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Publication Date

2024-05-01

DOI

10.1016/j.addbeh.2024.107971

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Peer reviewed

Classification of patterns of tobacco and cannabis co-use based on temporal proximity: a qualitative study among young adults

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Abstract

Purpose: Co-use of tobacco and cannabis is a common and complex behavior. The lack of harmonized measures of co-use yields confusion and inconsistencies in synthesizing evidence about the health effects of co-use. We aimed to classify co-use patterns based on temporal proximity and describe preferred products and motives for each pattern in order to improve co-use surveillance.

Methods: We conducted semi-structured interviews in a sample of 34 young adults ($M_{age}=22.8$ years, 32.4% female) during 2017-2019 in California, USA. We employed a qualitative thematic analysis to identify timing, reasons, and contexts for tobacco and cannabis co-use and classify co-use patterns.

Results: Four emergent patterns of co-use with increasing temporal proximity between tobacco use and cannabis use were: *Same-month different-day co-use (Pattern 1)*; *Same-day different-occasion co-use (Pattern 2)*; *Same-occasion sequential co-use (Pattern 3)*; and *Same-occasion simultaneous co-use (Pattern 4)*. Participants used various product combinations within each pattern. Similar motives for all patterns were *socialization*, *product availability*, and *coping with stress/anxiety*. Unique motive for temporally distant patterns (Patterns 1 and 2) was *seeking substance-specific effects* (e.g., stimulant effect from nicotine, relaxation effects from cannabis), while unique motives for temporally close patterns (Patterns 3 and 4) were *seeking combined effects from both substances* (e.g., more intense psychoactive effects, mitigating cannabis adverse effects) and *behavioral trigger* (e.g., cannabis use triggers tobacco use).

Conclusions: Our classification of co-use patterns can facilitate consistency for measuring co-use and assessing its health impacts. Future research should also measure product types and motives for different patterns to inform intervention efforts.

Keywords: marijuana smoking, e-cigarettes, nicotine, youth, co-use, polysubstance use, qualitative research.

1. Introduction

Use of both tobacco and cannabis (co-use) among US young adults (YAs aged 18-29 years old) is of public health concern (Cohn and Chen, 2022; Ramo et al., 2012). Of all US YAs who use tobacco, 48% reported using cannabis in the past 30 days (Cohn and Chen, 2022). Co-use prevalence is higher in young adults than older adults (Cohn and Chen, 2022; Goodwin et al., 2018), highlighting a need to address this issue in young adulthood. While data are limited about health impacts of co-use, current evidence in the general adult population suggests that co-use (versus single substance use) is associated with additional toxicant exposures (Meier and Hatsukami, 2016), more psychiatric and psychosocial problems (Peters et al., 2014, 2012), and an increased likelihood of anxiety and depression (Nguyen et al., 2023b). Adults who co-use report heavier use and dependence (Cohn et al., 2016; Crane et al., 2013; Hindocha and McClure, 2021) and poorer cessation outcomes for tobacco and cannabis than those who use single substances (Rabin and George, 2015). Cannabis legalization in the US may increase perceptions of cannabis safety and access to cannabis products, which may increase co-use with tobacco (Nargis and Asare, 2023). Thus, monitoring co-use among young adults is warranted to prevent progression of tobacco and cannabis use and negative health consequences.

Efforts to address co-use among YAs are challenged by the inherent complexity of this behavior (Hindocha and McClure, 2021; Nguyen et al., 2020). Co-use is an “umbrella” term - covering numerous behavioral patterns that vary by product and time. Regarding product types, co-use refers to combinations of all available products in the marketplace, such as cigarettes, e-cigarettes, cigars, hookah, and smokeless products for tobacco, as well as joints, Tetrahydrocannabinol (THC) or Cannabidiol (CBD) vape pens, edibles, tinctures, and many other products for cannabis. Regarding temporal proximity, YAs may use both substances on

different days within a month, different occasions within a day, and simultaneously or sequentially on the same occasion. However, the literature has predominantly investigated past-month co-use (using any tobacco and cannabis in the past 30 days). Patterns in a closer temporal proximity (e.g., on the same occasion or the same day) or with non-smoked products (e.g., vaporizers or edibles) are less commonly documented. A few studies have indicated that routes of administration and intensity of tobacco and cannabis use within several hours or the same day are highly correlated among YAs (Berg et al., 2019; Nguyen et al., 2023c; Roche et al., 2019; Wilhelm et al., 2020). Another study among YAs categorized past-year use of tobacco and cannabis into mutually exclusive groups (single-product use, concurrent use only, sequential use only, coadministration only, and both sequential use and coadministration) and found that co-use on the same occasion was associated with heavier use and greater problematic behaviors than using two substances separately (Tucker et al., 2019). Likewise, a study among adults found that a closer temporal connection of co-use was linked to a greater number of cigarettes smoked (Akbar et al., 2019). However, a variety of terminologies used in the co-use literature and the lack of harmonized measures of co-use contributes to confusion and inconsistencies in synthesizing evidence about its health effects (Hindocha and McClure, 2021; McClure, 2021; Meier and Hatsukami, 2016).

Proposed mechanisms underlying co-use include shared routes of administration or contexts (e.g., socialization), substitution effects (use one substance as a substitute for the other), and synergistic effects (use two substances at the same time or use of one substance while under the effect of the other to amplify positive effects or counteract negative effects between nicotinic and endocannabinoid systems) (Rabin and George, 2015). In addition, while Cox and Klinger's motivational model on substance use motives has been used to identify similar and unique

motives for tobacco and cannabis use (Cooper et al., 2016), it has not been applied to co-use. For example, one could compare motives for co-use on the same occasion and motives for co-use on different occasions within the same day. Such data are needed to explain different timing across co-use patterns.

