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Understanding emerging forms of cannabis use through an online cannabis community: an analysis of relative post volume and subjective highness ratings

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Abstract

Aims: Legalization of medical and recreational cannabis has coincided with an increase in novel forms of cannabis use and a burgeoning cannabis product industry. This research seeks to understand the occurrence of discussions about these emerging and traditional forms of use in an online social media discussion forum.

Methods: We analyzed posts to a cannabis-specific forum on the Reddit social media platform posted from January 2010-December 2016. For each of various keywords describing smoking, vaping, edibles, dabbing, and butane hash oil (bho) concentrate use, we analyzed (1) relative prevalence of posts mentioning these cannabis forms of use; (2) user-reported subjective ratings of "highness" on a scale of 1-10; (3) the ten most common words mentioned in posts; and (4) the frequency of adverse health effect terms.

Results: Form of use was mentioned in approximately 17.7% of 2.26 million posts; smoking was the most commonly mentioned form of cannabis use. From 2010 to 2016, relative post volume increased significantly for posts mentioning dabbing (3.63/1000 additional posts per year, $p<.001$), butane hash oil terms (3.16/1000, $p<.001$), and edible terms (2.84/1000, $p=.002$). Mean subjective highness was significantly greater for posts mentioning dabbing (mean=7.8, $p<.001$), butane hash oil terms (mean=7.5, $p<.001$), and edible terms (mean=7.2, $p<.001$) but not significantly different for vaping (mean=6.7, $p = .19$), when compared to smoking (mean=6.8).

Conclusions: Despite limitations in representativeness, findings indicate a significant increase in online discussion of emerging cannabis forms of use over time and greater subjective effects of dabbing, butane hash oil, and edible use.

Keywords

cannabis; online communities; route of administration; vaping; edible; digital health

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1. Introduction

There is growing evidence that legalization of medical and recreational cannabis in the United States and worldwide has coincided with increases in alternative methods of cannabis administration (Borodovsky et al., 2016; Krauss et al., 2017; Schauer et al., 2016) facilitated by a burgeoning cannabis product industry that is inconsistently regulated across multiple states (Gourdet et al., 2017; Room, 2014). Information on different forms (i.e. products or methods) of cannabis administration is a limited area of knowledge in the scientific literature. Such information will be critical for informing cannabis regulation efforts and reducing potential harms from cannabis legalization.

Although smoking of dried cannabis flowers or resin is the most traditional and common method of cannabis use, other methods include inhaling vaporized dried flowers or cannabis oil ("vaping"), orally ingesting edible products ("edibles") (Schauer, et al., 2016) and, more recently, inhaling vaporized high potency tetrahydrocannabinol (THC) butane hash oil concentrate products known as "wax" and "shatter," sometimes through a specialized glass heating and inhalation device (referred to as "dabbing") (Loflin & Earleywine, 2014). While technically a vaporized cannabis product, dabbing typically differs from vaping in that more highly concentrated THC products (up to 90% THC) are heated on a glass or titanium rod ("nail") and inhaled through a glass device ("rig") as opposed to the more general heating of cannabis concentrate or flower material to create vapor but not combusted smoke. Medical researchers have previously raised health concerns about increases in average THC concentration from seized flower samples, increasing from approximately 3% in 1992 (Compton et al., 2004) to 9% in 2008 (Mehmedic et al., 2010) and 12% in 2014 (ElSohly et al., 2016), with corresponding calls to better understand the effects of high-potency cannabis.

Different methods of administration produce different physiological and psychological effects, as well as variations in the timing and duration of onset and peak effects (Newmeyer et al., 2017). People may prefer one method over another based on accessibility, perceived effectiveness, motivations for use, THC or cannabidiol (CBD) content, and relative harms of different methods (e.g. smoke inhalation vs. delayed onset and longer duration of edibles). Subjective ratings of effects have also been found to vary across methods of administration and by frequency of cannabis use (Newmeyer, et al., 2017).

Analysis of social media data has been used to complement other epidemiologic methods as a strategy for understanding emerging trends in real time with limited social desirability or recall bias (Althouse et al., 2015). Prior work with Twitter conversations has found significantly greater reports of emerging product use in states permitting medical and/or recreational cannabis use, (Cavazos-Rehg et al., 2015; Daniulaityte et al., 2015; Lamy et al., 2016) and that physical and psychological effects of dabbing (Cavazos-Rehg et al., 2016) and edible use (Lamy, et al., 2016) are often disclosed. Despite the limited ability to determine the representativeness of creators of social media content and thus inform generalizability, social media data analysis can uncover behaviors not captured in traditional surveillance (Althouse, et al., 2015) and inform terminology and emerging behaviors that larger scale health surveys may wish to incorporate.

