Drug and Alcohol Dependence 237 (2022) 109520

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

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

Textual and pictorial enhancement of cannabis warning labels: An Online experiment among at-risk U.S. young adults

Sang Jung Kim [a,1], Matt Minich [a,1], Arina Tveleneva [b], Jiaying Liu [c], Alisa A. Padon [d], Lynn D. Silver [d], Sijia Yang [a,*]

[a] School of Journalism and Mass Communication, University of Wisconsin-Madison, 5115 Vilas Hall, 821 University Ave., Madison, WI 53706, USA
[b] Department of Marketing and International Business Michael G. Foster School of Business, University of Washington, PACCAR Hall, 4273 E Stevens Way NE, Seattle, WA 98195, USA
[c] Department of Communication Studies, University of Georgia, 628 Caldwell Hall, Athens, GA 30602, USA
[d] Public Health Institute, 555 12th, St Oakland, CA 94607, USA

ARTICLE INFO

Keywords:
Cannabis use
Young adults
Cannabis warning labels
Information recall
Negative emotions
Perceived message effectiveness

ABSTRACT

Background: This study experimentally examines whether enhanced cannabis warning labels (CWLs) outperform those currently required in the U.S. in improving recall of health risks, emotional responses, and perceived message effectiveness among at-risk young adults.
Method: We conducted an online national survey-based experiment in October 2020. Young adults aged 18–26 years old and at-risk for cannabis use ($N = 523$) were randomly assigned in an online experiment, to view either currently required CWLs in California with small font and a composite health risk statement, or enhanced single-theme CWLs with varying textual and pictorial components. We performed linear regression analyses to compare the enhanced with existing CWLs on information recall, negative emotions, and perceived message effectiveness. Furthermore, information recall and negative emotions were examined as parallel mediators to better understand the mechanisms underlying effective textual and pictorial enhancement of CWLs.
Results: Compared with currently required CWLs in California, both textually ($b = 0.30$, $p = .011$) and pictorially ($b = 0.59$, $p < .001$) enhanced CWLs increased recall accuracy. Pictorially enhanced CWLs outperformed their text-only counterparts ($b = 0.28$, $p = .019$) in improving information recall. Only pictorially enhanced CWLs improved perceived message effectiveness ($b = 0.31$, $p = .008$), which was mediated by negative emotions but not by information recall.
Conclusions: Given rapid expansion of the cannabis industry and declining perception of harm, currently required CWLs in the U.S. such as California's, would benefit from redesign to improve public understanding of health risks and to prevent youth use.

1. Introduction

After decades of prohibition, the adult use of cannabis products containing tetrahydrocannabinol (THC) is now legal in 19 U.S. states, two territories, and in the District of Columbia (National Conference of State Legislatures, 2022). Since successful referendums in Colorado and Washington in 2012 legalized non-medicinal cannabis use (Hall and Lynskey, 2020), a multi-billion-dollar legal cannabis industry has emerged (Spindle et al., 2019). Parallel to the rapid growth of the cannabis industry, young adults' perceptions of harm from cannabis have fallen, and perceptions of no-risk have risen (Azofeifa et al., 2016; Reboussin et al., 2019). For example, among those aged 18–25, perceived great risk of harm from smoking cannabis weekly declined from 19.1% in 2015 to 15% in 2019 (Substance Abuse and Mental Health Services Administration (SAMHSA), 2020). Furthermore, in 2019, 35.4% of young adults were past-year users of cannabis and 5.8% had a cannabis use disorder (CUD) (SAMHSA, 2020). Past-year use rates have risen significantly since 2002, and rates of CUD have risen since

* Corresponding author.
E-mail addresses: skim789@wisc.edu (S.J. Kim), mminich@wisc.edu (M. Minich), arinat@uw.edu (A. Tveleneva), jiaying.liu@uga.edu (J. Liu), apadon@phi.org (A.A. Padon), lsilver@phi.org (L.D. Silver), syang84@wisc.edu (S. Yang).
[1] Note: SJK and MM contributed equally to the manuscript hence sharing the first authorship.

https://doi.org/10.1016/j.drugalcdep.2022.109520
Received 24 December 2021; Received in revised form 4 May 2022; Accepted 28 May 2022
Available online 6 June 2022

their lowest level in 2014 (SAMHSA, 2020). For both measures, rates are notably higher among young adults than other age groups. Against the backdrop of increased legalization efforts, declining risk perceptions, and rapid market transformation, effective communication of health risks is essential to inform and protect at-risk young adults. Globally, legalization of medical use is expanding rapidly, including many countries in the Americas and Europe, while recreational cannabis use, though expanding, is prohibited in most countries apart from a few exceptions (e.g., Canada, Mexico, South Africa, Uruguay, 18 states and several districts in the U.S.). Experience from tobacco control and early cannabis research suggests that robust approaches for consumer information should form part of these new regulatory frameworks. Evidence on CWLs' educational and persuasive effects from at-risk young adults in the U.S. can inform policy both domestically and in other countries as legalization expands.

While cannabis has proven medicinal benefits, emerging evidence also highlights a host of associated harms and risks among both adolescents and adults. In addition to increased risk of motor vehicle crashes and of low birth weight in offspring of mothers who use cannabis while pregnant, the National Academies of Science, Engineering and Medicine (NASEM) has concluded that there is substantial evidence of an association of cannabis use with the development of schizophrenia and psychoses among frequent users (National Academies of Sciences, Engineering, and Medicine (NASEM), 2017). The relationship with psychosis and schizophrenia is supported by other recent studies (Hasan et al., 2020; Sami et al., 2020). The Surgeon General has noted that ongoing brain development through the mid-20 s renders young adults more vulnerable to the effects of addictive substances (Office of the Surgeon General, 2019), and frequent cannabis use during adolescence has been associated with neurological changes in areas responsible for attention, memory, decision-making, motivation, impaired learning, declines in IQ, school performance, high school, and college graduation rates and life satisfaction (Meier et al., 2012; Silins et al., 2014). Research is needed to examine effective communication strategies to improve young adults' awareness and understanding of such health risks to prevent early initiation, habitual use, and CUD.

Mandating warning labels on cannabis products is a promising communication-based regulatory strategy, as it can increase exposure to educational health messages among potential consumers en masse and with minimal expenditures to government. Extensive research has shown that tobacco control warning labels, particularly prominent labels enhanced with graphic visuals, can better attract attention, facilitate information recall, inform smokers about the health hazards of smoking, trigger strong affective responses, and encourage cessation. They may also prevent initiation by nonsmokers (Brewer et al., 2016; Noar et al., 2020). Whereas Canada has begun to translate the principles of designing effective tobacco warning labels to cannabis warning labels (CWLs) (Goodman et al., 2019; Mutti-Packer et al., 2018; Pepper et al., 2020; Winstock et al., 2021), the U.S. lags behind. Currently required CWLs in U.S. states are predominantly composite textual messages in hard-to-read fonts and often lack information on key evidence-based health risks (Goodman et al., 2019; Silver et al., 2020).

