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Research Paper

The impacts of packaging on preferences for cannabis edibles: A discrete choice experiment

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ABSTRACT

Backgrounds: Cannabis edibles recently gained considerable market share in the United States. The tobacco and food literatures consistently suggest that product packaging regulations are crucial to substance control, but little is known about how product packaging may impact cannabis edible use. This study aims to estimate the impacts of packaging on individual preferences for cannabis edibles and explore heterogeneities in preferences by cannabis use status and use purposes.

Methods: 1578 adults were recruited, who lived in 18 states and Washington D.C. in the United States that legalized recreational cannabis by the time of data collection in August and September of 2022. An online discrete choice experiment was conducted to elicit individual choices between cannabis edibles with variations in five packaging attributes: package style, health claim, potency indicator, warning label position, and warning label text. Mixed logit regressions were used to assess associations between package attributes and package choices. Subsample analysis was conducted by cannabis use status (users vs. nonusers) and use purposes (medical-only, recreational-only, and dual-purpose) to detect heterogeneities.

Results: Almost all subsamples prefer branded packages to plain packages, any health claim to no health claim, and any potency indicator to no potency indicator. Cannabis users, particularly recreational-only users and dual-purpose users, also prefer youth-appealing packages to branded packages. Warning label position and text have limited impacts on choices. Overall, package style is perceived to be the most important attribute among the five (relative importance 33.2–50.8%), followed by health claim (relative importance 22.6–30.5%).

Conclusion: In the United States, adults' preferences for cannabis edibles are associated with packaging features. Policies requiring plain package and prohibiting youth-appealing package and unsubstantiated health claims may be effective methods of cannabis control.

Introduction

With recreational cannabis legalized in over twenty states in the past decade in the United States (U.S.), non-combustion administration methods, such as ingesting edibles, have consistently gained popularity and market share. Estimates from 2020 data show that 60.8% of past-year cannabis users ingested cannabis edibles in the past year in states with recreational cannabis legalization, with 19.5% of recreational users and 23.8% of medical users reporting ingestion as their primary method of cannabis use. (Hammond et al., 2022; Shi, 2021) In 2022, cannabis edibles had a market share of 12.1% in U.S. legal cannabis markets. (Headset, 2022) Survey data show that edible use is substantially more prevalent in states with medical and/or recreational cannabis legalization compared to states without legalization, and that longer durations of legal cannabis markets and greater dispensary density are associated with higher prevalence of edible use. (Borodovsky, Crosier, Lee, Sargent & Budney, 2016; Hammond et al., 2022) Regulating cannabis edibles in legal markets is therefore an important avenue through which policymakers may reduce harms associated with problem cannabis use.

Cannabis edibles have unique health risks and public health concerns compared to other cannabis products, which create new challenges for public policymaking. Their psychoactive effects have delayed onset and extended duration and are often unpredictable because of inconsistent potency. As a result, cannabis edibles are associated with greater risks of overdose. (Barrus et al., 2016) Data on healthcare visits suggest that cannabis edibles were involved in most cases of acute cannabis intoxication. (Barrus et al., 2016; Monte et al., 2019) Cannabis edible packages are commonly designed to be youth-appealing. Studies found that

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10–15% cannabis edible packages imitated food brands that are popular among youths and approximately 20% recreational cannabis dispensaries carried youth-appealing products with edibles being responsible for the majority of them. (Ompad et al., 2022; Shi & Pacula, 2021; Tan et al., 2022) Unintentional ingestion of cannabis by youths has considerably increased in recent years, especially in states with medical and/or recreational cannabis legalization, and these cases mainly involved cannabis edibles. (Chiu, Leung, Hall, Stjepanovic & Degenhardt, 2021; Monte et al., 2019; Vo et al., 2018)

Many concerns discussed above can be mitigated by cannabis edible packaging regulations, such as those regulating package style, health claims, potency labels, and warning labels. A significant amount of research in tobacco control has found positive health impacts from requiring plain or standardized package designs, and implementing prominent and comprehensive health warning messages that usually involve large warning size, prominent positioning, graphics highlighting health risks, and rotating warning texts. (Buckell & Sindelar, 2019; Cunningham, 2022; Hammond, 2011; Moodie et al., 2022; Shang et al., 2020) Literature on food packaging also suggests that informative nutritional labels on the front of food packages may improve nutritional knowledge and health outcomes. (Crosetto, Lacroix, Muller & Ruffieux, 2020; Temple, 2020)

Cannabis edible packaging regulations vary greatly across states with recreational cannabis legalization in the U.S. and are often not enforced effectively. More than 20 states have legalized recreational cannabis, but only half of them have regulations specific to cannabis edibles. (Goundar, Macaulay & Szafron, 2021) All the states with specific regulations on edibles prohibit edible packages that appeal to youths, but the prohibition ranges from vague restrictions on all youth-appealing features to banning lists of specific features such as cartoon characters, real or fictional humans, bright colors, and bubble fonts. Connecticut, Massachusetts, and New Jersey have requirements to standardize the color of cannabis product packages. Such requirements are less comprehensive than Canada's, which prohibit graphics and images, branding elements, and multiple colors.

Some states entirely prohibit dietary and health claims on cannabis packaging. (Goundar et al., 2021) Despite these prohibitions, unsubstantiated health claims not evaluated by the FDA or supported by sufficient scientific evidence, such as those about pain, sleep, and anxiety, have been frequently observed in cannabis product packages, including edibles. (Barrus et al., 2016; Hoeper et al., 2022) Additionally, many unsubstantiated health claims are made in online descriptions of products, with pain and insomnia relief being the most frequent claims on dispensary websites. (Hoeper et al., 2022)

All states require potency labeling in either percentages or milligrams depending on the cannabis product type, and they all limit the tetrahydrocannabinol per serving and per package for edible products. (Schauer, 2021) However, this information is typically found in small text on an inconspicuous region of the package, potentially limiting their effectiveness. Researchers have identified unit-dose packaging as a promising policy for increasing consumer knowledge about edible serving sizes. (Goodman & Hammond, 2020) Consumer-friendly, front-of-package visual indicators that summarize nutritional information in large font or easily recognizable symbols have been suggested effective in nutritional labeling literature. (Temple, 2020) However, no studies have examined their effectiveness in cannabis control.

