Preventive Medicine Reports 60 (2025) 103306

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

"Well, if they exist, I ignore them": A focus group study of recall and reactions to cannabis health warnings by cannabis consumers in the United States

Zachary B. Massey [a,b,*], Chinomso Ibe [b], Michael A. Smith [a], Erin A. Vogel [a,c], James F. Thrasher [d], David Hammond [e]

[a] TSET Health Promotion Research Center, Stephenson Cancer Center, University of Oklahoma Health Campus, Oklahoma City, OK, USA
[b] Hudson College of Public Health, University of Oklahoma Health Campus, Oklahoma City, OK, USA
[c] Department of Pediatrics, University of Oklahoma Health Campus, Oklahoma City, OK, USA
[d] Department of Health Promotion, Education and Behavior, University of South Carolina, Columbia, SC, USA
[e] School of Public Health Sciences, University of Waterloo, Waterloo, Ontario, CA

ARTICLE INFO

Keywords:
Cannabis
Cannabis health warnings
Marijuana
Health communication
Cannabis labeling

ABSTRACT

Objective: This study used qualitative focus groups to examine how cannabis consumers in the United States (U.S.) recalled health warnings on products they used and reacted to hypothetical cannabis health warnings.
Methods: We conducted 12 focus groups (February–March 2025) with 77 cannabis consumers (≥ 21, used cannabis in the past 30 days, and lived in a U.S. state where recreational cannabis use was legal). Participants (aged 22–68; Median = 42.0, Interquartile range = 22.0) described health warnings on cannabis products they used before providing reactions to hypothetical cannabis health warnings.
Results: Participants reported being unaware of or choosing to ignore health warnings on cannabis products they used. When presented with hypothetical cannabis health warnings, many participants expressed disbelief about the accuracy of the health claims. Personal experience with cannabis harms was cited as a reason for believing or disbelieving the warnings. To improve warning effectiveness, participants requested sources be cited to support health claims and suggested using direct language and enhanced visuals.
Conclusions: Cannabis consumers mostly reported not noticing current cannabis health warnings and discredited warnings they did notice. Results suggest cannabis consumers require more evidence supporting claims in health warnings, more explicit statements of harms, and inclusion of visual cues to reinforce harms.

1. Introduction

As of July 2025, 26 states in the United States (U.S.) allow adult (≥ 21) access to cannabis for non-medical (i.e., recreational) uses (Chapekis and Shah, 2024). Cannabis can provide therapeutic benefits for managing conditions such as pain, multiple sclerosis, and other chronic conditions (National Academies of Sciences Engineering Medicine, 2017); however, cannabis has the potential for adverse effects, including developing cannabis use disorder (CUD) (Fischer et al., 2017), risk for adverse cardiovascular events (Bahji et al., 2024), onset of cannabis hyperemesis syndrome (CHS) (Sorensen et al., 2017), impaired driving (Asbridge et al., 2012), and worsened mental health symptoms (van Os et al., 2002). Other risks include secondhand smoke exposure (Posis et al., 2019) and potential fetal harm when cannabis is used during pregnancy (Lo et al., 2024). Several factors increase the risk of adverse cannabis outcomes, including early-onset use (i.e., before late adolescence), daily/near-daily use, and using high-potency THC (i.e., tetrahydrocannabinol) products (Fischer et al., 2017). Adult cannabis use prevalence has generally increased in the U.S. (Mattingly et al., 2024), while risk perceptions about cannabis have decreased (Waddell, 2022), underscoring the need to communicate cannabis health information to the public.

Health warning messages (i.e., health warnings) deliver product safety information at the point of purchase and during use (Wogalter et al., 2002). Reviews of tobacco (Hammond, 2011) and alcohol (Zuckermann et al., 2024) research demonstrated that health warnings

* Corresponding authors at: TSET Health Promotion Research Center, University of Oklahoma Health Campus, Oklahoma City, OK, USA.
E-mail address: zachary-massey@ou.edu (Z.B. Massey).

https://doi.org/10.1016/j.pmedr.2025.103306
Received 13 August 2025; Received in revised form 5 November 2025; Accepted 6 November 2025
Available online 7 November 2025

can improve consumer awareness about health risks. However, the effectiveness of health warnings depends on design features. For example, black lettering on yellow backgrounds helps distinguish warnings from packaging, thereby increasing the consumer's chances of noticing them (Lempert and Glantz, 2016). Health warnings that convey risks separately (i.e., single-theme warnings) can improve consumer recall compared to warnings that list multiple risks together (Kim et al., 2022). Pictorial warnings (versus text-only) also increase attention to and recall of warning information (Hammond, 2011). Comprehensive tobacco warnings combining these features increased the salience of warnings, accuracy of risk perceptions, and recall of warning information (Hammond, 2011).