There have been calls for a common classification of co-use patterns to address the variability of these behavioral intricacies (Hindocha and McClure, 2021; McClure, 2021; McRobbie et al., 2021; Nguyen et al., 2020). To address this gap, we analyzed qualitative data on YAs' experiences and motives around co-use of tobacco and cannabis and identified four patterns based on temporality and motives (Figure 1). To facilitate understanding of our results, we described terminologies related to co-use used in this study in Table 1. Qualitative data yield in-depth perspectives on *how* and *why* YAs engage in different co-use patterns. Our research questions were: (1) *How do YAs use both tobacco and cannabis, with regard to timing, reasons for, and contexts of co-use?* and (2) *How are motives for co-use patterns similar or different?* Addressing these questions is important to inform the development of harmonized measures of co-use, facilitating consistent examination of the health impacts in order to identify which patterns are most risky and should be prioritized for targeted intervention.

2. Materials & Methods

2.1. Design and participants

We analyzed data from a longitudinal qualitative study investigating use of multiple tobacco products among YAs (Nguyen et al., 2023a). Participants were 18-29 years old, resided in California, and used at least two tobacco products at baseline. Our age range was more inclusive than the traditional age range (18–24 years old) used in other studies among young

adults in order to cover the full span of young adulthood since the lifestyles of 25-29 years old are closer to young adults than older adults (Hammond, 2005). Participants provided informed consent and completed up to three annual interviews during 2017-2019. The University of California, San Francisco's Institutional Review Board approved the study. While cannabis use was not part of the inclusion criteria, 34 of the 60 participants reported past 30-day use of cannabis in at least one interview, and all of their interviews were included in the analysis. The sample had an average age of 22.8 years old (SD=3.5) and 32.4% were female (Table 2). Our sample reported diverse race/ethnicity and relatively high education levels. The most commonly used tobacco products were e-cigarettes and cigarettes. At baseline, the average numbers of days using various products during the past 30 days were 15.5 days for e-cigarettes, 12.8 days for cigarettes, and 15.9 days for cannabis.

2.2. *Data collection*

Before each interview, participants self-reported past 30-day use of tobacco and cannabis in an online survey. KAK, PML and the team conducted in-person/phone interviews lasting 60-90 minutes. KAK and PML led the team that developed the interview guide including questions related to routines of tobacco and cannabis use and co-use, reasons and contexts for use, perceived harms and benefits related to use, and changes in use between study years. We probed for details on practices and reasons for engaging in different co-use patterns (see Supplemental document). All interviews were transcribed verbatim and reviewed for accuracy. Transcripts were uploaded into Dedoose, a cloud-based application, for analysis.

2.3. *Data analysis*

We followed the thematic analysis approach described by Braun and Clarke: familiarization with data, generating initial codes, searching for themes, reviewing themes,

defining and naming themes, and producing the final analyses (Braun and Clarke, 2006). NN, SI, and KDL iteratively derived an initial set of a priori or deductive codes based on the interview guide and new codes emerged during transcript reading as we identified concepts, ideas, and experiences that appeared frequently across participants. Discrepancies were resolved by KAK and PML. We then categorized co-use patterns by temporal proximity (e.g., co-use on the same occasion or separate occasions) and product specificity (e.g., co-use via combustible or vaporized products). We iteratively compared motives across co-use patterns to identify prominent themes and sub-themes, and selected representative quotations. We visualized co-use patterns, along with their related temporal proximity, products, and motives, to develop the four patterns illustrated in Figure 1. We reported results following the Standards for Reporting Qualitative Research guideline (O'Brien et al., 2014).

3. Results

Co-use patterns varied by temporal proximity, products, and motives (Figure 1). The temporal factor played a key role in differentiating co-use patterns. Four emergent patterns of co-use, from most temporally distant to the most temporally close, were: *(Pattern 1) Same-month different-day co-use*; *(Pattern 2) Same-day different-occasion co-use*; *(Pattern 3) Same-occasion sequential co-use*; and *(Pattern 4) Same-occasion simultaneous co-use*. Patterns 1 and 2 can be grouped as “*Different-occasion co-use*” and Patterns 3 and 4 can be grouped as “*Same-occasion co-use*.” There was a diversity in the products used within each pattern. Many participants described behaviors fitting more than one pattern.

Six motives emerged for co-use: *(1) Socialization*; *(2) Product availability*; *(3) Coping with stress/anxiety*; *(4) Seeking substance-specific effects*; *(5) Seeking overlapping effects*; and

(6) *Behavioral trigger/Habit*. The first three motives were reported for all the patterns, while the last three motives were ascribed more frequently to only certain patterns. Below we present examples of practices, preferred products, and motives for each pattern. Exemplar quotes are also presented in Table 3.

3.1. Pattern 1: Same-month different-day co-use (Past 30-day co-use)

Participants described using tobacco and cannabis within the month, but not on the same day, such as using tobacco on weekdays and cannabis on weekends. Compared to other patterns, this pattern is the most temporally distant and did not produce any overlapping effects between substances. Participants often used tobacco when commuting, working, walking outdoors, and being with friends/co-workers during weekdays and used cannabis during weekends for leisure activities. There were no specific products preferred for this pattern. Products used varied by individual preferences and availability and were influenced by other people in their surroundings (e.g., friends, roommates).