Almost all states adopt lengthy and composite warning messages combining multiple themes, with no requirements on warning label positions. New York State is an exception, requiring three single-themed messages rotating on packages, but none of them are specifically related to edibles. Only a few states require additional warning messages that specifically warn about the delayed onset and prolonged psychoactive effects of edibles. Rotating single-themed short messages are proven effective, recommended by WHO, and required by FDA on cigarette packages, (Hammond, 2011), but they have not been studied in cannabis literature.

Studies evaluating the impacts of cannabis packaging have only emerged very recently and are still sparse. A major challenge is the lack of high-quality observational data linking individual outcomes to exposure to packages and related policies. Additionally, there are concerns about the endogeneity of the relationship between self-reported exposure and outcomes, which complicates analysis. As a result, most existing studies used between-individual experiments that randomized participants to view different packages and elicited self-reported ratings or perceptions. Some of these experiments analyzed real-world cannabis package policies such as Canadian plain packaging, Canadian versus U. S. state health warnings, and unit-dose packaging. (Goodman & Hammond, 2020; Goodman, Leos-Toro & Hammond, 2019, 2021) Another strand of the literature developed hypothetical cannabis packaging with various brand personality styles and novel health warnings not implemented by any governments such as graphic warnings. (Kowitt et al., 2022; Leos-Toro, Fong & Hammond, 2021; Mutti-Packer, Collyer & Hodgins, 2018)

This study aims to estimate the impacts of packaging attributes on individual preferences for cannabis edibles and explore heterogeneities in preferences by cannabis use status and use purposes. We implemented a discrete choice experiment (DCE), an experimental approach commonly used in tobacco research and health economics. (Regmi, Kaphle, Timilsina & Tuha, 2018; Soekhai, de Bekker-Grob, Ellis & Vass, 2019) The hypothetical nature of the experiment allows us to evaluate potentially effective packages that are not available in the U.S. markets, such as the plain package required by Canada. Compared to existing experimental studies on cannabis packaging that typically asked participants to state opinions with Likert scales or subjective descriptions, our DCE study asked participants to choose from package alternatives with systematic variations in package attributes. This DCE methodology has several advantages. (1) The outcome measure of selecting a product for hypothetical consumption in a DCE is more closely linked to real purchase and substance use behaviors. (2) DCEs assess not only between-individual variations but also within-individual variations, such that the findings may have stronger causal inferences. (3) The packages in our DCE varied multiple packaging attributes, including package style, health claim, potency indicator, warning label position, and warning label text, so we were able to evaluate multiple attributes in the same experiment without requiring a large number of trials and to quantify the independent impacts and relative importance of multiple attributes. Because the subpopulations characterized by different cannabis use status and use purposes may respond to packages differently and yield different policy implications, we also conducted subgroup analysis to explore heterogeneities.

Our study is also novel in its focus on cannabis package attributes. The few previously published DCEs on cannabis products have focused on products other than edibles (e.g., flowers) and on instrumental attributes of the products such as price and potency rather than solely packaging attributes. (Donnan, Johnston, Coombs, Najafizada & Bishop, 2023, Donnan, Johnston , Najafizada & Bishop, 2023; Shi, Cao, Shang & Pacula, 2019) Although these instrumental attributes are important factors in consumer choice, policymakers must regulate cannabis packaging regardless of price and potency, and directional effects of package attributes are important even if the magnitude is small compared to price and potency. Specifically regarding price, it may be unrealistic to expect consumers to show significant willingness to pay for package attributes alone without any variation in the underlying product characteristics. It is not uncommon for recently published DCEs in public health to omit price as a varying attribute. (Barrientos-Gutierrez et al., 2020; Hoek et al., 2022; Lee et al., 2021) Our study is also the first to examine the impacts of youth-appealing package features. Built upon the body of previous experimental work on cannabis packages, we developed novel experimental stimuli, most notably the hypothetical branded package with a counterpart youth-appealing version.

Our study is expected to provide important knowledge to policymakers about consumer preferences for cannabis packaging. Depending

on their goals, policymakers may use this knowledge to shape regulations on package attributes. If the policy goal is to reduce cannabis use, they may mandate that packages use the least preferred versions of the most impactful attributes from our study. Alternatively, if the policy goal is to improve health knowledge with minimal impact on consumer choice, they may target package attributes with the least impact on preferences. In this way, our analysis provides useful insights for a variety of policy goals in cannabis control.

Methods

Participants

In August and September of 2022, we recruited 1578 participants from online panels through Qualtrics, a company providing recruitment services and an online survey platform. The inclusion criteria are adults aged 18 and older living in one of the 18 states plus Washington, D.C., where recreational cannabis had been legalized by the time of data collection. The 18 states include Alaska, Arizona, California, Colorado, Connecticut, Illinois, Maine, Massachusetts, Michigan, Montana, Nevada, New Jersey, New Mexico, New York, Oregon, Vermont, Virginia, and Washington. We aimed to recruit 2/3 cannabis past-year users and 1/3 cannabis past-year nonusers. Cannabis past-year use is defined as using cannabis at least once in the past 12 months through any administration method. Fewer nonusers were sampled than users despite nonusers being more prevalent in the general population because users have a much greater exposure to cannabis packages and their preferences are more relevant to public health and policymaking. Nonusers were not excluded because packages may impact cannabis use initiation and resumption. Sampling quotas within the cannabis user and nonuser subsamples were created separately to make each subsample representative of the sex, age, and racial/ethnic distribution in the respective subgroup in the U.S. The quotas were calculated using the 2020 National Survey on Drug Use and Health, which was the most recent wave at the time of data collection in this large nationally representative, probability-based drug use survey. Due to an error in the quota-based recruitment on the online survey platform, recruitment was not halted when certain demographic quotas were filled. We sampled 1578 participants instead of 1500 and some quotas were overfilled before the error was corrected. We retained all participants in our study because our overlapping quota design does not allow us to drop participants from overfilled quotas without causing other quotas to become underfilled. Additionally, retaining the larger sample size gives us a marginally greater statistical power.