Joining a burgeoning body of literature that tests improved CWLs, this study sought to: 1) design improved CWLs with single themes, a larger font, potentially more effective language adapted from theme-matched Canadian CWLs, and visual enhancements; 2) test enhanced CWLs against a currently required U.S. CWL, specifically, California's, in relation to information recall, negative affect, and perceived message effectiveness (PME) among at-risk young adults; and 3) examine the respective mediating contributions of recall versus negative affect on PME for the best-in-show CWLs. Our focus on assessing these three outcomes to evaluate enhanced CWLs and establish an evidence base is motivated by past legal challenges surrounding the Food and Drug Administration (FDA)'s mandate to implement graphic tobacco control warning labels and more broadly, issues regarding the regulation of "compelled" speech that includes mandatory disclosures such as health warning messages. We focused on California's existing CWL, first because it is the nation's largest legal cannabis market, and second, because it exemplifies design weaknesses observed in currently required CWLs across states in which only a long and hard-to-read textual message in a small font on cannabis packaging is required (Silver et al., 2020). Additionally, because a bill for graphic front-of-pack cannabis warning labels was being developed in that state (introduced as S.B. 1097, 2022), our research had the potential to immediately inform translation efforts by providing scientific evidence for policy design, in California and beyond.

Because CWLs represent a form of "compelled speech", empirical evidence is needed to justify that the CWLs can directly and materially advance the government's substantial interest and are no more extensive than necessary (Kraemer and Baig, 2013; McKeon, 1980). To assess the ability of CWLs to advance these interests, we assessed the effects of alternate designs on three outcomes: message recall, perceived message effectiveness (PME), and the generation of negative emotions.

Message recall is thought to indicate audience's attention to, encoding and storage of persuasive messages (Johnson et al., 2005; McGuire, 1968; Meernik et al., 2016; Strasser et al., 2012), so it is often used as a proxy for comprehension and cognitive processing. This use is supported by associations of recall of tobacco warning labels with physiological measures of attention such as eye-tracking (Meernik et al., 2016). That said, successful encoding and storage precede, but do not necessarily guarantee, persuasion (Cappella, 2006; Fisher et al., 2018). Although high message recall is often found to predict persuasive outcomes (e.g., reduced tobacco cravings, Klein et al., 2017) including PME (Noar et al., 2020), recalled messages needed to be accepted before persuasion could occur. Acceptance of recalled messages depends upon moderating factors such as their argument strength, message recipients' preexisting attitudes, and the degree of counterarguing (Cappella, 2006; Carpenter and Boster, 2013). Whether or not message recall subsequently prevents at-risk young adults from initiating or habitually consuming recreational cannabis products, improving recall of cannabis health risks is necessary to fulfill the government's goal of educating vulnerable populations about health risks.

Government also has an interest in preventing cannabis initiation and habitual use among vulnerable populations such as minors and young adults. Towards this end, PME can be employed in individual-level analyses as a useful, though not perfect, proxy for warning labels' persuasive impacts on prevention and cessation as demonstrated by extensive research on tobacco control messages including warning labels (Cappella, 2018; Noar et al., 2020, 2018). Given that the inconsistency in the design and implementation of earlier PME scales has contributed to doubts about PME's measurement validity (Noar et al., 2018; O'Keefe, 2018), recent research has developed new PME measures focused on messages' behavioral references and impacts (dubbed "effects perceptions PME") (Baig et al., 2021; Rohde et al., 2021). These revised PME measures have shown superior psychometric properties when deployed to assess tobacco control messages and predict individual-level behavioral outcomes well (Baig et al., 2020, 2019; Rohde et al., 2020). Given our need to assess multiple CWLs per participant, and that one's behavioral intentions tend to stay comparatively stable and are not likely to vary meaningfully across individual CWLs, repeatedly measuring behavioral intentions (i.e., one measurement per CWL) is not appropriate. In contrast, the PME scale is tied to each individual CWL (e.g., "The health information in the warning label I just saw discourages me from wanting to use marijuana.") and hence is more sensitive to capture the impacts of individual CWLs when each participant needs to process multiple CWLs.

Second, the fact that pictorial tobacco control warning labels tend to produce negative emotions has made them a target of litigation by the tobacco industry on the grounds that they are unnecessarily emotional and not factual (Kraemer and Baig, 2013). This simplistic view that emotional and factual information are incompatible contradicts long-standing psychological and behavioral science, which has shown

that emotions and facts are oftentimes intertwined (Popova et al., 2017) and emotional processing can trickle down to improve behavioral changes (Hammond, 2011; Yotam et al., 2019). Graphic tobacco control messages, for example, were perceived as equally informative as their text-only counterparts (Popova et al., 2017). Graphic warnings do tend to induce more negative emotions; however, stronger emotionality, as indicated by neural activity, is associated with reduced urge to smoke (Rubinstein, 2015). Other studies have found similar enhanced effectiveness of pictorial messages (Yotam et al., 2019), whose emotional appeal can reduce intention to smoke either directly or by updating health beliefs (Skurka et al., 2018).

Anticipating that similar legal pushback may arise with regards to enhanced CWLs and their emotional impact, we sought to examine whether induced negative emotions mediate the persuasive effects of CWLs on PME, even after factoring in mediation by information recall. Though not conclusive, use of the parallel mediation test can provide preliminary evidence to clarify whether negative emotions represent an important pathway leading to enhanced CWLs' effectiveness in prevention efforts among at-risk young adults.

2. Methods

2.1. Participants

In fall 2020, we recruited a sample of 523 ($N_{female} = 246$) young adults aged between 18 and 26 from the Qualtrics online panel. The sample was matched to national distributions on sex, race, and ethnicity (see Table 1 for demographic information). We focused on participants at elevated risk of cannabis use and screened out those reporting "definitely no" to all of the following: a) use of marijuana in the next 6 months, b) willingness to try marijuana if one of their best friends offered it, and c) being curious about using marijuana. See Appendix A for the CONSORT flow chart summarizing participant recruitment, randomization, and retainment.