A common motive for this pattern was socialization in which participants were hanging out with their friends or social circles, as **P22** [28-year-old, Multiracial male] said:

“When you smoke a joint, you get in a circle and you pass it around and you talk to each other... like community aspect of that, which is also, strangely enough, with cigarettes. Because you make a lot of friends smoking cigarettes. The second you go outside of a bar and you start smoking a cigarette, it's almost like you can now talk to any other person smoking cigarettes... I would say both smoking [cigarettes] and toking weed [smoking cannabis] gives you like a communal vibe, social interaction.”

Another motive for this pattern was coping with stress/anxiety. Many participants preferred using tobacco for coping with daily life/work stressors, and using cannabis for coping with anxiety, as **P19** [28-year-old, White female] described:

“It [smoking cigarettes at a work break] was almost like a meditation for me, just like a moment of solitude where I could go behind the store and just not have to talk for 10 minutes, which is such a blessing sometimes. It is like, oh, it's my break, I can go smoke a cigarette. ... There has been like high CBD/low THC vaping products that I've used that have helped my anxiety... I have read about CBD being used for anxiety. So, sometimes, if my anxiety is really bad, I take a little bit of the tincture.”

Participants also elaborated on specific expectancies related to each substance. They noted that tobacco provided benefits for work/study productivity on weekdays, while cannabis paired with relaxing and enjoying leisure activities on weekends. Tobacco use was tied more to alcohol, while cannabis use was tied more to perceived therapeutic effects (e.g., sleep aid, pain relief, increasing appetite).

3.2. Pattern 2: Same-day different-occasion co-use

Participants used tobacco and cannabis on the same day but at different occasions, and the temporal distance conferred no overlapping effects of two substances. However, participants described co-use differently from Pattern 1, such that using tobacco as “*a light stimulant*” and for “*pairing with coffee*” in the morning to start their day and using cannabis as “*a sleep aid*” and for “*body relaxing*” at night to close their day. For example, **P27** [24-year-old, White male] said: “*I primarily smoke Indica at night. That's a bit more of like a body high and less of a mental thing. It's just like relaxing. Makes you a little bit sleepy.*”

Similar to Pattern 1, participants described using various products for both tobacco and cannabis. Unlike Pattern 1, participants favored the same routes of administration when using both substances on the same day. For example, **P68** [21-year-old, Multiracial male] described his routine of using JUUL daily and vaping cannabis with his Pax device before bed. Some participants described interchangeably using the same vaporizer device for co-use, as **P43** [28-year-old, Hispanic male] described replacing the nicotine vape cartridge in his vape with the hash cartridge for cannabis vaping. Participants expressed distinction between use of cannabinoids (CBD/THC) or strains (sativa/indica) in this pattern. Those who used cannabis during the daytime more frequently reported using CBD instead of THC or lower level of THC to avoid sedation and inactivity. For example, **P25** [26-year-old, Multiracial male] had a CBD cartridge for "daytime" and THC cartridge for "playtime." Similarly, **P10** [27-year-old, Asian male] rotated between CBD and THC vaping because CBD made him feel relax/sleep, while THC gave him the high feeling:

“The CBD will just kind of relax my body and just kind of get me on a really like calm and relaxed, versus THC kind of like hits my head and my body at the same time like, and it just kind of gets me like really slow and just like zone me out and stuff....I do switch back and forth [between CBD and THC vaping]. It depends on what I'm feeling that day. If I just want to get like really high and just chill, I would do the THC. But if I just want to like relax and know I'm gonna go to sleep and get something to eat, I'll probably just stick with the CBD.”

While Pattern 2 shared motives with Pattern 1 (i.e., socialization, product availability, coping with stress/anxiety, and getting substance-specific effects), the substance-specific effect motive was particularly common when describing daytime tobacco use and nighttime cannabis

use. Participants viewed tobacco use as a routine or habit, while cannabis was a therapeutic tool for reducing pain (e.g., CBD balm), aiding in sleep (e.g., CBD and THC tincture), and decompressing. For example, **P33** [24-year-old male] said:

“They're [cannabis vaping and tobacco vaping] totally different. They satisfy different urges or feelings. The nicotine is like a constant, ongoing sort of need, almost feels like it's controlling you in a way. But with weed, every time I smoke weed [vape cannabis], it's like I willingly choose to. I'm like I want to get high, I want to chill.”

3.3. Pattern 3: Same-occasion sequential co-use

Participants reported using tobacco and cannabis sequentially on the same occasion. They described both sequential orders: using tobacco following cannabis and cannabis following tobacco, as **P38** [18-year-old, Multiracial female] described: *“Most of the time when I'm smoking marijuana, I would just smoke a cigarette directly after. Then I just started, for some reason, picking up the habit of like - I was already smoking a cigarette and I decided to roll a joint. So, I'd gotten into the habit of liking both [sequential orders].”*

Products used in this pattern seemed to be facilitated by the same route of administration, pairing smoking cigarettes with cannabis joints or pairing vaporized products. For example, **P68** [21-year-old, Multiracial male] described vaping JUUL following his cannabis vaping: *“Normally I'll start with the weed vape, and then just see where I get. If I don't want to hit that [cannabis] anymore and I still want to smoke, I'll just hit my JUUL.”* Likewise, **P43** [28-year-old, Hispanic male] alternated nicotine e-liquid and hash oil cartridges in his vape pen, but avoided simultaneous co-use because of getting nauseous. Several participants combined combustible cannabis with vaporized nicotine. For example, **P06** [19-year-old, Asian female],

P22 [28-year-old, Multiracial male], and **P66** [20-year-old, White female] repeatedly took a hit from a bong followed by using an e-cigarette.

