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...
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 educators. For example, in the 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 compare 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

<table>
<thead>
<tr>
<th>Country</th>
<th>Name of survey</th>
<th>Implementation period</th>
<th>Period used in this study</th>
<th>Population age (approximately)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Korea</td>
<td>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>)</td>
<td>Every year</td>
<td>2014, 2016, 2018, 2021</td>
<td>12-17, 54,000</td>
</tr>
</tbody>
</table>

Participants 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>
<thead>
<tr>
<th>Variables Used in This Study</th>
<th>United States</th>
<th>Canada</th>
<th>England</th>
<th>South Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ever alcohol use</strong></td>
<td><strong>How old were you when you had your first drink of alcohol other than a few sips?</strong> &lt;br&gt; • No (I have never had a drink of alcohol other than a few sips) &lt;br&gt; • Yes (8 years 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)</td>
<td><strong>Have you ever had a drink of alcohol that was more than just a sip?</strong> &lt;br&gt; • No</td>
<td><strong>Have you ever had an alcoholic drink – a whole drink, not just a sip?</strong> &lt;br&gt; • No</td>
<td><strong>Have you ever had a drink of alcohol that was more than just a glass?</strong> &lt;br&gt; • No</td>
</tr>
<tr>
<td><strong>Current binge drinking</strong></td>
<td><strong>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)?</strong></td>
<td><strong>In the last 30 days, how often did you have 5 or more drinks of alcohol on one occasion?</strong></td>
<td><strong>How many times have you been drunk in the last 4 weeks?</strong></td>
<td><strong>In the last 30 days, what has been your average alcohol consumption?</strong>&lt;br&gt;</td>
</tr>
<tr>
<td><strong>Ever cigarette use</strong></td>
<td><strong>Have you ever tried cigarette smoking, even one or two puffs?</strong> &lt;br&gt; • No</td>
<td><strong>Have you ever tried cigarette smoking, even just a few puffs?</strong> &lt;br&gt; • Yes</td>
<td></td>
<td></td>
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<tr>
<td><strong>Ever e-cigarette use</strong></td>
<td><strong>Have you ever used an electronic vapor product?</strong> &lt;br&gt; • No</td>
<td><strong>Which did you try first: a cigarette or an e-cigarette (vape, vape pen, tank &amp; mod)?</strong></td>
<td>**Read the following statements carefully and tick the box next to the one which best describes you (cigarette smoking status) **</td>
<td><strong>Have you ever tried cigarette smoking, even one or two puffs?</strong></td>
</tr>
<tr>
<td><strong>Ever drug use</strong></td>
<td><strong>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?</strong> &lt;br&gt; • No (0 times) &lt;br&gt; • 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)</td>
<td><strong>Have you ever used or tried marijuana or cannabis / drug or substance / amphetamines, mdma, hallucinogens, heroin, cocaine, synthetic cannabinoids, bzp, bath salts, 2c, tryptamines, glue, salvia?</strong> &lt;br&gt; • No (No, I have never used this)</td>
<td><strong>Have you ever tried cannabis / speed or other Amphetamines / lsd / ecstasy / eemeron / poppers / tranquilizers / heroin / magic mushrooms / methadone / crack / cocaine / ketamine / methedrone / glue, gas, aerosols or solvents / nitrous oxide / ‘legal highs’ / other drugs (not from doctor)?</strong> &lt;br&gt; • No</td>
<td><strong>Are there any drugs or substances you have used habitually other than for therapeutic purposes? Examples: stimulants, tranquilizers, butane gas, bond, etc.</strong>&lt;br&gt;</td>
</tr>
</tbody>
</table>
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 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 (λ) 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>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>N</th>
<th>Alcohol</th>
<th>Binge drinking</th>
<th>Cigarette</th>
<th>E-cigarette</th>
<th>Drug</th>
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<td>17.4</td>
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<td>45.4</td>
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<td></td>
<td>2017</td>
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<td>12.0</td>
<td>22.5</td>
<td>40.0</td>
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<td></td>
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<td>12.1</td>
<td>16.9</td>
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<td>41.9</td>
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<td>2021</td>
<td>17,232</td>
<td>45.1</td>
<td>8.2</td>
<td>13.9</td>
<td>35.1</td>
<td>31.2</td>
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</table>

† Lo-Mendell-Rubin likelihood ratio test; ‡ Akaike information criterion; § 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 (λ > 0.7) than in other countries (λ = 0.48-0.68 in England, λ = 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.