2.2. Stimuli and experimental design

This study adopted a between-subject design and participants were randomly assigned to five different types of CWLs varying in textual and visual components: (a) one currently required CWL implemented in the state of California with a small font and a composite health risk statement (*CA-control*); (b) one mock-up CA-style CWL with additional information on mental health (*CA-mock*)[2]; (c) four single-theme CWLs with the *CA-control* CWL's component statemens broken down and enlarged on white background (*text single white*); (d) four enhanced text-only CWLs (*text enhanced yellow*), each with a theme-matched statement taken from Canadian CWLs, and yellow background; and (e) enhanced pictorial CWLs (*pictorial enhanced*) adding graphic imagery to *text enhanced yellow* background CWLs. A review of demographic characteristics across these conditions did not find evidence for the violation of participant exchangeability. Experimental conditions are described in Fig. 1. The study protocol was approved by the institutional review board at the corresponding author's institution.

In conditions a-b, participants were exposed to a single composite warning label containing information about multiple health risks. In conditions c through e, they were presented with four separate single-theme labels, each addressing one specific risk (impaired driving, mental health issues, brain development for youth, and risks during pregnancy and breastfeeding). Stimuli examples on risks during pregnancy and breastfeeding can be found in Fig. 2. All stimuli are displayed in Appendix B. Each CWL was fixed on the screen for six seconds before participants could proceed to the next screen. After each CWL, participants were asked to report emotions and perceived message effectiveness. After participants finished viewing all assigned CWLs, information recall was assessed.

2.3. Measures

2.3.1. Negative emotions

After exposure to each CWL, participants were asked to report negative emotions by indicating on a scale from 1 (strongly disagree) to 5 (strongly agree) to suggest the extent to which they agreed with each of the following statements "While viewing this health information, I felt disgusted/nauseous/afraid/scared/frightened." We averaged all these items to create a composite negative emotions scale ($M = 2.35$, $SD = 0.95$, Cronbach's $\alpha s > 0.9$ in all conditions). For participants randomized to conditions c through e, a composite negative emotions score was first obtained for each of the four CWLs viewed. Then, the four composite scores were once again averaged to calculate an aggregate negative emotions score, across all the CWL exposures, for each participant.

2.3.2. Recall Sensitivity

After all CWL exposures, participants were asked to complete a forced-choice recognition task to measure recall of information from the warning labels to which they were exposed. The list of health risks included two categories—eleven items corresponding to cannabis health risks stated on CWLs (true hits), and ten items representing risks NOT shown on any warning label (foils). Then, based on the signal detection theory (Macmillan, Hautus, and Douglas Creelman, 2021), the hit rate (number of recalled true hits/all items) and the false alarm rate (number of recalled foil items/all items) were first respectively z-transformed, and the difference between the two z-scores for each participant was retained as the measure for information recall sensitivity ($M = 0.94$, $SD = 0.90$). Though administrated near the end of our experimental protocol to allow time for potential memory decay, this recall measure captures the degree to which message content is encoded into memory at the moment of exposure as no health information was repeated during the time lapse.

2.3.3. Perceived message effectiveness (PME)

All participants were asked about the PME of warning labels by responding to five items (5-point Likert scale, 1 = strongly disagree and 5 = strongly agree) after each CWL exposure: "The health information I just saw… (a) discourages me from wanting to use marijuana (b) makes using marijuana seem unpleasant to me (c) makes me concerned about the health effects of using marijuana (d) puts thoughts in my mind about wanting to stay away from marijuana, (e) puts thoughts in my mind about wanting to use marijuana". The last two items were combined to measure *net thoughts* about avoiding marijuana use by using the following formula: net thoughts = [(d-e)/2] + 3 (Bigsby et al., 2013; Sutton et al., 2019). Then, items a through c plus net thoughts were averaged to form the PME score for each CWL ($\alpha > 0.8$ in all experimental conditions). Similar to negative emotions, for participants randomized to view multiple CWLs, CWL-specific PME scores were further averaged across the four viewed CWLs to form an overall PME score for each participant ($M = 2.80$, $SD = 0.85$).

Our PME scale focuses on perceived persuasive impacts of messages, dubbed as effects perceptions PME [33,34]. Compared with message perceptions PME (e.g., "this CWL is easy to understand"), recent research on tobacco control messaging has shown the superiority of effects perceptions PME as they better predict actual behavioral outcomes such as quitting behaviors (Baig et al., 2021) and reduced intentions for vaping (Rohde et al., 2021).

[2] One of the detrimental effects of cannabis use on adolescents is the increased risk of mental health issues, and Canadian CWLs include mental health risks (Mutti-Packer, Collyer, & Hodgins, 2018). Therefore, we included risk information regarding mental health on the CA-mock CWL.

Table 1
Demographic Information.

	CA Control		CA Mock		Text single white		Text ehanced yellow		Pictorial enhanced	
N	108		108		106		99		102	
Age										
18–20	60	55.56%	48	44.44%	54	50.94%	47	47.47%	51	50.00%
21–26	48	44.44%	60	55.56%	52	49.06%	52	52.53%	51	50.00%
Gender										
Female	58	53.70%	51	47.22%	61	57.55%	48	48.48%	59	57.84%
Male	50	46.30%	53	49.07%	43	40.57%	48	48.48%	41	40.20%
Other	0	0.00%	4	3.70%	2	1.89%	3	3.03%	2	1.96%
Race										
White	71	65.74%	67	62.04%	68	64.15%	61	61.62%	64	62.75%
Asian or Pacific Islander	7	6.48%	7	6.48%	11	10.38%	2	2.02%	9	8.82%
American Indian or Alaska Native	0	0.00%	2	1.85%	2	1.89%	3	3.03%	1	0.98%
Black or African American	24	22.22%	20	18.52%	16	15.09%	21	21.21%	20	19.61%
Other	4	3.70%	5	4.63%	6	5.66%	3	3.03%	3	2.94%
More than one race	2	1.85%	7	6.48%	3	2.83%	9	9.09%	5	4.90%
Ethnicity										
Not of Hispanic, Latino/a or Spanish Origin	94	87.04%	83	76.85%	80	75.47%	81	81.82%	78	76,47%
Mexican, Mexican American, Chicano/a	9	8.33%	13	12.04%	14	13.21%	9	9.09%	12	11.76%
Puerto Rican	2	1.85%	3	2.78%	5	4.72%	5	5.05%	5	4.90%
Cuban	1	0.93%	1	0.93%	2	1.89%	2	2.02%	1	0.98%
Another Hispanic, Latino, or Spanish Origin	2	1.85%	8	7.41%	5	4.72%	2	2.02%	6	5.88%
Income										
Less than $20,000	22	20.37%	28	25.93%	34	32.08%	26	26.26%	18	17.65%
$20,000-$29,000	22	20.37%	14	12.96%	11	10.38%	9	9.09%	13	12.75%
$30,000-$39,999	9	8.33%	7	6.48%	3	2.83%	8	8.08%	9	8.82%
$40,000-$49,999	12	11.11%	10	9.26%	17	16.04%	11	11.11%	13	12.75%
$50,000-$74,999	17	15.74%	18	16.67%	18	16.98%	24	24.24%	23	22.55%
$75,000-$99,999	8	7.41%	15	13.89%	9	8.49%	10	10.10%	15	14.71%
$100,000-$124,999	3	2.78%	5	4.63%	7	6.60%	10	10.10%	4	3.92%
$125,000-$149,000	7	6.48%	3	2.78%	1	0.94%	0	0.00%	3	2.94%
$150,000 – $249,999	3	2.78%	3	2.78%	0	0.00%	0	0.00%	3	2.94%
$250,000 or more	5	4.63%	5	4.63%	3	2.83%	1	1.01%	1	0.98%
Education										
Less than high school	4	3.70%	7	6.48%	7	6.60%	4	4.04%	3	2.94%
High school graduate	43	39.81%	41	37.96%	37	34.91%	27	27.27%	42	41.18%
Some college	38	35.19%	38	35.19%	37	34.91%	44	44.44%	36	35.29%
College graduate	15	13.89%	16	14.81%	17	16.04%	21	21.21%	21	20.59%
Post-graduate study or degree	8	7.41%	6	5.56%	8	7.55%	3	3.03%	0	0.00%
Sexual Orientation										
Completely heterosexual	63	58.33%	73	67.59%	55	51.89%	61	61.62%	68	66.67%
Mostly heterosexual	8	7.41%	12	11.11%	18	16.98%	8	8.08%	7	6.86%
Bisexual	18	16.67%	8	7.41%	17	16.04%	21	21.21%	16	15.69%
Mostly homosexual	4	3.70%	3	2.78%	6	5.66%	3	3.03%	2	1.96%
Completely homosexual	7	6.48%	7	6.48%	4	3.77%	3	3.03%	6	5.88%
Not sure	5	4.63%	1	0.93%	1	0.94%	1	1.01%	2	1.96%
Other	3	2.78%	4	3.70%	5	4.72%	2	2.02%	1	0.98%
Political affiliation										
Democrat	43	39.81%	48	44.44%	47	44.34%	49	49.49%	51	50.00%
Republican	27	25.00%	23	21.30%	17	16.04%	14	14.14%	15	14.71%
Independent	36	33.33%	29	26.85%	32	30.19%	29	29.29%	32	31.37%
Other	2	1.85%	8	7.41%	10	9.43%	7	7.07%	4	3.92%