Although research has identified criteria for effective warnings, labeling regulations for adult use (aged ≥21) recreational cannabis occur at the state level in the U.S., with inconsistent practices across jurisdictions. Each U.S. state with legal cannabis sales requires warnings on cannabis products, but these warnings are rarely based on research (Barry and Glantz, 2018) and often fail to communicate risk effectively (Massey et al., 2024). For example, a 2024 policy analysis found that U.S. cannabis health warning regulations were unlikely to impact consumers because the warnings used inconsistent language and small fonts that were difficult to read (Meek et al., 2024). The design of Canadian health warnings is the result of extensive consumer testing, including qualitative research with people who use cannabis to assess how they understand cannabis health warning designs (Government of Canada, 2025), and these perform better than U.S. warnings (Massey et al., 2024).

Qualitative research is a preliminary step for developing health warnings, providing rich insights into how people understand and respond to warnings. However, there is a lack of qualitative research on cannabis health warnings, with only five published studies that assess how cannabis consumers perceive health warnings (Government of Canada, 2025; Kosa et al., 2017; Ventresca and Elliott, 2022; Donnan et al., 2022; Ranney et al., 2025). Of these, only two were conducted in the U.S. (Kosa et al., 2017; Ranney et al., 2025), where research is urgently needed to inform cannabis policy liberalization in the absence of coordinated federal oversight (Barry and Glantz, 2018). A 2016 study conducted 12 focus groups with U.S. adults in two legal recreational cannabis states. Participants assessed cannabis edible packaging, including health warnings. While participants generally understood the warnings, some expressed confusion when warnings conflicted with product instructions or personal experiences (Kosa et al., 2017). In 2023, a study conducted six focus groups with U.S. adults in states with legalized recreational cannabis. Results showed that participants often overlooked existing cannabis health warnings but reacted positively to hypothetical warnings with larger fonts, brighter colors, and concise messages (Ranney et al., 2025).

While qualitative research has examined how U.S. cannabis consumers respond to health warnings on specific products, such as edibles (Kosa et al., 2017), and hypothetical warnings based on best practices for warning design (Ranney et al., 2025), there remains a lack of qualitative research investigating how U.S. cannabis consumers recall existing warnings or respond to hypothetical designs. To address these gaps in the research and regulatory literature, this study investigated U.S. cannabis consumers' recall and perceptions of cannabis health warnings on products they used, as well as reactions to draft hypothetical cannabis health warnings.

2. Methods

2.1. Sample

The research team collaborated with Research Associates, a market research firm, to recruit participants from a national U.S. consumer database. Purposeful sampling was used to recruit participants based on inclusion criteria: legal-age adults (aged ≥21) who reported past 30-day cannabis use (i.e., current use) and who lived in a U.S. state where recreational cannabis use is legal. During screening, participants were asked if they had ever used cannabis (1 = yes, 2 = no, 3 = don't know). Those who reported "yes" were retained and asked the last time they used cannabis (1 = more than 12 months ago; 2 = more than 3 months ago, but less than 12 months ago; 3 = more than 30 days ago, but less than 3 months ago; 4 = within the past 30 days) (Hammond et al., 2020). Those reporting past 30-day cannabis use were retained and asked how often they used cannabis (1 = every day or almost every day; 2 = one or more times a week; 3 = less than once per month). Two frequencies of current cannabis use were targeted in recruitment: (1) daily/near-daily use (i.e., reported using cannabis "every day or almost every day"; $n = 36$) and (2) non-daily use (i.e., reported using cannabis "one or more times a week" or "less than once a month"; $n = 41$) (Hammond et al., 2020). Focus groups were stratified by cannabis-use frequency to encourage open discussions. Participants provided consent before participating and received $95 for their participation.