Reddit (reddit.com) is a popular web content rating and discussion forum website where users submit and vote on posts and comments in a diverse range of topic-specific online discussion communities called "subreddits." Each subreddit has its own system of rules and guidelines as well as active and inactive members. Other studies with data from Reddit online communities have found that people use health related subreddits to ask questions and disclose information they may not disclose in person to family members or clinicians (Chen et al., 2015; Pavalanathan & De Choudhury, 2015; Sowles et al., 2017; Tamersoy et al., 2015).

A unique feature of Reddit is that users post pseudo-anonymously under a self-chosen username that is usually distinct from one's real name, which may engender greater tendencies to disclose substance use behavior than on other social networking sites such as Twitter, Facebook, and Instagram. As of October 2017, Reddit was the 4th most popular website in the United States and 8th most popular website in the world with 4 million daily users (Alexa, 2017). The most popular cannabis-related subreddit was created in October 2009. It has over 1 million subscribers and is in the top 100 most popular subreddits out of over 1 million subreddits. While this subreddit is decidedly pro-cannabis, a wide variety of topics and discussions occur, and any attempts to buy or sell cannabis are strictly prohibited.

In this study, we sought to determine (1) whether mentions of different cannabis products (smoking, vaping, edible terms, dabbing, butane hash oil terms) in a popular and established online cannabis-specific community are changing over time, (2) whether user-reported subjective highness differs across product mentions, and (3) the most commonly used words in posts containing different product mentions. We hypothesized that mentions of vaping, dabbing, and edibles would be increasing at a faster rate than mentions of smoking, and that edible and dabbing mentions would be related to greater subjective highness than for smoking.

2. Material and Methods

2.1 Data Acquisition and Cleaning

Ethical approval was provided by the University of California San Francisco Institutional Review Board (categorized as human subject exempt category 4). All posts analyzed are publicly available and no usernames of post authors were analyzed or reported here other than counts of anonymized unique usernames.

We downloaded timestamped post titles and content from publicly available repositories of historical Reddit data, focusing on the largest cannabis-specific subreddit from January 1, 2010 to December 31, 2016. We then created dichotomous variables to indicate whether the post title or content mentioned one of four specific forms of use: smoking, vaping, edibles, or dabbing, allowing for other word forms: smoke, smoked, smoking; vape, vaped, vaping; edible, edibles; dab, dabs, dabbed, dabbing. For smoking related posts, we excluded 4,724 posts that also mentioned synthetic cannabis terms (i.e. k2, spice, synthetic). For edibles, we also added the following food term combinations: space / cosmic / special / weed / pot / medicated + brownies / cake / cookies / gummies / candy. In reading through posts as well as scientific and marketing literature, we added a category for butane hash oil concentrate

terms that included: honey/hash/cannabis/cbd oil, wax, shatter, bho, concentrate(s), budder. Edible terms and food terms were analyzed together, but dabbing and butane hash oil terms were analyzed separately given that dabbing refers to a method of use while butane hash oil terms referred to specific products. We note however, that many posts (about 25% of each) mentioned both dabbing and butane hash oil products. This classification resulted in a total of five forms of use (i.e., product or method/route of administration): smoking, vaping, edible terms, dabbing, and butane hash oil terms. Subsets of posts were examined individually to make sure we were not capturing false positives with these keywords. For example, the terms "ate" and "eat" were not included in the edible list as these terms also picked up reports of increased appetite following cannabis consumption. To determine the number of unique username accounts posting, usernames were represented as a hashed random string of characters and frequencies of unique character strings were calculated.

A notable feature of cannabis related subreddits is that people may post how "high" they are on a scale of 0-10 in brackets or, less often, parentheses or curly brackets to indicate that they are getting higher or coming down (e.g., "Just tried my new vape pen [6}"). This is somewhat similar to the numeric pain scale or visual analog scale for pain used in medical settings (Bijur et al., 2001). Using regular expression notation, we extracted numeric values between 1 and 10 that were contained in brackets. Posts that reported more than one number in brackets were excluded (3%), as were bracketed numbers of 0 (indicating soberness) or over 10.

2.2 Proportion and Trends of Product Mentions

Counts of post titles mentioning smoking, vaping, edible, dabbing, and butane hash oil terms were normalized to total number of posts in this subreddit to determine the prevalence of posts mentioning these cannabis forms of use (i.e. a relative post volume, similar to "relative search volume" in Google search term analyses) (Paul et al., 2016). To describe the rate of change in post volume over time we ran linear regressions with relative post volume as a function of time in years, as both linear and quadratic functions.