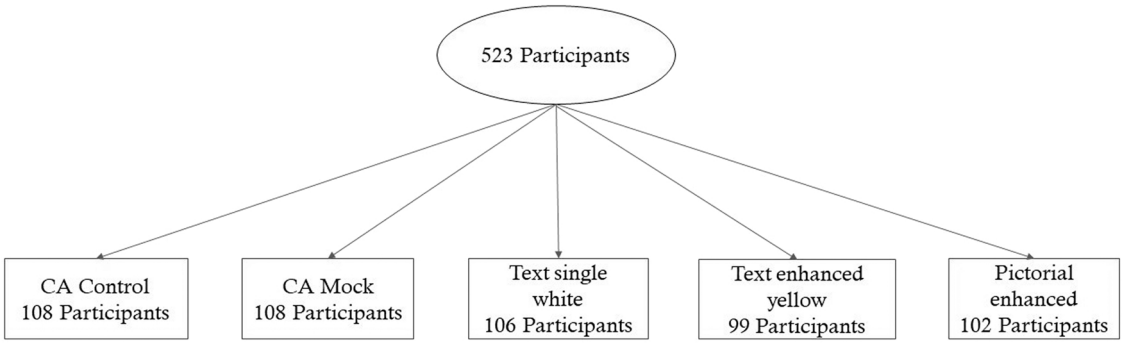

Fig. 1. Experimental Procedure.

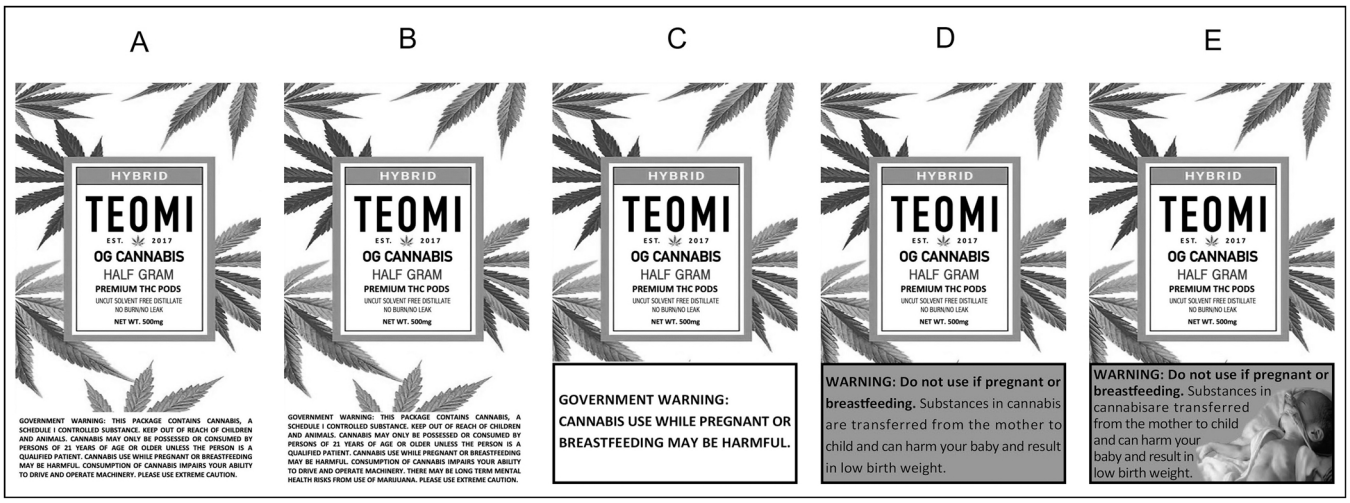

Fig. 2. Examples of Experimental Stimuli. *Note.* CWL conditions: a) CA-control, b) CA-mock, c) text single white, d) text enhanced yellow, and e) pictorial enhanced. * $p < .05$, * * $p < .01$, * ** $p < .001$.

2.4. Statistical analysis

We carried out two sets of analyses. First, we compared each of the enhanced CWLs (conditions c through e) to the two control CWLs, CA-control and CA-mock, respectively, to examine whether they outperformed the currently required California-style CWL in terms of negative emotions, information recall, and PME. To do so, we created three dummies—each contrasting one of the enhanced CWLs with the control (CA-control or CA-mock)—and used ordinary least squares (OLS) linear regressions to perform the comparisons (see Table 1 for numeric results and Fig. 3 for visual depiction). It should be noted that our key comparisons were against the CA-mock CWL because this mocked-up CWL included mental health risks in all three enhanced conditions while consistent in formatting and style as the CA-control CWL, allowing a better control of health risk information and a comparison more focused on design differences.