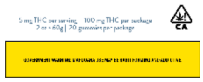
This survey was approved by the Human Research Protections Program at the University of California San Diego.

DCE design

The central part of the survey involved a DCE with participants choosing from a choice set which contained two unlabeled cannabis package alternatives and an opt-out option. The selection of package attributes was based on whether they were commonly studied in cannabis, tobacco, and food package literature, frequently regulated, and could plausibly have significant public health impacts. (Schauer, 2021)

The following five package attributes were varied (attribute levels in parentheses): (1) package style (plain, branded, and youth-appealing), (2) health claim (none, pain relief, sleep aid, and stress relief), (3) potency indicator (none, dial, dots, and text), (4) warning label position (top and bottom), and (5) warning label text (one long and composite message and four short, single-themed messages including that focusing on addictive, delayed onset, driving impairment, and mental health effects of edible use). All other aspects of the packaging were held constant, and no instrumental attributes of the cannabis edible product itself such as price, potency, or flavor were varied. Table 1 lists the details

Table 1
Discrete choice experiment attributes and levels.

Choice Attribute	Levels of the Attribute
Package Style	1. Plain   2. Branded  3. Branded Youth-Appealing 
Health Claim	1. None 2. Pain Relief 3. Sleep Aid 4. Stress Relief
Potency Indicator	1. None 2. Dial  3. Dots  4. Text 
Warning Label Position	1. Bottom 2. Top
Warning Label Text	1. Long, Composite Message “Government Warning: Do not drive a motor vehicle or operate heavy machinery while using marijuana. The intoxicating effects of this product may be delayed by 2 or more hours. Marijuana use may be habit forming and addictive. Frequent and prolonged use of marijuana can contribute to mental health problems over time, including anxiety, depression, stunted brain development, and impaired memory.” 2. Short, Single Theme: Habit-Forming/Addictive “Government Warning: Marijuana use may be habit forming and addictive.”

(*continued on next page*)

Table 1 (*continued*)

Choice Attribute	Levels of the Attribute
	3. Short, Single Theme: Delayed Onset of Effects "Government Warning: The intoxicating effects of this product may be delayed by 2 or more hours." 4. Short, Single Theme: Driving Impairment "Government Warning: Do not drive a motor vehicle or operate heavy machinery while using marijuana." 5. Short, Single Theme: Mental Health "Government Warning: Frequent and prolonged use of marijuana can contribute to mental health problems over time, including anxiety, depression, stunted brain development, and impaired memory."

with image examples where relevant, and Fig. 1 displays an example choice set.

The package style attribute involves the most drastic visual changes between levels, and was likely the most salient attribute to participants during choice scenarios. We worked with a professional graphic designer to create cannabis edible package images. The plain package design follows the packaging requirements for cannabis sold in Canada, with a plain white background, highly limited branding text, and no branding imagery. The branded package is more aesthetically pleasing with coloration, patterns, a brand logo, and an image of gummy edibles. This branded package was a close recreation of a real cannabis edible product found in online legal cannabis marketplaces in the U.S. We based this design on a real product to increase realism and avoid introducing unintended bias with a fictional and entirely novel graphic design. We selected this particular package to replicate because it was featured as a popular product, was visually similar to many other popular packages, used mostly neutral colors, and had segmented package regions. The youth-appealing package uses the same base image as the branded package but replaces two features with fictional youth-appealing versions that did not appear on the original real package: the brand name is displayed in a colorful bubble font style, and the brand logo is replaced with a colorful cartoon animal character.

The health claim attribute has one of three claims written in large font on each package: "Pain Relief," "Sleep Aid," or "Stress Relief." We selected these three health claims because they have been commonly displayed on online cannabis marketplace product packages and descriptions and noted in cannabis literature. (Barrus et al., 2016; Hoeper et al., 2022) No health claim is also included as a reference level.

The potency indicator attribute has one of three icons, each indicating the same "medium" level of potency: a dial ranging from green to yellow to red with a pointer towards the middle yellow region, dots with two out of three filled, and the text "Medium Potency." These potency indicators were created by our graphic designer based on similar nutritional indicators tested in food labeling literature. (Blitstein, Guthrie & Rains, 2020; Crosetto et al., 2020; Mejean, Macouillard, Peneau, Hercberg & Castetbon, 2013) No potency indicator is also included as a reference level.

The warning label position attribute includes top and bottom of the package. The warning text attribute includes one of four short, single-themed health warning messages and a long, composite warning containing all four of the short messages. The precise wording of each warning text was composed by examining the mandated warning texts in states with recreational cannabis legalization and selecting the most common themes and phrasings. (Schauer, 2021)

A full factorial design is not feasible due to the enormous number of possible attribute-level combinations, so we implemented a D-Optimal design with six blocks of 10 choice sets per block. Each participant was randomly assigned to one block to complete the 10 choice sets. Our design is unlabeled, with partial overlap of attribute levels permitted. The design is 94.6% as efficient as a full factorial experiment.