2.2. Procedures

We conducted 12 Zoom focus groups from February to March 2025, moderated by ZBM using open-ended questions. During the first part of focus groups, participants were asked to describe the cannabis products they used and recall of health warnings on those products. In the second part, participants viewed four of 16 hypothetical cannabis health warning images (described in full below), rating each on perceived message effectiveness (see Supplemental Fig. S1 and Table S1). After individual ratings, participants were shown each warning on the screen again, one at a time, and discussed their impressions, comprehension, relevance, and perceived effects of each warning. Each session lasted approximately 60 min and was audio-recorded for transcription. The University of Oklahoma Health Sciences Institutional Review Board (#17276) approved the study.

2.3. Hypothetical health warning stimuli

To develop hypothetical cannabis warnings, we first conducted a review of the clinical and epidemiological literature on the health effects of cannabis. Next, we drafted a pool of text-only and pictorial versions of cannabis health warnings. Our team and external experts in addiction science and public health reviewed and edited the warnings as necessary. The final set included one text-only and one pictorial warning for each of eight health effects, totaling 16 hypothetical cannabis health warnings.

Fig. 1 presents examples of hypothetical cannabis health warnings (see Supplemental Fig. S1 for all warnings). These warnings described risks for addiction and developing CUD, cardiovascular disease events, gastrointestinal diseases, impaired driving, smoke exposure, risk during pregnancy, and youth brain development and mental health effects. The hypothetical cannabis health warnings included three components for effective warnings: (1) an attention-grabbing signal word (e.g., Warning!), (2) an explanation of the risk mechanisms, and (3) descriptions of the effects of the risk (Wogalter et al., 2002). Pictorial warnings used pictures to exemplify the health effects because congruency between pictures and text supports comprehension of health warnings, including among lower-literacy groups (Fong et al., 2009). We avoided graphic images of bodily harm since cannabis has therapeutic applications, and the goal of the warnings was to educate about health effects without deterring therapeutic use. Some scholars argue that fear-arousing health warnings in anti-tobacco campaigns may cause people who smoke to feel stigmatized (Riley et al., 2017). Relatedly, we avoided framing the warnings as fear appeals (i.e., a persuasive message that arouses fear by describing the dangers of ignoring message recommendations). Instead, we focused on explaining the risk mechanism and effects (Wogalter et al., 2002). All warnings were matched on length (e.g., 22–29 words), font size, layout, and color scheme.

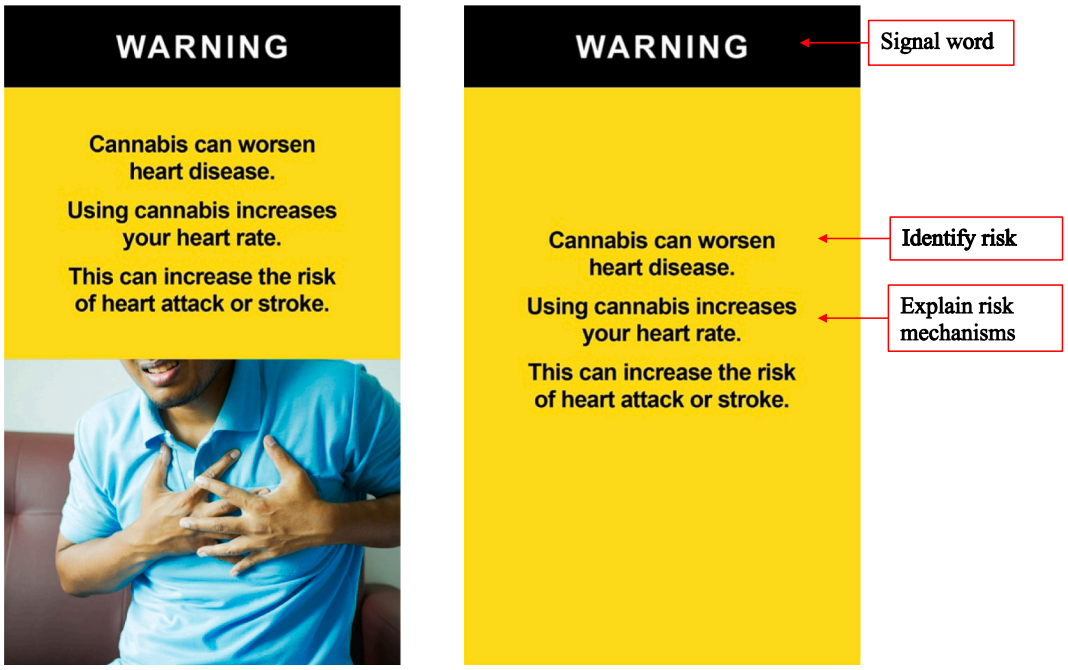

Fig. 1. Example images of pictorial (left) and text-only (right) versions of hypothetical cannabis health warnings.