Second, since we identified pictorial enhanced CWLs as the best-performing CWLs across all enhanced CWLs, we performed parallel mediation analysis to better understand the respective roles played by negative emotions versus information recall in channeling pictorial enhancements' superiority in PME. We modeled negative emotions and information recall as parallel mediators with covariance allowed, regressed on condition contrast dummies and predicted PME. Direct effects of condition contrasts on PME were also allowed. Bootstrapping (samples = 10,000) was used to obtain bias-corrected 95% confidence intervals for indirect effects.

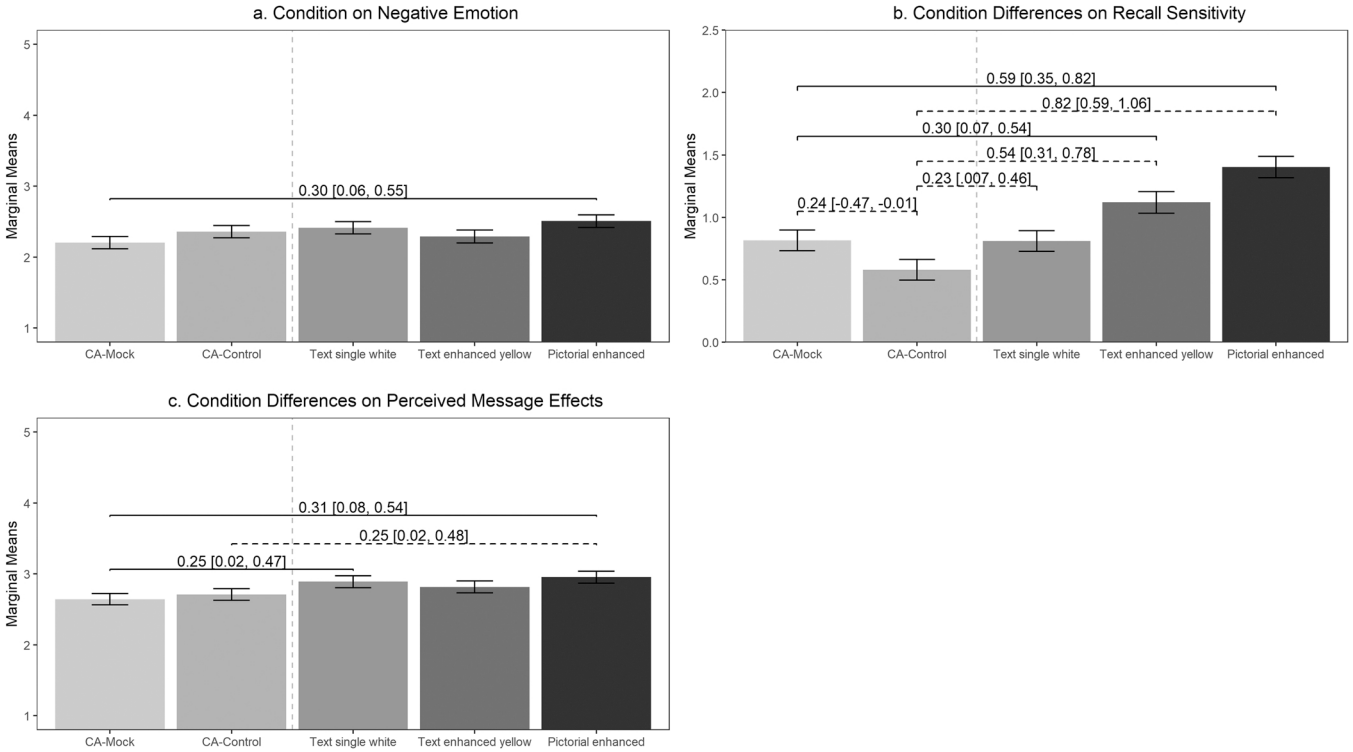

Fig. 3. Condition Differences on Participants' Level of Negative Emotions, Recall Sensitivity, and Perceived Message Effects. *Note.* CWL conditions (from left to right): a) CA-mock, b) CA-control, c) text single white, d) text enhanced yellow, and e) pictorial enhanced.* $p < .05$, * * $p < .01$, * ** $p < .001$.

3. Results

3.1. Negative emotions

As illustrated in Fig. 3a, participants experienced higher negative emotions when viewing pictorial enhanced CWLs than the CA-mock control (b = 0.30, p = .016, 95% CI [0.06, 0.55]). When comparing enhanced CWLs with either the CA-mock or CA-control CWLs, neither was statistically significant.

3.2. Recall sensitivity

As illustrated in Fig. 3b, compared with the CA-mock CWL, text enhanced CWLs with textual statements taken from theme-matched Canadian CWLs and a yellow background significantly improved recall accuracy (text enhanced yellow vs. CA-mock, b = 0.30, p = .011 95% CI [0.07, 0.54]). Similarly, pictorially enhanced CWLs also improved recall accuracy (pictorially enhanced vs. CA-mock, b = 0.59, p < .001, 95% CI [0.35, 0.82]).

When the CA-control CWL was set as the baseline, even simply breaking down the existing CA CWL's composite statement into single components and providing a white background increased information recall (text single white vs. CA-control, b = 0.23, p = .049, 95% CI [0.01, 0.46]). Both CWLs with textual enhancements plus a yellow background (text enhanced yellow vs. CA-control, b = 0.54, p < .001, 95% CI [0.31, 0.78]) and pictorial enhanced CWLs (pictorial enhanced vs. CA-control, b = 0.82, p < .001, 95% CI [0.59, 1.06]) significantly improved recall accuracy.

Importantly, pictorial enhanced CWLs also outperformed text enhanced yellow background CWLs (b = 0.28, p = .019, 95% CI [0.04, 0.52]).

3.3. Perceived message effects

Participants who viewed pictorial enhanced CWLs reported higher PME than those who were exposed to either the CA-mock (b = 0.31, p = .008, 95% CI [0.08, 0.54]) or the CA-control CWL (b = 0.25, p = .037 [0.02, 0.48]). PME was also higher for text single statement white background CWLs than the CA-mock CWL (b = 0.25, p = .034, 95% CI [0.02, 0.47]). Other PME comparisons were not statistically significant (see Fig. 3c and Appendix C).

3.4. Mediation analysis

To assess the relative importance of message recall and message-induced negative emotions on PME, we estimated a path model in which the effects of pictorial enhanced CWLs were mediated by each in parallel (Fig. 4). Other condition comparisons were included in the model but omitted to simplify the presentation of results. The direct effect of condition on PME was not significant in this model. Whereas the indirect effect pathway via negative emotion was statistically significant (indirect ES = 0.07, 95% bootstrapped CI [0.05, 0.31]), the pathway via information recall was not supported by data. Furthermore, we observed that recall negatively correlated with negative emotions (b = −0.19, 95% CI [−0.25, −0.12]).