Unique motives for Pattern 3 included seeking overlapping effects of both substances and behavioral triggers. Participants elaborated that they smoked cigarettes following smoking cannabis to get the overlapping effects “*like a cross high.*” Some participants described that smoking cannabis triggered them to smoke cigarettes right after since it was a “*full package.*” For **P13** [23-year-old, Multiracial male] and **P35** [25-year-old, Hispanic male], smoking cannabis triggered them to smoke cigarettes afterward. For **P33** [24-year-old, Asian male], cannabis vaping triggered his tobacco vaping: “*Sometimes I like to do both [cannabis vaping and tobacco vaping]. So, if I get high, I think it's nicer to have some nicotine. Usually when you're high and you're chilling, it's easier to sort of just hit nicotine.*”

3.4. Pattern 4: Same-occasion simultaneous co-use

This pattern had the most temporally close proximity. Simultaneous co-use made possible by combining products most typically in one route of administration, with spliffs and blunts being the most commonly used. For example, **P27** [24-year-old, White male] used spliffs in the evening when hanging out with friends, while **P17** [21-year-old, Multiracial female] described using spliffs during the day when hiking: “*Daytime smoking spliffs is also more of a social activity because we're out in nature. That's something we like to do. We'll smoke one to two spliffs on the hike.*” Another common practice was “moking” - smoking both tobacco and cannabis at the same time. **P66** [20-year-old, Hispanic female] and **P13** [23-year-old, Multiracial male] reported moking with a ratio of 60% tobacco and 40% cannabis in a bong, while **P38** [18-year-old, Multiracial female] described preferred moking practice with a joint and a cigarette in

each hand. Interestingly, participants introduced new terminologies (e.g., “*e-moking*” and “*techno spliffing*”) to describe co-use with vaporized products. **P16** [18-year-old, Multiracial male] said: “*This thing called e-moking, which is like - you have a vaporizer, like a weed vaporizer, and then a box mod, and you just rip them at the same time, and it’s e-moking or 21st century mokes.*” Similarly, **P22** [28-year-old, Multiracial male] said: “*The last time I did that I thought I was being a smartass. I took my JUUL and my [THC] vape pen and I stuck them in my mouth. And I said, look at this guys, it’s techno spliffing.*” In addition, **P57** [19-year-old Hispanic male] described a taste like a Sour Patch when he mixed nicotine salt and watermelon CBD juice in his vape.

Seeking overlapping effects was the most important motive for this pattern. The combined effects could be either “*more intense/enhancement*” or, paradoxically, “*less intense/leveling-off*” effects. For example, **P16** [18-year-old, Multiracial male] thought moking was “*1000 times better*” than smoking cannabis alone due to enhanced high:

“That just gets you like a smack of the face, off the face of the earth, and people love it. I love it... It’s just an insane head rush... Imagine there’s an oil tanker on the Atlantic, and it just gets nuked. Just like two explosive feelings just coming together to make something crazy... That’s just kind of knocks you out. That kind of puts you in a whole another state. Well, obviously, there’s no real benefits to it. It’s killing brain cells. It’s killing your lung capacity. But yeah, it’s just more fun.”

Conversely, **P17** [21-year-old, Multiracial female] mixed cannabis with cigarettes in spliffs because “*one or the other is too intense of one thing.*” Likewise, **P13** [23-year-old, Multiracial male] compared spliffs and a cannabis joint: “*If you smoke a joint and it’s just flower,*

it's a lot more harsh. You'll be coughing and stuff. If you mix tobacco with weed, it's a lot more smooth. You're not coughing. It's just more relaxing.”

Participants also described other motives (e.g., socialization, product availability). They often used spliffs/blunts when these products were passed around by their friends. They also described co-use via vaporized products as “*a communal activity*” by sharing devices with friends. **P68** [21-year-old, Multiracial male] narrated that moking made him feel more social and awake whereas smoking cannabis alone made him sleepy or antisocial. With moking, he could join his friends who had higher cannabis tolerance levels:

“I have an extremely low tolerance for weed, and my friends don't, and, as a result, I would be extremely antisocial and kind of go into my own world, and tobacco helps prevent that significantly...Spliffs are the ideal social in my head because if you were sitting around and all your friends are taking dabs [inhaled cannabis concentrates], you are gonna be too high in about five minutes.”

Notably, participants described cravings, perceived addiction, and health effects in this pattern. **P66** [20-year-old, Hispanic female] felt that using spliffs increased her cannabis consumption because of cravings. She also reported moking made her “*really addicted to tobacco*” because “*when you mix them together, like in a bong, it hits you really hard, which is a weird feeling you start to crave when you do them a lot.*” Likewise, **P21** [19-year-old, Asian male] stopped moking via a bong because he perceived negative health effects from this pattern of co-use as “*very intense doming effect*” and “*hurts your lungs.*”

4. Discussion

This study provides a classification of tobacco and cannabis co-use patterns based on a spectrum of temporal proximity. It also provides nuances embedded in practices of co-use among YAs, specifying both conventional combustible products (e.g., cigarettes, joints, blunts) and newer products (e.g., tobacco e-cigarettes and cannabis vapes), and similar and unique motives across co-use patterns. Patterns and motives varied between individuals and across contexts within an individual. Different temporal proximity (same-occasion vs. different-occasion) and preferred products (e.g., combustible vs. vaporized products) across the four patterns of co-use appeared to link to different levels of nicotine and cannabis consumption and dependence and different health impacts. Thus, using our classification of the four patterns can facilitate consistency for co-use measures and comparisons in future studies and improve co-use surveillance.

