2007. p. 224–239.