Because PME was assessed immediately after message exposure in our design and recall was assessed later, we considered the possibility that the causal pathways could be reversed. We tested an alternative model in which PME served as a mediator and both message recall and negative emotions served as outcomes. Fit indices suggested that our original model (CFI = 0.85, TLI = 0.65, RMSEA = 0.11, 90%CI [0.08, 0.15]) fit the data better compared to this alternative model (CFI = 0.79, TLI =0.61, RMSEA = 0.12, 90%CI [0.10, 0.14]). This supports our theoretical model where PME approximated downstream persuasion following information encoding and emotional reactions.

4. Discussion

Given the spread of legalization and the decline in young adults' perceived harms of cannabis use (Azofeifa et al., 2016; Reboussin et al., 2019), it is in governments' substantial interest to inform the public, and particularly vulnerable populations, about known health risks associated with cannabis use through means such as CWLs. Compared with currently required CA-control CWL and our CA-mock CWL (i.e., CA-control plus mental health risks), enhanced textual CWLs using single-themed health risk statements, larger font, yellow background, and easier-to-understand language adapted from Canadian CWLs (Goodman et al., 2021) increased information recall, a necessary step towards improving harm perceptions and knowledge gain. Notably, we used a forced-choice recognition measure based on the signal detection theory (Macmillan et al., 2021) and adjusted for falsely recalled foil items. This finding is consistent with recent research (Goodman et al., 2021) employing a free recall measure when comparing Canadian to U. S. CWLs. This convergence of evidence, robust to different measures of information recall, supports the superiority of text-enhanced CWLs in fulfilling the goal of improving awareness and knowledge gain. Similarly, we found that pictorially enhanced CWLs also outperformed both control CWLs in helping young adults retain critical information about cannabis-related health risks. Importantly, among U.S. at-risk young adults, we uncovered novel evidence that, when compared to CA-control CWL and CA-mock CWL, pictorially enhanced CWLs were even more effective than their text-only versions lacking graphics, replicating the

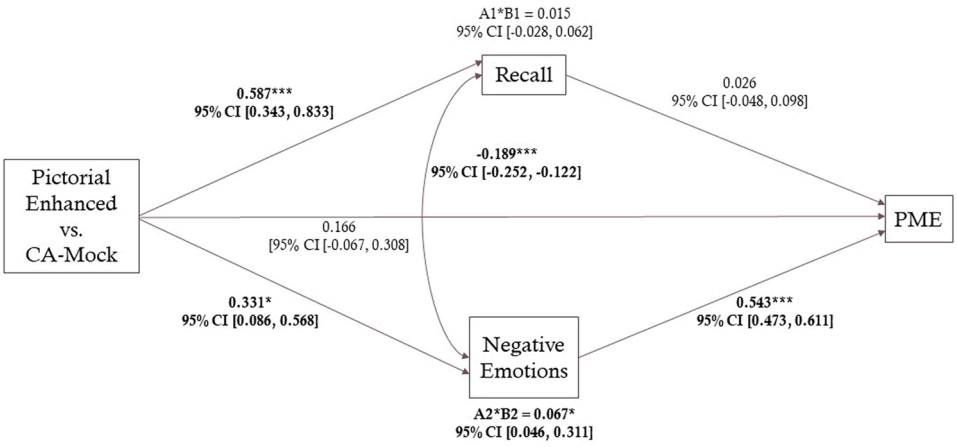

Fig. 4. Parallel Partial Mediation by Message Recall and Negative Emotions. *Note.* Complete path model included comparison of all conditions (CA-control, text single white, text enhanced yellow, and pictorial enhanced) with CA-mock condition. Other comparisons are excluded here to simplify presentation.

superiority of graphic tobacco warning labels over their textual counterparts (Noar et al., 2020). These findings suggest that U.S. regulators, such as state governments, may wish to consider implementing pictorial CWLs, or at a minimum CWLs with textual enhancement, to help young adults better encode and retain information about cannabis-related health risks.

Beyond information recall, we found evidence to support pictorial enhanced CWLs' superiority, as measured by increased perceived message effectiveness (PME), a proxy for CWLs' persuasiveness in tempering young adults' intentions for cannabis use. In contrast, text enhanced CWLs without visuals were no more persuasive than currently required CWLs. When the government's goal is to prevent risky cannabis use, our findings suggest that such pictorial enhancements are worth considering, echoing a recent study showing the superiority of pictorial CWLs over text-only CWLs in Canada (Whitehill et al., 2020). Compared with the previous CWL research that used a single-item measure for PME, we followed recent recommendation (Baig et al., 2021; Sutton et al., 2019) and employed a multi-item scale measuring effects perceptions PME, previously found to have higher validity than message perceptions items (e.g., "this message is believable"). This methodological adjustment increases our confidence in advocating for pictorial CWLs when the goal is to improve persuasiveness.

Persuasive as pictorial CWLs may appear, they still need to pass legal muster before being eligible for wide-scale implementation. The FDA's mandated graphic tobacco control labels were once challenged in court, largely due to their capacity to produce strong negative emotions (Kraemer and Baig, 2013). Since that litigation, researchers have gathered evidence to dispute this simplistic dichotomous view of emotions versus facts (Yotam et al., 2019; Leos-Toro et al., 2019). However, similar analyses have not yet been reported regarding CWLs. To fill this gap, we carried out parallel mediation analyses and found that negative emotions indeed channeled pictorial CWLs' effectiveness in enhancing PME whereas information recall did not. This finding joins related work on graphic tobacco control warnings (Yotam et al., 2019; Leos-Toro et al., 2019) and highlights the importance of emotional reactions as one of the primary pathways leading to CWLs' improved persuasiveness.

In contrast, we did not find the indirect effects through message recall that could have otherwise helped explain the superiority of pictorial enhanced CWLs in producing PME. We offer two speculations. First, consistent with dual-process models of persuasion such as the Elaboration Likelihood Model (Petty et al., 1983), cognitive processing of encoded health information and negative emotions may represent two separate routes towards persuasion. In one previous study on graphic tobacco warning labels, Kees et al. (2010) found that participants were less likely to recall information correctly when viewing graphic labels that elicited strong negative emotions, and it was negative emotions and not information recall that in turn improved quitting intentions. In our study, although pictorial enhanced CWLs increased both recall accuracy and negative emotions, these two variables were negatively correlated, which supports this dual-process interpretation. Further, when audience members pay close attention and use a "central" processing strategy that involves careful consideration, they may have engaged in the construction of counterarguments. This is likely because perceived harms of cannabis products among young adults have been rapidly declining (Azofeifa et al., 2016; Reboussin et al., 2019). Therefore, although visual enhancements improved the memorability of health risks, they may still fall short of making such risk information acceptable. Negative emotions experienced by the audience may have compensated for this insufficiency in the cognitive route to render pictorial enhanced CWLs more persuasive overall than control CWLs as measured by PME. That said, the documented superiority of redesigned CWLs in improving information recall warrants efforts to revise currently required CWLs in the U.S., because it is in the governments' substantial interest to better inform the public about the health risks associated with a Schedule 1 drug now undergoing expanding legalization.