DCE procedure

To improve DCE data quality, after survey eligibility screening and

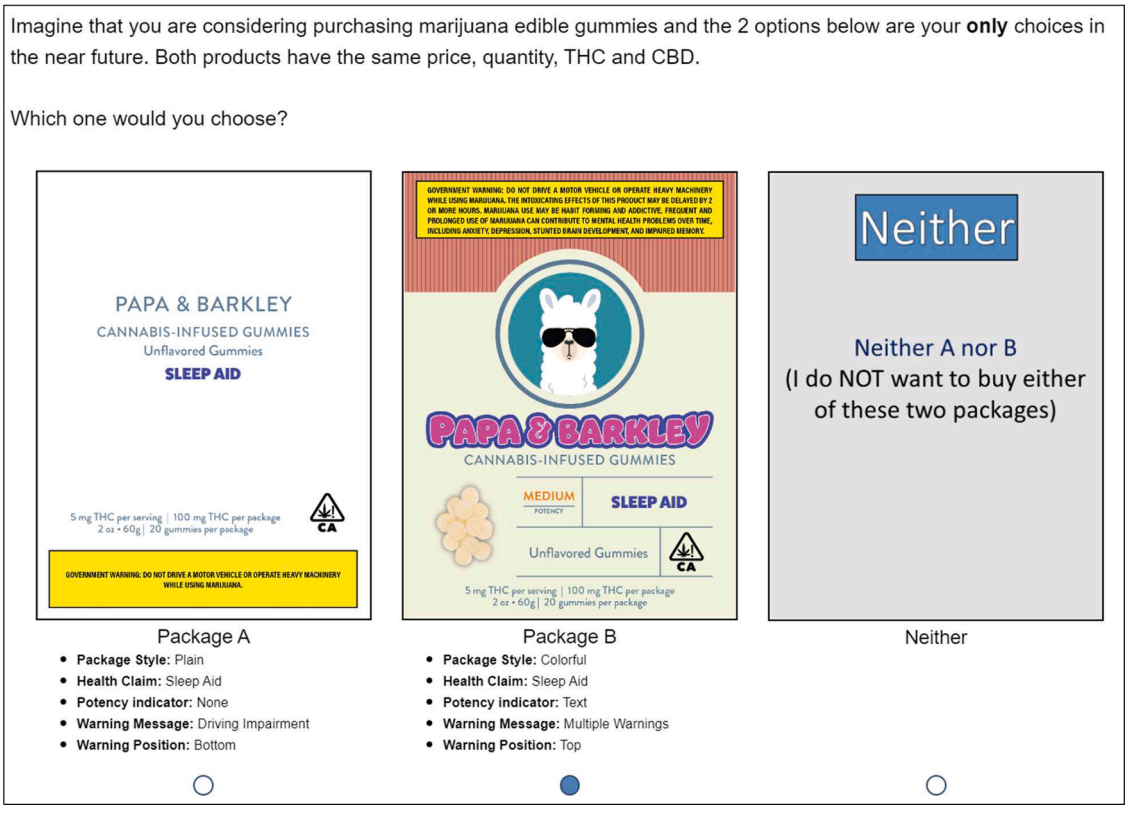


Fig. 1. An example of choice set.

before assignment to DCE scenarios, participants were educated about the scenarios in which the choices would be made. Participants may select one of the two cannabis edible products for personal use, and these two products are the only cannabis products available to them in the near future. The products cannot be shared, exchanged, or resold in any manner. Both products are assumed to have the same price that is the typical/average market price for this type of product. The products are assumed to contain identical cannabis edible gummies inside: 20 unflavored gummies with 5 mg THC per gummy. Participants should consider only the health claim and warning message on each package itself, and not to carry the information over to any other packages. Before the DCE, participants were presented with brief descriptions of the package attributes and provided an image of an example DCE choice set to help familiarize themselves with the tasks. These are recommended by the Conjoint Analysis Task Force as good research practices to increase comprehension prior to choice scenarios. (Bridges et al., 2011)

We included two attention checks in the survey. First, at the end of each DCE block, participants were presented with a repeat choice set randomly selected from the 10 completed choice sets. Second, we asked which day of the week it is. Participants who either selected an inconsistent package choice in the repeat choice set or answered the day incorrectly were flagged as potentially inattentive. We retained all participants in our main analysis because inconsistent choices may be due to learning or fatigue as opposed to inattention, but we dropped them in robustness check analysis. (Bateman, Burgess, Hutchinson & Matthews, 2008; Hess, Hensher & Daly, 2012)

Other survey components

After the DCE, participants completed a short survey asking about demographic information and substance use status. The variables included in our analysis are sex, age, race/ethnicity, education, income, substance use (cannabis, alcohol, and cigarettes), and state of residence (Table S1).

Data analyses

In the full sample, we analyzed participants' propensity to always opt out in all of the 10 choice sets using a logistic regression, controlling for individual-level demographic and substance use covariates mentioned above.

Among those who did not always opt out, we analyzed participants' preferences for package attributes using mixed (random parameters) logit regressions. The mixed logit regression assumes that the probability of choosing an alternative is a function of attribute levels and a random error allowing for individual-specific variations in preferences. Compared to the conventional multinomial logit (conditional logit) models, it relaxes the irrelevant alternative independence assumption and allows for heterogeneities of regression coefficients across individuals. (Train, 2009) In our analysis, the dependent variable is the likelihood of choosing one alternative over others and the covariates are attribute levels and an alternative-specific constant representing the baseline preference for the opt-out option. All the attributes were treated as categorical variables and the coefficients were assumed to be normally distributed. Standard errors in our mixed logit regressions were clustered at the participant level.

Because different subsamples may have heterogeneities in preferences and yield different policy implications, the regressions were separately conducted in the following subsamples: 1) by cannabis use status: cannabis users and nonusers, and 2) among cannabis users, by cannabis use purposes: medical-only (past-year use primarily for medical purposes to treat health conditions or mitigate symptoms), recreational-only (pasty-year use primarily for recreational purposes to attain pleasure or satisfaction), and dual-purpose (both medical and recreational purposes). We also performed regressions with full sets of interaction effects between package attributes and subsample indicators. The significance and magnitude of the interaction effect coefficients provide formal tests of the between-group differences observed in the stratified subsample analysis.

Based on mixed logit regression results, we calculated the relative importance of each attribute in each subsample categorized by cannabis use status and use purposes. The relative importance was calculated by subtracting each attribute's maximum part-worth (i.e., coefficient) from the minimum part-worth to determine the part-worth range of that attribute, and then dividing this range by the sum of all attribute part-worth ranges. (Hauber et al., 2016) It represents the relative impact of the considered attribute on the total utility (i.e., benefit to the consumer) a participant could receive from choosing a cannabis edible package. The scores are summed to 100% and visualized in pie charts.

In robustness analysis, we dropped participants who failed either of the two attention checks and repeated the regressions.

All analyses were conducted in Stata SE 17.0. Logistic regressions were conducted using the "logistic" package with default options, and mixed logit regressions were conducted using the "mixlogit" package with the number of Halton draws increased to 500 and default options otherwise.

Results

Sample characteristics

The sample characteristics are described in Table S1 with separate columns for cannabis users ($N = 1009$) and cannabis nonusers ($N = 569$). Among cannabis users, 30.13%, 41.53%, and 28.34% are medical-only, recreational-only, and dual-purpose users, respectively. Table S2 shows a comparison of our study sample and the 2020 National Survey on Drug Use and Health on which our sampling quotas were based.