2.4. Data analysis

The Research Associates transcribed and anonymized transcripts. Using a qualitative description approach (Neergaard et al., 2009), ZBM read all transcripts and developed a codebook based on themes following participants' discussions. ZBM trained CI and MAS on the codebook. CI and MAS then independently coded one transcript. The team discussed and resolved coding discrepancies. CI and MAS then coded the remaining transcripts. Once coding was completed, all authors reviewed coded transcripts, wrote memos summarizing results for each code, and met to discuss the memos. Coded sections from segmented groups were analyzed side-by-side to assess differences between groups. Responses were not noticeably different between the segmented groups, so data were summarized across all groups. ZBM synthesized summaries from memos. NVivo software was used by the research team to analyze anonymized transcripts, and SPSS (version 29) was used to compute summary statistics. Data were reported following the Standards of Reporting Qualitative Research (O'Brien et al., 2014).

3. Results

The sample (Table 1) consisted of individuals 22–68 years old (Median = 42.0, Interquartile Range = 22.0) and was 50.6 % male, 74.0 % white, 79.2 % non-Hispanic, Latino/a/x origin, with 59.8 % reporting Bachelor's degree or higher education. Focus groups (N = 77) ranged from five to eight participants per group (Median = seven per group). A total of 36 participants indicated daily/near daily cannabis use compared to 41 who were not classified as using cannabis daily/near daily.

3.1. Recall of health warnings on cannabis products

Most participants did not recall any warnings on cannabis products they used. Some participants claimed there were no warnings on the products. "I never heard of any warnings," said one participant (male, 56). "Mine [cannabis product] comes as cookies and they don't come with a warning." Some participants attributed the lack of warnings to recent legalization: "Minnesota is still in its infancy […] I haven't seen it on the packages" (male, 37). Others mentioned not seeing warnings because they purchased cannabis illicitly: "I still get mine [cannabis] from the dealer. I don't have packaging" (female, 46).

Several participants described intentionally ignoring warnings: "I really don't care what it says. I'm going to use it [cannabis] anyway" (female, 57). One participant ignored warnings because legalization made cannabis use feel safe to her, compared to pre-legalization purchases: "We used to have to meet strangers to get marijuana […]. So, for me, I really don't look at the warning" (female, 39). Another participant was unaware of warnings but intended to ignore them anyway: "Well, if they exist, I ignore them" (male, 62).

The few participants who recalled cannabis health warnings on their products largely focused on colors and symbols but not warning content (e.g., "A triangle with a pot leaf inside of it. I don't know what that would indicate, but it was next to a warning;" female, 38). Several noted warnings were too small to read (e.g., "…the printing is minuscule;" female, 50). Participants described the visual appeal of cannabis product packaging as distracting from health warnings: "They make these packages really nice and pretty and cute. And sometimes you can't even see a little warning or how much THC and CBD [Cannabidiol] and stuff is in there" (female, 42). Those who recalled specific warning themes mentioned harms for children, the risk for impaired driving, fetal harm, smoke exposure, addiction, and exposure to THC.

3.2. Reactions to hypothetical cannabis health warnings

A common reaction to the hypothetical cannabis health warnings was disbelief. Participants criticized the hypothetical warnings as being "misleading," or "scare tactics," using "shock value" or "gaslighting." Some participants thought the hypothetical warnings fabricated terminology. One participant (female, 57) described the term hyperemesis as "a big word that doesn't mean anything." Others suspected pharmaceutical companies of trying to discourage cannabis, with a participant (female, 45) stating, "It's not a warning against pot. It's a *big pharma* promotion." Later, the same participant claimed the government was promoting "propaganda" against cannabis use: "It goes back to *Reefer Madness*, where they try to get everybody in a frenzy." Overall, many participants rejected the hypothetical cannabis health warnings outright, often focusing on the intentions of warning designers.

Table 1
Characteristics of adult cannabis consumers in the United States who reported past 30-day cannabis use (2024).