This study is not immune to limitations. First, participants were exposed to one CWL in the two control conditions but to four CWLs in the enhanced CWL conditions. For the enhancement conditions, we averaged key outcomes across the four exposures to allow comparisons with the control conditions. Although this design and analytical strategy are necessary to test potential improvement against currently required CWLs, they may obscure the differences between labels. Future work could use a larger sample and a between-subject design to tease out theme-specific and label-specific effects. Second, our outcome measures were self-reported and captured short-term effects. To better assess how well these labels would perform in a real-world setting, future studies could assess message recall, knowledge gain, and cannabis use behaviors in a longitudinal design.

5. Conclusions

Through an online experiment with a national sample of at-risk young adults, we gathered evidence that both textual and pictorial enhancements can improve information recall and perceived message effectiveness (PME). Furthermore, we found that negative emotions, but not information recall, emerged as an important pathway through which pictorial enhanced CWLs accrued gains in PME. Given the rapid expansion of the cannabis industry and declining perceptions of harm, currently required CWLs in the U.S. such as those mandated in California are overdue for a redesign to improve knowledge and to help prevent early or habitual use among vulnerable populations such as at-risk young adults.

Acknowledgements

This work was supported by the Office of the Vice Chancellor for Research and Graduate Education at the University of Wisconsin–Madison with funding from the Wisconsin Alumni Research Foundation, USA, under grants number MSN231886 and MSN249368 to Sijia Yang; and by The Getting it Right from the Start program at the Public Health Institute to Lynn Silver.

Contributors

Everyone who contributed significantly to the work has been listed as an author.

Contributors

All authors have read and approved the manuscript for submission to Drug and Alcohol Dependence; have made a substantial contribution to the conception, design, gathering, analysis and/or interpretation of data and a contribution to the writing and intellectual content of the article; and acknowledge that they have exercised due care in ensuring the integrity of the work.

Declaration of Competing Interest

No conflict declared. All authors declare no conflict of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2022.109520.

References

An act to add Sections 26070.3, 26121, and 26151.5 to the Business and Professions Code, Relating to Cannabis, S.B. 1097. (2022).

Azofeifa, A., Mattson, M.E., Schauer, G., McAfee, T., Grant, A., Lyerla, R., 2016. National estimates of marijuana use and related indicators - national survey on drug use and health, United States, 2002-2014. Mmwr. Surveill. Summ. 65, 1–28.