Predictors of always opting out

Among cannabis users, 3.96% always opted out. Among cannabis nonusers, 30.40% always opted out. The majority of participants (76.44%) who always opted out reported the reason as not wanting to use cannabis at all in the near future.

Table 2 reports regression results on always opting out in the full sample. The following individual characteristics are associated with a higher propensity of always opting out: age 35+, non-Hispanic other minority, lower income, not using cannabis, not drinking alcohol, and not smoking cigarettes.

Preferences for package attributes

Table S3 shows the unadjusted percentage of each attribute level being chosen.

Table 3 reports the results of mixed logit models by cannabis use status. Both cannabis users and nonusers prefer branded packages over plain packages, any health claim over no health claim with the "Stress Relief" claim being most preferred, and any potency indicator over no potency indicator with the "dial" indicator being most preferred. Cannabis users prefer youth-appealing packages over branded packages and top position of the warning text over bottom position, but such findings are not observed among nonusers. Cannabis nonusers prefer the "long and composite" warning text over the short, single-themed "addictive" warning text, whereas users prefer the short, single-themed "delayed effects" and "driving impairment" warning texts over the "long and composite" warning text. Standard deviation estimates indicate substantial heterogeneity in preferences for package style, with more heterogeneity among nonusers than users. Moderate heterogeneity is also detected among preferences for health claims.

Table 4 reports the results of mixed logit models among cannabis users by cannabis use purposes. Most results are consistent with the

Table 2
Logistic regression on "always opt out", full study sample.

	Odds Ratio	95% CI
Sex:		
Female	reference	
Male	1.39	[0.97, 2.00]
Age:		
18–25	reference	
26–34	0.45*	[0.23, 0.87]
35+	1.81*	[1.11, 2.93]
Race/Ethnicity:		
Non-Hispanic White	reference	
Non-Hispanic Black	1.29	[0.74, 2.25]
Hispanic	0.82	[0.49, 1.37]
Non-Hispanic Other	2.05*	[1.18, 3.54]
Education:		
High School or Less	reference	
Some College	0.94	[0.60, 1.47]
Bachelor's Degree	1.03	[0.63, 1.68]
Graduate Degree	1.00	[0.56, 1.79]
Income:		
< $25k	reference	
$25k-$50k	0.93	[0.57, 1.52]
$50k-$75k	0.38***	[0.21, 0.67]
> $75k	0.50*	[0.30, 0.85]
Decline to State	0.94	[0.44, 1.99]
Substance Use:		
Past-year Cannabis User	0.10***	[0.07, 0.15]
Past-month Alcohol User	0.60**	[0.42, 0.86]
Past-month Cigarette User	0.51*	[0.29, 0.91]
Participants, N	1574	

* $p < 0.05$,.
** $p < 0.01$,.
*** $p < 0.001$
Notes: State indicators were also included in the regression but not shown.

results for the overall cannabis user population reported in Table 3. Several observations are unique to users with certain purposes. For example, recreational-only users and dual-purpose users prefer youth-appealing packages over branded packages, but this preference is not observed among medical-only users. Medical-only users most prefer the "Pain Relief" health claim, whereas recreational-only and dual-purpose users most prefer the "Stress Relief" claim. Medical-only users are indifferent between the bottom and top positions of the warning label. The variation in warning text has no impacts on preferences in all the three subsamples with the only exception being that dual-purpose users prefer the short, single themed "driving impairment" warning text over the "long and composite" warning text. We detect no meaningful differences in heterogeneous preferences between subsamples by use purposes.

Tables S4 and S5 present the results of mixed logit regressions including interaction terms between package attributes and cannabis use status and interaction terms between package attributes and cannabis use purposes, respectively. The interaction coefficients support our findings from the stratified analysis in Tables 3 and 4.

We visualize the relative importance of attributes in pie charts in Fig. 2. Both cannabis users and nonusers perceive package style to be the most important attribute, but users place a greater relative importance on it (49.0%) compared to nonusers (33.2%). The health claim is the second most important attribute for both groups, with users placing the relative importance at 23.5% and nonusers at 30.5%. Both groups consider the warning label position to be the least important. The calculations by use purposes show that recreational-only and dual-purpose users have similar relative importance weights on most attributes: they place much lower weights on health claim and warning text but a greater weight on package style compared to medical-only users.

Robustness checks

We show the results of robustness checks in Tables S6 and S7, where we repeated our main analysis while omitting participants who failed either of the two attention checks. This reduces the sample size to 1129. Key results reported in the main analysis are not altered.

Table 3
Mixed logit regression on package choices, by cannabis use status.

	Cannabis Users		Cannabis Nonusers	
	Coefficient [95% CI]	Standard Deviation [95% CI]	Coefficient [95% CI]	Standard Deviation [95% CI]
Alternative-Specific Constant:				
Opt Out	−2.13*** [−2.42, −1.83]	2.35*** [2.13, 2.57]	−1.15*** [−1.70, −0.60]	3.12*** [2.68, 3.56]
Package Style:				
Branded	reference	reference	reference	reference
Plain	−1.11*** [−1.25, −0.96]	1.37*** [1.20, 1.54]	−0.95*** [−1.25, −0.66]	1.85*** [1.51, 2.18]
Youth-Appealing	0.45*** [0.32, 0.58]	1.43*** [1.26, 1.59]	0.21 [−0.04, 0.46]	1.76*** [1.40, 2.13]
Health Claim:				
None	reference	reference	reference	reference
Pain Relief	0.67*** [0.53, 0.81]	0.81*** [0.60, 1.03]	0.88*** [0.63, 1.13]	0.86*** [0.49, 1.23]
Sleep Aid	0.41*** [0.28, 0.54]	0.77*** [0.57, 0.97]	0.92*** [0.67, 1.17]	0.96*** [0.65, 1.27]
Stress Relief	0.75*** [0.62, 0.88]	0.67*** [0.46, 0.87]	1.07*** [0.84, 1.30]	1.09*** [0.73, 1.45]
Potency Indicator:				
None	reference	reference	reference	reference
Dial	0.48*** [0.37, 0.60]	0.47*** [0.25, 0.70]	0.40*** [0.18, 0.62]	0.67*** [0.28, 1.05]
Dots	0.33*** [0.22, 0.43]	0.06 [−0.90, 1.02]	0.37*** [0.18, 0.55]	0.02 [−0.42, 0.47]
Text	0.28*** [0.17, 0.39]	0.37** [0.11, 0.63]	0.36*** [0.16, 0.56]	0.13 [−0.28, 0.54]
Warning Position:				
Bottom	reference	reference	reference	reference
Top	0.12*** [0.06, 0.19]	0.28* [0.06, 0.51]	0.03 [−0.09, 0.15]	0.23 [−0.23, 0.68]
Warning Text:				
Long and Composite	reference	reference	reference	reference
Addictive	−0.03 [−0.16, 0.11]	0.47** [0.12, 0.83]	−0.28* [−0.51, −0.06]	0.42 [−0.26, 1.11]
Delayed Effects	0.16* [0.02, 0.30]	0.41* [0.01, 0.80]	0.06 [−0.20, 0.31]	0.84*** [0.52, 1.17]
Driving Impairment	0.25*** [0.10, 0.39]	0.44** [0.14, 0.75]	0.00 [−0.25, 0.26]	0.64 [−0.08, 1.35]
Mental Health	0.08 [−0.05, 0.20]	0.34* [0.06, 0.63]	−0.10 [−0.31, 0.12]	0.12 [−1.18, 1.42]
Choice Observations, N	29,070		11,880	
Participants, N	969		396	