	Overall[a] $N = 77$	Daily/near-daily cannabis use $n = 36$ (46.7 %)	Non-daily cannabis use $n = 41$ (53.3 %)
	n (%)	*n* (%)	*n* (%)
Age			
Median (Interquartile Range)	42.0 (22.0)	42.5 (19.0)	40.0 (25.0)
Sex			
Male	39 (50.6)	15 (41.7)	24 (58.5)
Female	38 (49.4)	21 (58.3)	17 (41.5)
Racial identification			
American Indian or Alaska Native	0 (0%)	0 (0)	0 (0)
Asian	5 (6.5)	4 (11.1)	1 (2.4)
Black or African American	10 (13.0)	5 (13.9)	5 (12.2)
White	55 (71.4)	23(63.8)	32 (78.0)
More than one race	5 (6.5)	2 (5.5)	3 (7.3)
Unknown/Not reported	2 (2.6)	2 (5.5)	0 (0)
Hispanic, Latino, Latina, or Latinx origin			
No	61 (79.2)	29 (80.6)	32 (78.0)
Yes	16 (20.8)	7 (19.4)	9 (22.0)
Education			
High School or GED[b]	6 (7.8)	1 (2.8)	5 (12.2)
Some college/technical school associate degree	25 (32.5)	13 (36.1)	12 (29.3)
Bachelor's degree	31 (40.3)	18 (50.0)	13 (31.7)
Graduate school	15 (19.5)	4 (11.1)	11 (26.8)
Household Income			
$25,000 or less	5 (6.5)	3 (8.3)	2 (4.9)
$25,000 - $34,999	3 (3.9)	1 (2.8)	2 (4.9)
$35,000 - $49,999	6 (7.8)	5 (13.9)	1 (2.4)
$50,000 - $74,999	22 (28.6)	7 (19.4)	15 (36.6)
$75,000 - $99,999	20 (26.0)	10 (27.8)	10 (24.4)
$100,000 or more	21 (27.3)	10 (27.8)	11 (26.8)
Frequency of cannabis use			
Less than once per month	7 (9.1)	0 (0)	7 (17.1)
One or more times per week	34 (44.2)	0 (0)	34 (82.9)
Every day/almost every day	36 (46.8)	36 (100.0)	0 (0)
Frequency of medical cannabis use in past 30 days			
Mean (SD)[c]	9.8 (11.4)	16.5 (12.3)	4.0 (6.2)
Frequency of non-medical cannabis use in past 30 days			
Mean (SD)	14.8 (10.9)	21.3 (11.2)	9.1 (6.5)
Recall seeing health warnings on cannabis products or packages in past 12 months			
Mean (SD)[d]	4.8 (3.0)	5.3 (2.9)	4.3 (3.1)

[a] The entire sample reported using cannabis in the past 30 days. Participants who reported using cannabis "every day or almost every day" were coded as "daily/near daily use" with all other responses (e.g., "use cannabis one or more times per week" or "less than once per month") coded as "non-daily use."

[b] GED = general education development, which is a high school equivalency credential in the United States.

[c] SD = standard deviation.

[d] Recall was scored from 1= "not very often" to 9 = "extremely often"

3.2.1. *Checking against experience*

Participants evaluated hypothetical cannabis health warnings based on personal experiences. One participant dismissed the hypothetical impaired-driving warning, saying: "I've never had a problem driving on cannabis" (male, 36). Other participants mentioned people they knew: "I've been around a lot of people that had smoked their entire lives. It has never been any issues" (male, 43). Another cited medical authorization for disbelieving a hypothetical pregnancy warning: "Doctors do allow [cannabis use] if it will help your blood pressure come down; if it will help relax your body, it will help your baby" (female, 39).

While experience was a reason for disbelief, many believed hypothetical cannabis health warnings based on experience. One participant mentioned family experience with CHS: "My mom's a nurse, and she sees people all the time go in because they took way too much weed, and they're essentially vomiting all the time" (male, 28). During a discussion about the hypothetical impaired-driving warning, one participant (male, 55) disagreed with the group about cannabis being harmless for driving:

> I was going down the freeway and […] I was like, I can't sit up straight. And it [cannabis] was affecting my driving because I was trying to compensate for my sitting crooked with the vehicle. So, I hate to disagree with you folks, but I think it [cannabis] can be dangerous.

Across groups, participants regularly evaluated the veracity of hypothetical cannabis health warnings based on their experience or the experiences of people they knew.