2.3 Subjective Highness

The distribution of numerical value of subjective highness ratings was assessed for posts mentioning different forms of use. Because posts with ratings sometimes mentioned more than one form of use, only distributions of ratings mentioning one form of use were compared. Based on skewness and kurtosis values, means and standard deviations were reported. Differences in means were compared between posts mentioning smoking and posts mentioning other forms of use. Since this resulted in multiple t-tests on the same mean, we used on a Bonferroni correction to determine statistical significance (i.e., alpha of .05/4 tests requires a *p*-value of .0125 to achieve statistical significance).

2.4 Most Frequent Words and Adverse Effects

Using the *tm* package in R, we tokenized words, converted to lower case, and removed stop words (common but uninformative words such as "a," "the", "in") before creating a document term matrix based on a term frequency – inverse document frequency (tf-idf) metric, which measures and weights the importance of a word within a document (e.g. a

post) relative to its appearance in a corpus (e.g. a collection of posts). We then examined the top ten most commonly used words across product types.

To examine how frequently adverse effects were being reported and if this differed by product type, we also examined the frequency of potential acute adverse events (Hall, 2009; Volkow et al., 2014) and grouped them into eight categories: (1) anxious, anxiety, panic, nervous; (2) vomit, puke, barf, throw up; (3) pass(ed) out; (4) too high; (5) cough; (6) injure, injury; (7) memory, can't remember, couldn't remember; (8) paranoia, paranoid, psychotic. Upon inspection of posts titles mentioning "cough," post titles containing "strawberry cough," a particular strain, were not included. Chi-squared tests (using Fisher's exact p-value if a term occurred less than 5 times) comparing each form of use to smoking was used to assess specific differences in proportions of posts mentioning adverse effects.

3. Results

There were 2.26 million posts in this online community from January 2010 to December 2016, with a peak in post volume in early 2012. Form of use was mentioned in 17.7% of posts (approximately 400,000 posts), and subjective highness was reported in 15.5% of those form of use posts. Across all seven years of data, smoking was the most commonly mentioned form of use, mentioned in 152 per 1000 posts, compared to 13 per 1000 for vaping, 10 per 1000 for edibles, 7 per 1000 posts for dabbing, and 8 per 1000 posts for butane hash oil terms. [Table 1]

From 2010 to 2016, relative post volume increased for all forms of use [Figure 1], most dramatically for dabbing with 3.63/1000 additional posts per year (p<.001). [Table 1] Increases were also statistically significant for butane hash oil terms (3.16/1000 additional posts per year; p<.001), and edible terms (2.84/1000 additional posts per year; p=.002). While there was a linear increase in post volume for smoking (6.88/1000) and vaping; 1.54/1000), these increases were not statistically significant (p=.187 and p=.123, respectively). Quadratic increases were not significant, except for edible term posts (coefficient = .60, p=.003).

Distributions of subjective highness ratings by form of use ranged from 1 to 10 and were only slightly skewed (skewness between −.41 and −.90, indicating a normal distribution), so we examined differences in means. Compared to mean subjective highness for smoking posts (mean = 6.8), mean subjective highness was significantly greater for posts mentioning dabbing (mean = 7.8, p < .001), butane hash oil terms (mean = 7.5, p < .001), edible terms (mean = 7.2, p <.001) but not significantly different for posts mentioning vaping (mean = 6.7, p = .19).[Figure 2] In sensitivity analyses including posts that mentioned more than one form use, means and comparisons were similar.

The top three most frequently used terms weighted relative to their importance in the total collection of post titles were "spot", "weed", "today" for smoking post titles; "pen," "smoke," and "question" for vaping post titles; "first," "question," and "make" for edible post titles; "first," "time," and "rig" for dabbing post titles; and "wax", "shatter", "bho" for butane hash oil term post titles. [Table 1]To better understand the context of these words, we

examined what other words were most highly correlated with each of the words listed above using the *findAssocs* function in the *tm* package. Of note, "first" and "time" were highly correlated across all forms of use (.4-.6) and "today" and "spot" were correlated (at .4) in smoking posts.

Adverse effect terms occurred much less frequently for each product (1.2% for smoking, .5% for vaping, .7% for edible, .7% for dabbing, and .4% for butane hash oil terms). Of the searched for adverse effect terms, the most commonly mentioned relative to form of use post volume were anxiety-related terms for smoking, edibles, and butane hash oil terms and "cough" for vaping and dabbing. However, there were no statistically significant differences of adverse effect term occurrence across products. We also note that we were not able to examine in detail differences in adverse effects following cannabis use or the use of cannabis to address similar symptoms.