* $p < 0.05$,.
** $p < 0.01$,.
*** $p < 0.001$
Notes: Standard errors were clustered at the participant level.

Discussion

We find several interesting results with policy implications from our

Table 4
Mixed logit regression on package choices, cannabis users only by use purposes.

	Medical-only Users		Recreational-only Users		Dual-purpose Users	
	Coefficient [95% CI]	Standard Deviation [95% CI]	Coefficient [95% CI]	Standard Deviation [95% CI]	Coefficient [95% CI]	Standard Deviation [95% CI]
Alternative-Specific Constant:						
Opt Out	−1.96***	2.46***	−2.27***	2.42***	−2.27***	2.67***
	[−2.49, −1.43]	[2.07, 2.85]	[−2.78, −1.75]	[1.73, 3.11]	[−2.91, −1.62]	[2.01, 3.33]
Package Style:						
Branded	reference	reference	reference	reference	reference	reference
Plain	−1.09***	1.42***	−0.95***	1.34***	−1.34***	1.28***
	[−1.36, −0.82]	[1.08, 1.76]	[−1.17, −0.72]	[0.98, 1.70]	[−1.60, −1.07]	[0.95, 1.60]
Youth-Appealing	0.08	1.13***	0.65***	1.52***	0.55***	1.64***
	[−0.13, 0.28]	[0.81, 1.46]	[0.42, 0.89]	[1.21, 1.83]	[0.29, 0.82]	[1.33, 1.95]
Health Claim:						
None	reference	reference	reference	reference	reference	reference
Pain Relief	0.94***	0.97***	0.42***	0.61*	0.78***	0.77***
	[0.66, 1.22]	[0.67, 1.28]	[0.21, 0.64]	[0.01, 1.22]	[0.50, 1.05]	[0.43, 1.11]
Sleep Aid	0.42***	0.48	0.35**	1.02***	0.53***	0.69**
	[0.18, 0.65]	[−0.41, 1.37]	[0.11, 0.60]	[0.71, 1.34]	[0.28, 0.78]	[0.23, 1.15]
Stress Relief	0.57***	0.77***	0.81***	0.76***	0.90***	0.42
	[0.33, 0.81]	[0.47, 1.07]	[0.60, 1.02]	[0.46, 1.05]	[0.65, 1.14]	[−0.33, 1.17]
Potency Indicator:						
None	reference	reference	reference	reference	reference	reference
Dial	0.49***	0.47*	0.40***	0.64*	0.63***	0.37
	[0.29, 0.70]	[0.08, 0.86]	[0.21, 0.58]	[0.07, 1.21]	[0.41, 0.86]	[−0.11, 0.85]
Dots	0.18	0.19	0.38***	0.10	0.45***	0.37
	[−0.01, 0.36]	[−0.28, 0.66]	[0.20, 0.55]	[−3.16, 3.35]	[0.23, 0.67]	[−0.29, 1.03]
Text	0.31**	0.37	0.23*	0.21	0.31**	0.28
	[0.12, 0.51]	[−0.12, 0.86]	[0.05, 0.40]	[−1.72, 2.14]	[0.10, 0.52]	[−0.02, 0.58]
Warning Position:						
Bottom	reference	reference	reference	reference	reference	reference
Top	−0.02	0.31	0.14*	0.29	0.26***	0.15
	[−0.14, 0.11]	[−0.05, 0.66]	[0.02, 0.27]	[−0.18, 0.77]	[0.14, 0.39]	[−0.50, 0.80]
Warning Text:						
Long and Composite	reference	reference	reference	reference	reference	reference
Addictive	−0.22	0.60	0.04	0.41	0.01	0.60
	[−0.46, 0.02]	[−0.08, 1.28]	[−0.17, 0.25]	[−0.22, 1.03]	[−0.24, 0.26]	[−0.08, 1.29]
Delayed Effects	0.22	0.33	0.15	0.75***	0.07	0.18
	[−0.03, 0.46]	[−1.71, 2.36]	[−0.08, 0.38]	[0.40, 1.10]	[−0.17, 0.31]	[−0.32, 0.68]
Driving Impairment	0.25	0.51*	0.20	0.32	0.30*	0.72***
	[−0.01, 0.51]	[0.03, 0.99]	[−0.03, 0.43]	[−0.89, 1.53]	[0.03, 0.56]	[0.35, 1.08]
Mental Health	0.07	0.51*	0.02	0.53*	0.14	0.23
	[−0.16, 0.29]	[0.09, 0.93]	[−0.18, 0.23]	[0.05, 1.00]	[−0.09, 0.37]	[−0.83, 1.28]
Choice Observations, N	8670		12,090		8310	
Participants, N	289		403		277	

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$
Notes: Standard errors were clustered at the participant level.