We suggest that co-use should be measured by at least three indices - *Time*, *Product*, and *Quantity*. “*Time*” is a key factor to differentiate behavioral patterns since it can be operationalized by increasing temporal proximity of co-use: *Same-month*, *Same-day*, *Same-occasion sequential*, and *Same-occasion simultaneous*. “*Products*” are continuously evolving and changing, resulting in difficulties defining co-use patterns by product (McClure, 2021). We found that products with the same routes of administration tended to facilitate same-occasion co-use (Patterns 3 and 4). In addition to combustible products (e.g., blunts, spliffs, bong) which are commonly documented in previous research, YAs also reported same-occasion co-use via vaporized products, which they named “*e-moking*” and “*techno spliffing*.” Studies showed that co-use of vaporized tobacco and cannabis products among YAs is increasing and linked to more respiratory symptoms compared to use of single product (Braymiller et al., 2020; Buu et al., 2023; Roberts et al., 2022), calling for more attention to address this emerging issue. In addition,

individuals with same-occasion co-use patterns may be at greater risk for heavy use and addiction as we found that increases in temporal closeness of co-use were accompanied by narratives of more frequent use and more cravings for tobacco and cannabis, particularly same-occasion simultaneous co-use (Pattern 4). This finding aligns with previous studies showing that levels of use and dependence differ across the patterns (Akbar et al., 2019; Nguyen et al., 2023c; Ream et al., 2008) and same-occasion co-use is associated with worse physical and mental functioning compared to different-occasion co-use (Tucker et al., 2019). The frequent use of tobacco and cannabis observed in the same-occasion simultaneous co-use is concerning as this pattern may lead to additive health harms (e.g., respiratory conditions); however, evidence on the health impacts of this pattern of co-use and how it may differ from other patterns (e.g., same-month different-day co-use) is limited due to a lack of nuance in how data are collected (Hindocha and McClure, 2021). Thus, future studies should quantify the amount of tobacco and cannabis consumed or “*Quantity*” of co-use to better measure health impacts. Intensive data collection methods (e.g., ecological momentary assessment, daily diary) may be helpful to collect granular data on *Quantity*, particularly for the same-occasion co-use patterns (Nguyen et al., 2020). In addition to self-reported data, biomarkers may be considered when possible to provide a more objective measures of tobacco and cannabis exposures (Andersen et al., 2021; Volkow et al., 2015).

Consistent with the literature (Berg et al., 2018; Pedersen et al., 2020), we found that socialization, product availability, and coping with stress/anxiety were shared motives for all four patterns. This study extends the literature by identifying unique motives for same-occasion co-use (Patterns 3 and 4) driven by seeking overlapping effects of both substances and behavioral trigger, while unique motives for different-occasion co-use (Patterns 1 and 2) driven by

substance-specific effects (e.g., nicotine for stimulant effects, cannabis for sleep and pain). Interactions of pharmacological effects of nicotine and THC might explain the unique motives for same-occasion co-use. The combination of tobacco and cannabis can increase release of neurotransmitters (e.g., dopamine), resulting in a more pronounced euphoric effects and increased feelings of pleasure (Viveros et al., 2006). Conversely, the stimulant properties of nicotine may counteract the sedating effects of cannabinoids, enabling individuals to remain alert and engage in social activities (Hernandez Mejia et al., 2021; Kohut, 2017). Another potential synergistic connection associated with same-occasion co-use is YAs' pursuit of enhanced mood effects by using cannabis to enhance perceived nicotine mood boost and compensating with additional nicotine when the boost diminishes (Kendall et al., 2022).

Our identified motives for the four patterns have important treatment implications for co-use. Clinical interventions for co-users may need to be tailored based on the different motivations associated with different co-use patterns (Agrawal et al., 2012; McClure et al., 2020; Nguyen et al., 2020). Addressing the shared motives may help to reduce co-use in general, while addressing the unique motives may help to tailor supports to meet individual needs. Same-month different-day co-users (Pattern 1) may be willing to give up one product but not the other, while same-occasion simultaneous co-users (Pattern 4) may need to quit both products simultaneously.

Our study has several limitations. Our findings in California may be different from states without cannabis legalization. California legalized recreational use of cannabis in 2018 and has become the world's largest legal cannabis market (Young-Wolff et al., 2022), making it an ideal context for investigation of co-use of tobacco and cannabis. A common goal of qualitative research is to generate findings that are transferable to other contexts that share similar features (Carminati, 2018). Thus, the degree to which our findings, drawn from a sample of

predominantly young men, are transferable to other contexts is unknown. In addition, our findings are likely limited by the inclusion criterion that required participants to use at least two of three tobacco products; however, using multiple tobacco products is common among YAs, alleviating some concerns (Osibogun et al., 2018). Participants' narratives of tobacco and cannabis use may be subject to social desirability bias and recall bias.

In conclusion, this study offers a foundational base from which future research can classify tobacco and cannabis co-use patterns on the spectrum of temporal proximity. Future research should measure *Time*, *Product*, *Quantity*, and the health impacts of different co-use patterns. The observed behavioral heterogeneity underscores a need for tailored interventions for different co-use patterns.

Funding: This research was supported by the California Tobacco-Related Disease Research Program (grant numbers T31FT1564 and T32KT5071 to NN, and TRDRP 27IR-0042 to PML), by the Food and Drug Administration Center for Tobacco Products and the National Heart, Lung, and Blood Institute (grant number U54 HL147127 to NN and PML), and by the National Cancer Institute (grant number R01CA141661 to PML). NN is also supported by the UCSF Clinical and Translational Science Institute (grant UL1 TR001872-06). The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies.