Baig, S.A., Noar, S.M., Gottfredson, N.C., Lazard, A.J., Ribisl, K.M., Brewer, N.T., 2021. Incremental criterion validity of message perceptions and effects perceptions in the context of anti-smoking messages. J. Behav. Med. 44, 74–83.
Bigsby, E., Cappella, J.N., Seitz, H.H., 2013. Efficiently and effectively evaluating public service announcements: additional evidence for the utility of perceived effectiveness. Commun. Monogr. 80, 1–23.
Brewer, N.T., Hall, M.G., Noar, S.M., Parada, H., Stein-Seroussi, A., Bach, L.E., Hanley, S., Ribisl, K.M., 2016. Effect of pictorial cigarette pack warnings on changes in smoking behavior: a randomized clinical trial. JAMA Intern. Med. 176, 905–912.
Cappella, J.N., 2018. Perceived message effectiveness meets the requirements of a reliable, valid, and efficient measure of persuasiveness. J. Commun. 68, 994–997.
Carpenter, C.J., Boster, F.J., 2013. The relationship between message recall and persuasion: More complex than it seems. J. Commun. 63, 661–681.
Goodman, S., Leos-Toro, C., Hammond, D., 2019. The impact of plain packaging and health warnings on consumer appeal of cannabis products. Drug Alcohol Depend. 205, 107633.
Goodman, S., Rynard, V.L., Iraniparast, M., Hammond, D., 2021. Influence of package colour, branding and health warnings on appeal and perceived harm of cannabis products among respondents in Canada and the US. Prev. Med. 153, 106788.
Hall, W., Lynskey, M., 2020. Assessing the public health impacts of legalizing recreational cannabis use: the US experience. World Psychiatry 19, 179–186.
Hammond, D., 2011. Health warning messages on tobacco products: a review. Tob. Control 20, 327–337.
Hasan, A., von Keller, R., Friemel, C.M., Hall, W., Schneider, M., Koethe, D., Leweke, F. M., Strube, W., Hoch, E., 2020. Cannabis use and psychosis: a review of reviews. Eur. Arch. Psychiatry Clin. Neurosci. 270, 403–412.
Johnson, B.T., Maio, G.R., Smith-McLallen, A., 2005. Communication and Attitude Change: Causes, Processes, and Effects. In: Albarracín, D. (Ed.), The Handbook of Attitudes. Lawrence Erlbaum Associates Publishers, New Jersey, pp. 617–669.
Kees, J., Burton, S., Andrews, J.C., Kozup, J., 2010. Understanding how graphic pictorial warnings work on cigarette packaging. J. Public Policy Mark. 29, 265–276.
Klein, E.G., Quisenberry, A.J., Shoben, A.B., Cooper, S., Ferketich, A.K., Berman, M., Peters, E., Wewers, M.E., 2017. Health warning labels for smokeless tobacco: the impact of graphic images on attention, recall, and craving. Nicotine Tob. Res 19, 1172–1177.
Kraemer, J.D., Baig, S.A., 2013. Analysis of legal and scientific issues in court challenges to graphic tobacco warnings. Am. J. Prev. Med. 45, 334–342.
Leos-Toro, C., Fong, G.T., Meyer, S.B., Hammond, D., 2019. Perceptions of effectiveness and believability of pictorial and text-only health warning labels for cannabis products among Canadian youth. Int. J. Drug Policy 73, 24–31.
Macmillan, N.A., Hautus, M.J., Douglas Creelman, C., 2021. Detection Theory: A User's Guide. Routledge, United Kingdom.
McGuire, W.J., 1968. Personality and attitude change: an information-processing theory. Psychol. Found. Attitudes 171, 196.
McKeon, K., 1980. Central Hudson Gas & (and) Electric Corp. v. Public Service Commission of New York.
Meernik, C., Jarman, K., Wright, S.T., Klein, E.G., Goldstein, A.O., Ranney, L., 2016. Eye tracking outcomes in tobacco control regulation and communication: a systematic review. Tob. Regul. Sci. 2, 377–403.
Meier, M.H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R.S.E., McDonald, K., Ward, A., Poulton, R., Moffitt, T.E., 2012. Persistent cannabis users show neuropsychological decline from childhood to midlife. Proc. Natl. Acad. Sci. U. S. A. 109, E2657–E2664.
Mutti-Packer, S., Collyer, B., Hodgins, D.C., 2018. Perceptions of plain packaging and health warning labels for cannabis among young adults: findings from an experimental study. BMC Public Health 18, 1361.
National Academies of Sciences, engineering, and medicine, 2017. The health effects of cannabis and cannabinoids: the current state of evidence and recommendations for research (health and medicine division, board on population health and public health practice, committee on the health effects of marijuana: an evidence review and research agenda). National Academies Press.
National Conference of State Legislatures; [cited 2022 May 4]. Available from: https://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx.
Noar, S.M., Bell, T., Kelley, D., Barker, J., Yzer, M., 2018. Perceived message effectiveness measures in tobacco education campaigns: a systematic review. Commun. Methods Meas. 12, 295–313.
Noar, S.M., Rohde, J.A., Barker, J.O., Hall, M.G., Brewer, N.T., 2020. Pictorial cigarette pack warnings increase some risk appraisals but not risk beliefs: a meta-analysis. Hum. Commun. Res 46, 250–272.
Office of the Surgeon General, 2019. Surgeon general's advisory: Marijuana use & the developing brain [WWW Document]. HHS.gov. URL https://www.hhs.gov/surgeongeneral/reports-and-publications/addiction-and-substance-misuse/advisory-on-marijuana-use-and-developing-brain/index.html (Accessed 14 April 2022).
Pepper, J.K., Lee, Y.O., Eggers, M.E., Allen, J.A., Thompson, J., Nonnemaker, J.M., 2020. Perceptions of U.S. and Canadian cannabis package warnings among u.s. adults. Drug Alcohol Depend. 217, 108275.
Petty, R.E., Cacioppo, J.T., Schumann, D., 1983. Central and peripheral routes to advertising effectiveness: the moderating role of involvement. J. Consum. Res. 10, 135–146.
Popova, L., Owusu, D., Jenson, D., Neilands, T.B., 2017. Factual text and emotional pictures: overcoming a false dichotomy of cigarette warning labels. Tob. Control. https://doi.org/10.1136/tobaccocontrol-2016-053563.
Reboussin, B.A., Wagoner, K.G., Sutfin, E.L., Suerken, C., Ross, J.C., Egan, K.L., Walker, S., Johnson, R.M., 2019. Trends in marijuana edible consumption and perceptions of harm in a cohort of young adults. Drug Alcohol Depend. 205, 107660.
Rohde, J.A., Noar, S.M., Prentice-Dunn, H., Kresovich, A., Hall, M.G., 2021. Comparison of message and effects perceptions for the real cost e-cigarette prevention ads. Health Commun. 36, 1222–1230.
Rubinstein, M.L., 2015. Scanning the brain for answers about effectiveness of graphic warning labels. Tob. Control.
Sami, M., Quattrone, D., Ferraro, L., Tripoli, G., Cascia, E.L., Gayer-Anderson, C., Selten, J.-P., Arango, C., Bernardo, M., Tarricone, I., Tortelli, A., Gatto, G., Del Peschio, S., Del-Ben, C.M., Rutten, B.P., Jones, P.B., van Os, J., de Haan, L., Morgan, C., Lewis, C., Bhattacharyya, S., Freeman, T.P., Lynskey, M., Murray, R.M., Forti, M.D., 2020. Association of extent of cannabis use and psychotic like intoxication experiences in a multi-national sample of first episode psychosis patients and controls. Psychol. Med. 1–9.
Silins, E., Horwood, L.J., Patton, G.C., Fergusson, D.M., Olsson, C.A., Hutchinson, D.M., Spry, E., Toumbourou, J.W., Degenhardt, L., Swift, W., Coffey, C., Tait, R.J., Letcher, P., Copeland, J., Mattick, R.P., 2014. Young adult sequelae of adolescent cannabis use: an integrative analysis. Lancet Psychiatry 1, 286–293.
Silver, L.D., Naprawa, A.Z., Padon, A.A., 2020. Assessment of incorporation of lessons from tobacco control in city and county laws regulating Legal Marijuana in California. JAMA Netw. Open 3, e208393.
Skurka, C., Byrne, S., Davydova, J., Kemp, D., Safi, A.G., Avery, R.J., Dorf, M.C., Mathios, A.D., Niederdeppe, J., 2018. Testing competing explanations for graphic warning label effects among adult smokers and non-smoking youth. Soc. Sci. Med. 211, 294–303.
Spindle, T.R., Bonn-Miller, M.O., Vandrey, R., 2019. Changing landscape of cannabis: novel products, formulations, and methods of administration. Curr. Opin. Psychol. 30, 98–102.
Strasser, A.A., Tang, K.Z., Romer, D., Jepson, C., Cappella, J.N., 2012. Graphic warning labels in cigarette advertisements: recall and viewing patterns. Am. J. Prev. Med. 43, 41–47.
Substance Abuse and Mental Health Services Administration (SAMHSA), 2020. Key substance use and mental health indicators in the United States: Results from the 2019 national survey on drug use and health [WWW Document]. URL https://store.samhsa.gov/product/key-substance-use-and-mental-health-indicators-in-the-united-states-results-from-the-2019-national-survey-on-Drug-Use-and-Health/PEP20–07-01–001 (Accessed 14 April 2022).
Sutton, J.A., Yang, S., Cappella, J.N., 2019. Perceived effectiveness of objective features of pictorial warning messages. Tob. Control 28, e24–e30.
Whitehill, J.M., Trangenstein, P.J., Jenkins, M.C., Jernigan, D.H., Moreno, M.A., 2020. Exposure to cannabis marketing in social and traditional media and past-year use among adolescents in states with legal retail cannabis. J. Adolesc. Health 66, 247–254.
Winstock, A.R., Lynskey, M.T., Maier, L.J., Ferris, J.A., Davies, E.L., 2021. Perceptions of cannabis health information labels among people who use cannabis in the U.S. and Canada. Int. J. Drug Policy 91, 102789.
Yotam, O., Emily, B., Maloney, E.K., Cappella, J.N., 2019. The effects of graphic warning labels' vividness on message engagement and intentions to quit smoking. Commun. Res. 46, 619–638.