analysis of preferences for cannabis edible package attributes. Package style is the most important attribute among the five with an estimated relative importance 33.2–50.8% among subsamples. This result is sensible because the package style attribute involves the most drastic visual changes and therefore was likely the most noticeable and salient attribute during choice scenarios. All subsamples prefer the branded package style over plain package style, implying that the plain packaging regulatory requirements in Canada may be effective in reducing the appeal of cannabis products. This result aligns with a common result in tobacco control literature that plain packaging reduces the appeal of tobacco products. (Moodie et al., 2022) We also find that cannabis users prefer packages with youth-appealing features. Since we only included adults in the sample, this finding implies that youth-appealing packages are also appealing to adults and regulating these attributes may reduce the appeal of cannabis products among adults. Currently some states prohibit cannabis edible packages that appeal to youth, but audit studies show that youth-appealing packages have been commonly found in legal marketplaces. (Ompad et al., 2022; Shi & Pacula, 2021; Tan et al., 2022) This may be due to the ambiguity and the lack of comprehensiveness in laws and/or weak enforcement. Regulators may consider banning specific youth-appealing features or mandating plain packaging like Canada to reduce the room for cannabis producers to increase sales by using these youth-appealing features on packages. Law enforcement efforts such as regular law compliance checks are also recommended.

Health claim is the second most important attribute with an estimated relative importance 22.6–30.5% among subsamples. It is considered particularly important by medical-only cannabis users, who consume cannabis primarily for its health effects, and nonusers, who may have limited or no experience with cannabis use and insufficient knowledge about the health effects of cannabis. If unsubstantiated health claims especially influence the cannabis consumption of these two subsamples, these groups may risk negative health effects of cannabis use without receiving the medical relief they expect from the package marketing. Currently only a small number of U.S. states prohibit health claims on cannabis packaging. (Goundar et al., 2021) Wide proliferation of such laws with stringent enforcement is worth consideration given the strong preference for health claims measured in our experiment.

Potency indicator accounts for 11.4–15.9% of the total importance, with all the subsamples preferring some indicator to no indicator.

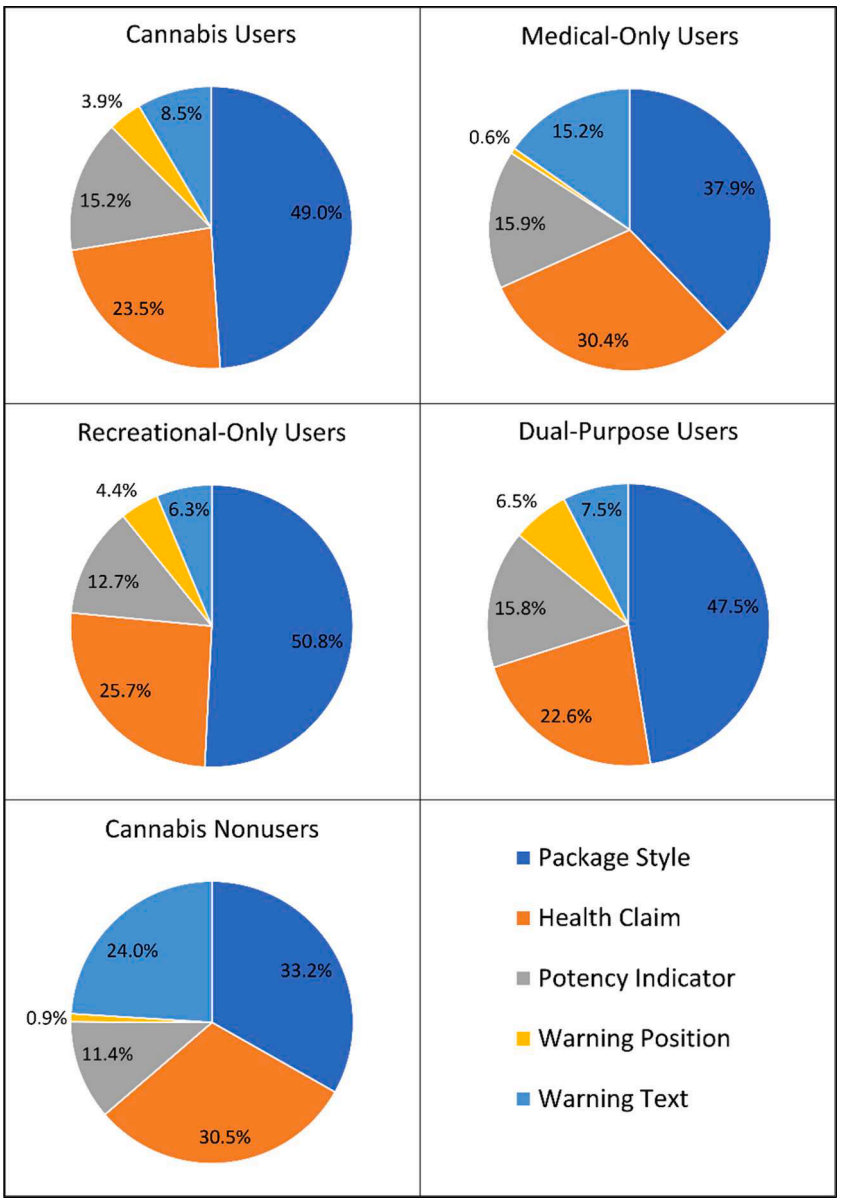


Fig. 2. Relative importance of choice attributes by cannabis use status and use purposes.