Declaration of competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement: The qualitative data underlying this article, even deidentified, may include some information that can sufficiently specify the participant, therefore cannot be shared outside the research team. The quantitative data including tobacco use and socio-demographic characteristics will be shared on reasonable request to the corresponding author.

Acknowledgements: The authors express their gratitude to the participants who participated in the interviews. We would also like to thank Emily Keamy-Minor, Cindy Kim, Minji Kim, Shannon Lee Watkins, Julia McQuoid, and Sarah Olson for their input into the data collection and analysis process.

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Table 1: Terminology related to co-use of tobacco and cannabis in this study

Terminology	Description
Co-use patterns	
Same-day different-occasion co-use	Use of tobacco and cannabis on different times of the day
Same-month different-day co-use	Also known as "Past 30-day co-use." Use of tobacco and cannabis on different days of the week/month
Same-occasion sequential co-use	Also known as "Chasing." Use of tobacco and cannabis sequentially on the same occasion
Same-occasion simultaneous co-use	Also known as "Co-administration." Use of tobacco and cannabis simultaneously on the same occasion
Different-occasion co-use	Includes both patterns of "Same-month different-day co-use" and "Same-day different-occasion co-use"
Same-occasion co-use	Includes both patterns of "Same-occasion sequential co-use" and "Same-occasion simultaneous co-use"
Products and practices	
Blunt	A cigar that is hollowed out and filled with cannabis for smoking
Bong or Water pipe	A smoking device commonly used to smoke cannabis and tobacco. It consists of a chamber filled with water, a bowl or slide to hold cannabis and tobacco, and a mouthpiece for inhaling the smoke.
Cannabis	Also known as marijuana or weed; "Cannabis" refers to all products derived from the cannabis plant, including various forms of cannabis consumption, such as combustible, vaporized, edible, and tincture products; "Marijuana" refers to the cannabis plant or products that contain high concentration of delta-9-THC.
CBD (Cannabidiol)	A compound in the cannabis plant that does not have psychoactive effects, typically derived from the hemp plant that contains low delta-9-THC concentration.
Chasing	Also known as "Same-occasion sequential co-use," (e.g., smoking cigarettes right after smoking cannabis joints)
Dab or wax or shatter	A concentrated form of cannabis typically containing a high concentration of cannabinoids, particularly THC (tetrahydrocannabinol). Dabs are typically consumed through a dab rig ("dabbing") applying a small amount of concentrate to a heating element to vaporize the product for inhalation.
E-moking or "Techno spliffing"	Use of a tobacco vaporizer and a cannabis vaporizer simultaneously
Hash oil	Cannabis oil, such as THC or CBD oil, which can be vaporized or inhaled

Indica	A primary strain of cannabis plants; perceived as being associated with its relaxing and sedating effects (e.g., pain relief, sleep aid) and described as producing a “body” high
Joint	A traditional and popular way to use cannabis by rolling dried cannabis flower into a cigarette-like tube form, typically using rolling papers
Moking	Smoking both tobacco and cannabis simultaneously in a device (e.g., mixing tobacco leaf and cannabis flower via bong)
Overlapping effects	A situation where the effects of tobacco and cannabis interact or coincide, resulting in combined or intensified effects
Sativa	A primary strain of cannabis plants; perceived as being associated with increased creativity, focus, sociability, and described as producing a "head" high
Spliff	A rolled cigarette or joint that typically contains both tobacco and cannabis mixed together
THC (delta-9-Tetrahydrocannabinol)	A primary psychoactive component of cannabis. This substance is responsible for the “high” or euphoric effects that people experience from cannabis.
Tobacco	Includes nicotine products, such as cigarettes, e-cigarettes, cigars/cigarillos, hookahs, smokeless tobacco, and heated tobacco products
Toking	Smoking cannabis or taking a puff from a joint or smoking device

Table 2: Sample characteristics at baseline (N=34)

Characteristics	N (%) or M (SD)
Age (years), Mean (SD, range)	22.8 (3.5, 18-29)
Assigned sex at birth	
Male	23 (67.6%)
Female	10 (32.4%)
Participants' highest education attainment	
High school or less	8 (24.2%)
Started college but not finished	3 (9.1%)
Currently in college	15 (45.5%)
Have college degree or higher	7 (21.2%)
Race and ethnicity	
Non-Hispanic White	8 (23.5%)
Non-Hispanic Asian	7 (20.6%)
Non-Hispanic Other/Multi-race	9 (26.5%)
Hispanic/Latino/a/x	10 (29.4%)
Frequency of tobacco and cannabis use in the past 30 days	
Number of days using cigarettes, Mean (SD)	12.8 (9.2)
Number of days using e-cigarettes, Mean (SD)	15.5 (11.9)
Number of days using cannabis, Mean (SD)	15.9 (12.5)