**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].

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

<table>
<thead>
<tr>
<th>Latent Class</th>
<th>Gender, male (vs. female)</th>
<th>Age</th>
<th>Year</th>
<th>2015</th>
<th>2017</th>
<th>2019</th>
<th>2021</th>
</tr>
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<tr>
<td>United States</td>
<td>Ref</td>
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<td>1.03</td>
<td>0.97</td>
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<td>(0.97-1.11)</td>
<td>(0.90-1.13)</td>
<td>(0.93-1.06)</td>
</tr>
<tr>
<td>Canada</td>
<td>Ref</td>
<td>1.08</td>
<td>2014</td>
<td>1.13</td>
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<td>1.07</td>
<td>1.05</td>
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<tr>
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<td>(1.08-1.18)</td>
<td></td>
<td></td>
<td>(1.08-1.18)</td>
<td>(1.03-1.14)</td>
<td>(1.03-1.12)</td>
<td>(1.01-1.10)</td>
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<tr>
<td>England</td>
<td>Ref</td>
<td>1.11</td>
<td>2014</td>
<td>1.08</td>
<td>1.08</td>
<td>1.00</td>
<td>0.96</td>
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<tr>
<td></td>
<td>(1.06-1.15)</td>
<td></td>
<td></td>
<td>(1.06-1.15)</td>
<td>(1.05-1.12)</td>
<td>(0.98-1.03)</td>
<td>(0.96-1.03)</td>
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<tr>
<td>South Korea</td>
<td>Ref</td>
<td>1.40</td>
<td>2014</td>
<td>1.95</td>
<td>1.87</td>
<td>1.59</td>
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<td>(1.85-2.05)</td>
<td>(1.76-1.98)</td>
<td>(1.50-1.68)</td>
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<td>4.03</td>
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<td>(1.42-1.47)</td>
<td>(1.51-1.57)</td>
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</table>
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 compromised 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]. Government-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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Conflict of interest

The authors declared no conflict of interest.

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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


25. Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apleberg BJ, et al. Tobacco use among middle and high school stu-


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%9B%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%20%EC%9D%B4,7.%5D


45. Ng CW, Luo N, Heng BH. Health status profiles in communi-
ty-dwelling elderly using self-reported health indicators: A latent
text 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
doi.org/10.1111/j.1751-9004.2007.00054.x
47. Muthén B. Statistical and substantive checking in growth mix-
ture modeling: comment on Bauer and Curran. Los Angeles:
48. Lo Y, Mendell NR, Rubin DB. Testing the number of compo-
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 com-
mercialization on substance use, mental health, and injury: A
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. Front-
fpsyt.2022.984485
among students in mainland China: A systematic review and
dep.2017.12.047
52. Hardon A, Hymans TD. Ethnographies of youth drug use in
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 Associa-
http://doi.org/10.26606/kaac.2020.10.4.7
54. Park SS. Youth substance addiction prevention strategy, Kor-
http://doi.org/10.26606/kaac.2017.7.4.3
55. Kim BS. Korean drug courts a bridge between correction and
org/10.35275/pnulaw.2018.59.1.010
56. Park SS. A study on the revitalization of drug addiction pre-
vention project. Korean Association of Addiction Crime Re-
2022.12.4.4
57. Koreapro. Why more young South Koreans are grappling with
drug abuse and addiction [Internet]. Seoul: Koreapro. 2023
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]. Van-
couver: Asian Pacific Foundation of Canada. 2023 [cited 2024
Jun 10]. Available from: https://www.asiapacific.ca/publica-
tion/rising-drug-use-south-korea-forces-government-res-
pond-adapt
D, et al. Analysis of the UK government’s 10-year drugs strategy—a resource for practitioners and policymakers. Journal of
pubmed/dfac114
60. Government of Canada. Canadian Drugs and Substances
Strategy: Prevention and education [Internet]. Ottawa: Gov-
ernment of Canada. 2023 [cited 2024 Mar 20]. Available from:
https://www.canada.ca/en/health-canada/services/sub-
stance-use/canadian-drugs-substances-strategy/preven-
tion-education.html
61. Saltz RF, Paschall MJ, McCaffigan RP, Nygaard PMO. Alcohol
risk management in college settings: The safer California uni-
versities randomized trial. American Journal of Preventive
pre.2010.08.020
62. Substance Abuse and Mental Health Services Administration.
Screening, Brief Intervention, and Referral to Treatment (SBIRT)
63. Centers for Disease Control and Prevention. Underage drink-
ing [Internet]. Atlanta: Centers for Disease Control and Pre-
www.cdc.gov/alcohol/fact-sheets/underage-drinking.ht-
ml#:~:text = Increased%20risk%20of%20suicide%20and,Mis-
use%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-commu-
unities/core-resource-on-alcohol/mental-health-issues-al-
cohol-use-disorder-and-common-co-occurring-conditions
65. Toumbourou JW, Gregg MED, Shortt AL, Hutchinson DM,
Slaviero TM. Reduction of adolescent alcohol use through