Research has reported that even in jurisdictions with recreational cannabis legalization consumers' knowledge on cannabis potency was low. (Hammond & Goodman, 2022) Our finding suggests that adding potency indicator has great potential to more efficiently communicate and increase the awareness of cannabis potency levels. This is also supported by the rich evidence on front-of-pack nutritional graphic icons, which are found to improve comprehension and health outcomes in the food labeling literature. (Crosetto et al., 2020; Roberto & Khandpur, 2014)

Warning label position plays a rather minor role in preferences for cannabis packages (0.6–6.5% relative importance), with a slightly greater preference among cannabis users for warning labels placed on the top. This implies that a policy requiring warnings to appear on the top of cannabis packages would likely cause no utility loss for consumers, while potentially reaping several benefits of top-placed warnings found in tobacco control literature such as increased visual attention towards warnings. (Hwang et al., 2018)

Medical-only cannabis users and cannabis nonusers place greater weight on warning label text (24.0% and 15.2% relative importance, respectively). Several short, single-themed warning texts are preferred over the long, composite text in some subsamples and only one short, single-themed warning text ("addictive") is associated with a reduced utility. Tobacco control literature suggests that short rotating warning messages may be more effective than static long messages due to the novelty of new warnings. (Hammond, 2011) The short, single-themed cannabis warning messages with rotation have the promise of being effective in risk communication and would not lead to a meaningful loss of utility for consumers.

Summing up the findings discussed above, we recommend different policy options for different policy goals. Policymakers may consider banning youth-appealing packaging, mandating plain packaging, and prohibiting unsubstantiated health claims to deter cannabis use, as these are the least preferred versions of the most impactful attributes on consumer choices. Policymakers may instead consider requiring potency indicators and top-positioned, short, single-themed warning messages on packages to communicate health risks, as these versions of the attributes have no major impacts on consumer choices and would not yield considerable utility losses.

Our mixed logit models provide insight on heterogeneity in preferences which may have additional policy implications. We detect

substantial heterogeneity in preferences for package style, even more so among nonusers who presumably have less experience viewing cannabis packaging. Future research may explore the association between cannabis consumer profiles and preferences for certain package styles, as the findings may imply differential impacts on certain populations in cannabis-related health outcomes from regulating those styles. Preferences for health claims are also highly heterogeneous, possibly due to sample heterogeneity in underlying health conditions relevant to each health claim.

As policymakers weigh various regulations on legal cannabis edible products, they may also consider unintended effects of legal market regulations on the demand for unregulated edible products such as those sold in illicit markets. However, the direction of the effects is unclear. Packages in illicit markets could mimic regulated packages in legal markets, so consumers purchasing in illicit markets could also benefit from package regulations. If packages in illicit markets are not influenced by package regulations in legal markets, package regulations that are too stringent (either by increasing the production cost or reducing the utility by making the package less attractive) may drive some consumers away from legal markets towards illicit markets.

Our study has several limitations, some of which are common to the DCE study design. First, the selection of alternatives in our DCE may deviate from actual behaviors in reality for the following reasons. (1) Participants make hypothetical decisions in hypothetical scenarios. We attempted to mitigate the hypothetical bias by designing package styles based on a real product, providing clear instructions and practice rounds to participants before the experiment, and highlighting the potential contribution of this study to science and policymaking. (2) Our DCE offered only two edible package alternatives with limited variation in attributes, which differs from the richer product menu offered in storefront and online marketplaces. The limited number of alternatives and attributes is inevitable due to the need to reduce cognitive burden and have a controlled setting in experimental research. (3) We only measured preferences for packages, which do not provide a direct link to cannabis consumption, purchase behavior, or resultant health outcomes. Despite these common limitations, DCEs have been widely used in substance use behavior and public health research and proved to provide reasonable predictions of real-world choices. (de Bekker-Grob, Donkers, Bliemer, Veldwijk & Swait, 2020; Huls & de Bekker-Grob, 2022)

Second, as mentioned above we evaluated a limited number of attributes. Other attributes important to consumer decisions, such as price and potency, were not included due to the concerns that these attributes would significantly outweigh any purely cosmetic package features. How package features may interact with price and potency is worth future investigation. Our design was unable to isolate the effects of shorter warning texts from the effects of single-themed messages as both features vary simultaneously in our study design. We measured the relative importance of several attributes compared to each other, but these attributes have varying visual salience. The drastic visual changes between package styles may have overshadowed some of the more subtle attributes such as potency indicators.

Third, we used a convenience quota-based sampling approach, so our sample may not be accurately representative of the broader U.S. adult population. However, this method allowed us to recruit a much larger sample at a lower cost. Additionally, due to an error in the quota settings in our survey software, we overfilled certain demographic quotas but were unable to cleanly remove these 78 participants from our sample of 1578 without underfilling other quotas. This slightly reduced our sample representativeness but slightly increased our statistical power. Due to this issue, our results regarding nonusers should be seen as less generalizable than our results regarding users. In a related issue with representativeness, we did not measure whether participants had any health symptoms relevant to health claims. If our sample has a different incidence of these health symptoms than in the population, our estimates of preferences for health claims may not be representative of the broader population.

Fourth, in order to hold all other package features constant while varying only specific package attributes, we created packages based on a real popular cannabis edible product in legal marketplaces in the U.S. It is possible that the effects detected in our study would differ if we had chosen a different specific product package to mimic in our package designs. Similarly, the effects of the youth-appealing package style may differ had we designed different versions of fictional youth-appealing features (i.e., a different cartoon mascot). Additionally, youth-appealing package features may have less effect when they are placed on packages that are already busy with many other colorful features.

Further, our study focuses on cannabis edible packages only because certain package features such as youth-appealing styles are more likely to be used on edible products. Future research that assesses the impacts of packaging on alternative cannabis products such as concentrates and vaping devices is warranted.

Finally, the study sampled adults in states with recreational cannabis legalization in the U.S. The findings may not generalize to youths or populations outside of the U.S. Several additional U.S. states have legalized recreational cannabis since the time of data collection in late 2022, and our findings may not generalize to those states, either.

Conclusion

This is the first study using a DCE approach to systematically assess individual preferences for cannabis edible product packaging. Our results show that both cannabis users and nonusers prefer branded packages over highly regulated plain packages, and that cannabis users prefer youth-appealing packages to branded packages. Both cannabis users and nonusers also place a high importance on health claims, with a preference for packages with any health claim over packages with no health claim. Policies requiring plain packaging, prohibiting youth-appealing package features, and removing unsubstantiated health claims may be effective methods in cannabis control.

Ethics approval

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

This study was approved by the Human Research Protections Program at the University of California San Diego (protocol number 200684).

The authors declare that the work reported herein did not require ethics approval because it did not involve animal or human participation.

CRediT authorship contribution statement

Michael Cooper: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Yuyan Shi:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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.

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Supplementary materials

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