Table 3: Exemplar quotes for patterns of co-use of tobacco and cannabis

Pattern	Exemplar quotes
<p>Same-month different-day co-use (Pattern 1)</p>	<p>P05 [29-year-old, Asian male]: <i>“I smoke Newport cigarettes probably mostly during the workweek. It’s probably one [cigarette] when I wake up, one when I go on my way to work, and one probably like before work. And then, after that, I use my vaporizer [e-cigarettes] throughout work, because I’m too lazy to go outside.”</i></p> <p>P45 [18-year-old, White male]: <i>“Some days I won’t smoke [cigarettes] at all and some days I might smoke two or three times a day. It varies on what I’m doing or if I want to or stuff like that. I’d say the biggest factor for me smoking [cigarettes] would be a social reason.”</i></p> <p>P10 [27-year-old, Asian male]: <i>“That one [his e-cigarette for nicotine vaping] I maybe do in between my breaks at work... If I’m off or something like on the weekends, I’ll just pull out my THC vape pen and do it [vape cannabis]. I try not to use that [cannabis vaping during weekdays] much because it gets me a little lazy sometimes.”</i></p> <p>P02 [26-year-old, Hispanic male]: <i>“I normally do a long run on Saturdays. The THC usually helps with whatever pains...it kind of gets you in the zone of just thinking about the run.”</i></p> <p>P68 [21-year-old, Multiracial male]: <i>“I’m a pretty anxious person. So, for me, weed has always been a way for a lot of things. It helps me go to sleep. It helps me keep my head straight when I’m trying to go to sleep. It’s so easy to just stop thinking about things. It also makes me really hungry and I’m a pretty skinny dude, so I like to have an excuse to eat.”</i></p>
<p>Same-day different- occasion co-use (Pattern 2)</p>	<p>P32 [20-year-old, White female]: <i>“My morning smoke [cigarettes] with my coffee, my smoke after meal, my smoke when I get in the car, it’s [smoking cigarettes] just all ritual.... For weed, it’s literally hit or miss. I mean, sometimes, I’ll go days without smoking any weed....But Wednesday was the day all the co-workers went out after work. We definitely smoked, like, five joints [cannabis] that night.”</i></p> <p>P09 [25-year-old, Black male]: <i>“I use the JUUL whenever I’m at work... When I didn’t have marijuana, it [JUUL] kind in a sense substituted the place of the weed. But it didn’t give me the same effects. It just feels nice to have something to smoke for the sake of it....After work, when I hang out with my coworkers, I use marijuana since it’s always been around. But sometimes when I don’t have that [cannabis] on me, I will use the JUUL.”</i></p> <p>P13 [23-year-old, Multiracial male]: <i>“I smoke [cannabis] every night. It helps me with sleeping. It helps me unwind after a long day of school and work all day. But during the day I don’t really smoke it because it just slows me down. Once I smoke, that’s usually like me checking out for the day.”</i></p>

	<p>P24 [19-year-old, Hispanic male]: <i>“It [cannabis] kind of just takes you out of your element. Like, it makes you think about things you wouldn't particularly think about, and I think it slows you down mentally, not physically. It's like you kind of just stop thinking about responsibilities and stuff. That's why I would only do it at the end of the day or when I know I have nothing going on. Because when I'm high, it's hard to be productive.”</i></p> <p>P25 [26-year-old, Multiracial male]: <i>“It depends [when to use CBD or THC]. There's like daytime and there's play time. Day time is more like CBD if I use it [cannabis] at all. But I'll go higher THC if I'm like just for fun, hang out with people or chilling at night.”</i></p>
<p>Same-occasion sequential co-use (Pattern 3)</p>	<p>P38 [18-year-old, Multiracial female]: <i>“Most of the time when I'm smoking marijuana, I would just smoke a cigarette directly after. Then I just started, for some reason, picking up the habit of like - I was already smoking a cigarette and I decided to roll a joint. So, I'd gotten into the habit of liking both [sequential orders].”</i></p> <p>P68 [21-year-old, Multiracial male]: <i>“Normally I'll start with the weed vape, and then just see where I get. If I don't want to hit that [cannabis] anymore and I still want to smoke, I'll just hit my JUUL.”</i></p> <p>P35 [25-year-old, Hispanic male]: <i>“I feel like once I've had [smoked weed], a little bit that I do kind of want to have a cigarette at the end when I've smoked some weed.”</i></p> <p>P33 [24-year-old, Asian male]: <i>“Sometimes I like to do both [cannabis vaping and tobacco vaping]. So, if I get high, I think it's nicer to have some nicotine. Usually when you're high and you're chilling, it's easier to sort of just hit nicotine.”</i></p> <p>P43 [28-year-old, Hispanic male]: <i>“It was more like a cross high. Like you have the kind of that head change and then you also combine that with a body high of the weed...So, it's just like a different kind of high.”</i></p> <p>P13 [23-year-old, Multiracial male]: <i>“Marijuana is like an everyday thing in my life. So, marijuana actually triggers me to smoke cigarettes. If I smoke a little load of hash, immediately afterwards, I'll finish it off with a cigarette. To me it's not complete without it...It's like a trigger. It's like the little cream of the crop, cherry on top, finish smoking a joint and then smoke that [cigarettes].”</i></p>
<p>Same-occasion simultaneous co-use (Pattern 4)</p>	<p>P27 [24-year-old, White male]: <i>“We'll smoke a spliff, like cigarette and weed together. That's almost a nightly sort of tradition that we just hang out and do that. So, yeah, that's part of the regular day.”</i></p> <p>P68 [21-year-old, Multiracial male]: <i>“If you're an experienced spliff person, you buy like American Spirits or something similar like the pouch tobacco, that's made for rolling your own cigarettes. If you're someone like me who smokes an occasional spliff, I use like a pack of cigarettes, and I just unroll a cigarette.”</i></p> <p>P38 [18-year-old, Multiracial female]: <i>“I will smoke marijuana and smoke tobacco at the same time, like a joint and a cigarette in each</i></p>

hand. There may be something subconsciously that I'm not aware of, or maybe it's just like the taste of both of them together."