3.2.2. *Skepticism*

In evaluating hypothetical cannabis health warnings, participants mentioned concerns but defended cannabis and expressed skepticism about warnings. One participant (female, 53) questioned the pregnancy warning: "I don't know if it's true or not. I haven't seen proof. Show me the proof." Another expressed skepticism about the addiction warning: "Where is the research? Where is it noted? What three in 10? How do they know that? I want to know where they got their research" (female, 68). Many requested citations for claims from federal sources like the "FDA [U.S. Food and Drug Administration]," "NIH" [U.S. National Institutes of Health], or the U.S. Centers for Disease Control and Prevention (i.e., CDC) to reduce skepticism. Several suggested adding hyperlinks or QR codes so consumers could follow up and verify the warning information.

In expressing skepticism, participants focused on probabilistic language commonly used in public health to communicate individual risks: "Words like *can*. Cannabis *can* harm mental health, it's not really definitive. *May* worsen mental health […]. *May* lead to psychosis. And so, it's not really black and white" (male, 52). Responding to the hypothetical hyperemesis warning, another participant said: "Cannabinoid, hyper-*whatever*, syndrome. So, it has a more medical-sounding explanation […]. It's not that convincing, I guess. Because anything *may* do this or *may* do that" (male, 42). Some wanted terminology defined. "I don't know what cannabis use disorder is," said one participant (male, 48): "It needs to tell us what it is so we can know whether we believe it."

Participants often found text-only warnings to be minimally persuasive, emphasizing the importance of images. Commenting on the hypothetical warning for pregnancy, one participant asked: "Wouldn't this be a lot more effective if there was a picture of a pregnant mom?" (male, 67). Another participant described how removing images would undermine the effectiveness of the hypothetical health warnings: "I'm a visual person. I think many people are visual people. I think that if you took out the picture, it would not have a big impact" (male, 30). In another group, participants suggested adding a picture to improve the text-only hypothetical mental health warning: "Not having an image is extremely detrimental. I would not read this because there's no image (male, 31). Thus, participants expressed skepticism about hypothetical cannabis health warnings by focusing on evidence for claims, probabilistic language, or the lack of imagery.

3.2.3. Qualifying by consumer characteristics

Participants downplayed hypothetical health warnings by discussing how health effects may only apply to specific consumer groups. In questioning the hypothetical addiction warning, one participant noted: "I need to know that those three in 10 people just don't have addictive personalities" (female, 38). In another group, a participant was skeptical about cannabis use disorder based on perceived lack of addiction risk: "I could be one of the seven that doesn't get addicted. That's 70% won't get addicted. I'm good" (male, 60). Another participant qualified effects by sensitivity to THC: "There's a very small percentage of people that shouldn't smoke at all" (male, 52).

Participants also compared the risk for adverse cannabis outcomes to risks of behaviors like gambling, playing video games, or using smartphones. Discussions highlighted dangers of overindulging in foods (e.g., soda, coffee, sugar) or exposure to toxic substances, such as car exhaust or plastics. As one participant put it: "If you eat too much cotton candy, you're going to throw up. If you drink too much alcohol, you have alcohol poisoning, you're going to throw up. Like, overabundance of anything, you're going to throw up" (female, 57). Another participant responded to the hypothetical hyperemesis warning by saying: "there's very few things in life that you should just go *ham* on nonstop" (male, 30), with *ham* being slang for excessive behavior. Qualifying effects by consumer characteristics was a common reaction in questioning the veracity of hypothetical cannabis health warnings.

4. Discussion

Participants often reported being unaware of or ignoring health warnings on cannabis products they used, indicating that current U.S. warnings did not effectively capture consumer attention in our sample. This finding is consistent with recent qualitative research (Ranney et al., 2025) as well as previous research showing lower recall of U.S. cannabis health warnings compared to Canadian health warnings, which use effective design elements to enhance visibility, such as single-themed warning messages, contrasting label colors, and restrictions on cannabis product branding (Massey et al., 2024). Notably, participants in our study suggested similar practices to improve the effectiveness of cannabis health warnings in the U.S.

Personal experience with cannabis harms was a common reason for believing or disbelieving hypothetical cannabis health warnings, providing insights into how consumers process cannabis-risk information. Cannabis legalization is relatively new in the U.S., and there remains no nationally coordinated communication about cannabis health effects. Many cannabis consumers may be unaware of adverse health effects and might see them as unlikely, contributing to distrust of warnings. Past research found that frequent cannabis consumers (vs. infrequent consumers) had lower risk perceptions about adverse cannabis effects, consistent with *optimism bias*, wherein one rates their health risk lower than others (Goodman and Hammond, 2022). Informing the public about possible adverse effects—including stories from other cannabis consumers—may be a strategy to improve individual acceptance of cannabis health warnings and is a potential avenue for future research.

Participants' use of personal experiences highlights the complexity of health warning policies for cannabis products. While tobacco and alcohol products share some public health considerations with cannabis, cannabis is widely used for medicinal purposes, necessitating varied messaging strategies. Mandated health warnings on cannabis products must compete for limited space on packaging and withstand legal challenges, potentially limiting the use of varied message framings (Popova et al., 2024), including the lived experiences and personal goals of cannabis consumers. However, such communications may be appropriate for medication inserts, educational interventions, or health campaigns designed to complement mandated product warnings. Such approaches can expand on product labeling with practical guidance for safer consumption—such as avoiding high-potency products, not mixing substances, and understanding dosage (Popova et al., 2024).

Participants expressed skepticism about hypothetical cannabis health warnings but offered suggestions for improvement, such as citing health agencies and providing resources for follow-up information. This finding aligns with previous research, where U.S. cannabis consumers requested links to credible information when considering whether to believe claims in cannabis health warnings (Massey et al., 2025; Ranney et al., 2025). Other countries, like Japan, have successfully implemented similar policies, such as featuring links in tobacco warnings to the Japanese Ministry of Health (Weiger et al., 2020). However, a 2022 national survey of U.S. adults highlighted differing levels of trust in local and federal health agencies, including complex reasons for trusting different governmental organizations (SteelFisher et al., 2023). Identifying trusted sources for cannabis information across local and federal jurisdictions is a key area for future research on cannabis health warnings in the U.S.

5. Limitations

The generalizability of the results is limited, a common limitation in qualitative research. While Zoom extended the study's geographic reach, it may have inadvertently led to sampling bias, favoring individuals with internet access. The sample had a higher socioeconomic status (i.e., SES), with 53.3 % reporting annual income of $75,000 or more, which may have influenced results. However, past research found that reactions to tobacco health warnings were similar across SES status (Cantrell et al., 2013). This project focused on regulatory research and did not explore different types of health communications applicable in long-form formats, such as media campaigns. While this study did not focus on stigma, it is important to avoid stigmatizing health conditions, including for people who use cannabis for medicinal purposes. Research should continue to evaluate the effects of cannabis health communications across varied formats and populations to identify appropriate warnings for each format and audience.

6. Conclusions

As U.S. states continue to legalize recreational cannabis use, consumer-driven data can be used to help improve the design of cannabis health warnings. Using a qualitative approach among cannabis consumers from a range of states where recreational cannabis is legal, we found low awareness and credibility of current cannabis health warnings. Many cannabis consumers in our focus groups wanted more evidence to support harm claims, more explicit statements of harms (e.g., causes vs may cause), and the inclusion of visual cues to reinforce harms.

Authors contribution

ZBM secured funding, conceptualized the study (consulting with DH and JT), and developed the study protocol. ZBM led data analysis (consulting MAS and CI) and wrote the first draft. All authors (ZBM, CI, MAS, EAV, DH, JFT, and DH) contributed to the conceptualization, formal analysis, writing, reviewing and editing, and manuscript revisions. All authors have read and agreed to the final version of this article for submission and publication. ZBM is responsible for the overall content as guarantor.

CRediT authorship contribution statement

Zachary B. Massey: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Chinomso Ibe:** Writing – review & editing, Formal analysis. **Michael A. Smith:** Writing – review & editing, Formal analysis. **Erin A. Vogel:** Writing – review & editing, Formal analysis. **James F. Thrasher:**

Writing – review & editing, Formal analysis. **David Hammond:** Writing – review & editing.

Funding

ZBM and EAV received support for their time, in part, from the Oklahoma Tobacco Settlement Endowment Trust (TSET; STCST00400_FY25) and the OU Health Stephenson Cancer Center through an NCI Cancer Center Support Grant (P30CA225520). ZBM and EAV also received support from the National Institute on Drug Abuse (K01DA057395; K01DA055073). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the National Institute on Drug Abuse. The funders had no role in study design, data collection and analysis, decisions to publish, or preparation of the manuscript.

Declaration of competing interest

DH has served as a paid expert witness on behalf of public health authorities in response to legal challenges from the cannabis, tobacco, and vaping industries. The other authors have no conflicts of interest to report.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.103306.

Data availability

The authors do not have permission to share data.

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