P57 [19-year-old, Hispanic male]: *"Last year, I had one of those box mod vapes that a friend gave me. And I would pour nicotine salt mixed in with CBD. I would just vape that a lot. It was good, but it was just really harsh... And I realized, when I mixed it [nicotine e-juice] with my watermelon CBD juice, it tasted like a Sour Patch."*

P66 [22-year-old, Hispanic female]: *"Well, weed is like when you had a - it's kind of mellow. Like you just feel fine. And cigarettes, when you smoke a cigarette, you kind of get that rush, that nicotine rush. So, when you mix them together, like in a bong, it hits you really hard, which is a weird feeling you start to crave when you do them a lot."*

P21 [19-year-old, Asian male]: *"If you put [tobacco and cannabis] in a glass water pipe, which a lot of college students nowadays do, they call it moking or chopping...like the different ways to pack it and stuff. I used to do it because the doming effect is very intense. It's a very intense doming effect. It hurts your lungs a bit but then like a big rush to the head... I used to like it like when I was a freshman, but not so much anymore because I felt it like affecting my health way too much."*

Temporally distant

Temporally close

Non-overlapping effects

Overlapping effects

Same-month
different-day
co-use
(Past 30-day)

Same-day
different-occasion
co-use
(Same-day co-use)

Same-occasion
sequential
co-use
(Chasing)

Same-occasion
simultaneous
co-use
(Co-administration)

Products and practices

E.g.: Tobacco use on weekdays & cannabis use on weekends
Product varies by individual preferences and availability
No particular product type was most common

Products and practices

E.g.: Same day daytime tobacco & nighttime cannabis use
Products varied, but those with the same route of administration were commonly paired

Products and practices

Sequential use in either order: tobacco following cannabis, or cannabis following tobacco
Common combined products: cigarettes and cannabis joints
Often paired products with the same route of administration

Products and practices

Simultaneous use combining products at any time of day
Common combined products: Spliffs and blunts
“Moking:” mixing tobacco leaf and cannabis flower via bong
“E-moking:” using 2 vaporized products together

Similar motives for all the co-use patterns

Socialization
Product availability
Coping with stress/anxiety

Unique motives

Seeking specific effects on different days: tobacco for mental focus during weekdays and cannabis for relaxation on weekends

Unique motives

Seeking specific effects by time of day: tobacco as stimulant in the morning and cannabis as sleep aid at night

Unique motives

Seeking combined effects: enhanced euphoria, more intense or longer lasting “high”
Behavioral trigger or habit

Unique motives

Seeking overlapping effects, both rewarding/enhancement effects or leveling-off/reducing effects.
Behavioral trigger or habit

Figure 1: Patterns of tobacco and cannabis co-use among young adults along the spectrum of temporal proximity of use of tobacco and cannabis

Interview guide with open-ended questions and probes by study topic

Topic	Examples of Probes
Tobacco use	<ul style="list-style-type: none"> • Can you tell me about your experience with tobacco products: cigarettes, electronic cigarettes, hookah, smokeless/dip/chew, other tobacco products? • How many times a day or a week or a month do you use each of those products: cigarettes, electronic cigarettes, hookah, smokeless/dip/chew, other tobacco products? • What determines when you use [a tobacco product]? <p>Probe for:</p> <ul style="list-style-type: none"> - Timing or routine of use (typical weekday and weekend use) - Context of use (at home or at work, with other people or alone, etc.) <ul style="list-style-type: none"> • Any perceived benefits or harms related to tobacco use? • Has your tobacco use changed since the last year? Can you describe more about changes, if any? Were there any changes in your life or work that was related to changes in your tobacco use? • By this time next year, what do you think your use of [a tobacco product] is going to look like?
Cannabis use	<ul style="list-style-type: none"> • Can you tell me about your experience with cannabis or marijuana or weed if any? • What cannabis products do you usually use? • How do you use cannabis? <p>Probe for:</p> <ul style="list-style-type: none"> - Method of consumption (smoke/vape, eat, topical) - Device type (e.g., joint, vape, bowl, edible) - Cannabinoids (do they use THC? CBD? What ratio?)

	<ul style="list-style-type: none"> - Form (do they use flower/hash oil/other concentrates?) • What determines when you use [a cannabis product]? <p>Probe for:</p> <ul style="list-style-type: none"> - Timing or routine of use (typical weekday and weekend use) - Context of use (at home or at work, with other people or alone, etc.) • Any perceived benefits or harms related to cannabis use? • Where and how do you usually get cannabis products? • Have you have changed your use of cannabis products? Were there any changes in your life or work that was related to changes in your cannabis use?
<p>Co-use of tobacco and cannabis</p>	<ul style="list-style-type: none"> • During the past 30 days, how many days have you used cannabis and tobacco products on: different days, different times of the day, at the same time? • Can you tell me about how you combined tobacco and cannabis for use? <p>Probe for:</p> <ul style="list-style-type: none"> - Potential co-use patterns: whether tobacco and cannabis were mixed together in spliffs, blunts, or bongos; whether tobacco was used right before or after cannabis (chasing); and other combinations; or why they used tobacco and cannabis products separately - Products or devices used or preferred for co-use: combustible or vaporized or edible products, etc. <ul style="list-style-type: none"> • When and where did you often use [a pattern of co-use]? <p>Prob for:</p> <ul style="list-style-type: none"> - Contexts or situations or circumstances of each co-use pattern - Timing of co-use - Reasons for co-use <ul style="list-style-type: none"> • What was you experience with [a pattern of co-use]? <p>Probe for:</p> <ul style="list-style-type: none"> - Feelings, emotions, physical states, what's going on around them that may have triggered co-use

	<ul style="list-style-type: none">- What did co-use do for participants: explore mixing/overlapping effects or benefits that participants may perceive or experience; explore different effects of co-use compared to using either tobacco or cannabis
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