4. Discussion

In this study of mentions of emerging forms of cannabis use posted to an online cannabis community across seven years, smoking remains the most common mode of use, but online discussion of dabbing, butane hash oil, and edible terms is increasing and at a faster rate. Posters also report greater subjective highness these forms of use. Very few adverse effects were reported.

The most dramatic increase in proportion of dabbing posts and greater subjective highness for dabbing corroborates other research and popular press articles stating that dabbing is becoming an increasingly popular mode of use that produces more intense effects (Miller et al., 2016; Stogner & Miller, 2015). This increase in Reddit post volume mirrors an increase in dabbing related Google searches from 2010 to 2015 (Zhang et al., 2016). In a survey with Craigslist users, Loflin et al. found that dabbing is preferred by some because it requires fewer "hits" and produces stronger effects, although using flower cannabis is perceived as safer (Loflin & Earleywine, 2014). In that study there were no significant differences in reports of negative consequences and accidents between dab users and flower users, yet dab users did report higher average tolerance and withdrawal symptoms compared to flower users. In a content analysis of a subset of randomly sampled dabbing related tweets gathered in January 2015, researchers found that the most common theme was in reference to recent use of dabbing followed by references to intense highs and extreme physiological and psychological effects such as passing out, respiratory effects, and confusion or distorted reality (Cavazos-Rehg, et al., 2016). In an international online survey, Chan et al. found that people who reported using butane hash oil reported stronger negative effects and less positive effects compared to flower cannabis use (Chan et al., 2017).

While edibles are considered by some to be a safer method of use than smoking because of the lack of combustion and respiratory side effects, the delayed onset of effects, variability due to inconsistent or lacking THC content labeling, and differences in metabolism of ingested vs. inhaled cannabis also raises health concerns (Cao et al., 2016; MacCoun & Mello, 2015). Examinations of edible related tweets by Lamy et al. have found that the majority (56.8%) of user tweets in 2015 conveyed positive attitudes while a minority

(13.2%) conveyed negative attitudes that primarily concerned unreliable THC content labeling and lack of knowledge about safe use (Lamy, et al., 2016). Although we did not find many mentions of adverse effects related to edible consumption, and fewer mentions of "cough" than for other products, we find it notable that "question" and "help" were two of the most frequently occurring words in edible posts, suggesting concerns and gaps in user knowledge when using cannabis edibles. Furthermore, posts mentioning edibles with a subjective highness score had the widest variation, which supports reports of extreme variability in THC content (Vandrey et al., 2015). While the scientific reliability and validity of this subjective highness scale have not been established, the face validity of this widely adopted and cannabis user-created scale should not be discounted.

Although large scale epidemiological data is not yet available on prevalence of use of emerging forms of use, other studies examining different methods of cannabis use have found that while smoking remains the dominant mode of use, other methods of use may be growing. A consumer panel online survey conducted in the United States in 2014 (Schauer, et al., 2016) found that the majority (92.1%) of current cannabis users reported combustible use (i.e. smoking) with a small but notable proportion reporting past month edible (16.1%) and vaping (7.6%) use. A study of Facebook-recruited individuals who use cannabis found that those residing in states with medical marijuana laws were more likely to have tried vaping or edibles than those in states without such laws, but were not necessarily more likely to prefer these methods over smoking (Borodovsky, et al., 2016). That study also found that prevalence of ever using vaping or edibles was related to length of time that a state had a medical marijuana law, suggesting that as more states implement and continue with medical and recreational marijuana laws, the prevalence of using other methods of use other than smoking may continue to increase. Other studies have also found evidence of greater popularity of new cannabis products in states where cannabis use is legal (Krauss, et al., 2017). While our study did not have location data of Reddit posters, we noted a faster increase in prevalence of posts mentioning edibles, butane hash oil, and dabbing, coinciding with the increase in number of states legalizing medical and recreational cannabis use.

The frequent occurrence of the word "first" for vaping, dabbing, and edibles indicates that many posters are using or considering using for the first time. In general, people are increasingly accessing online peer generated health information, with at least 60% of U.S. adults seeking health information online (Fox & Duggan, 2013). Research has found that information is perceived as credible when specific, mentioned by multiple individuals, consistent with one's own opinions and experiences, and delivered by peers perceived to be similar (Rupert et al., 2016). With diverging medical and scientific opinions regarding the efficacy and safety of cannabis use, new and experienced cannabis users may be seeking out peer-generated information in online communities and social media about these newer forms of use. More research is needed on how people may be seeking out information specifically regarding diverse forms of cannabis use and what they see as trusted sources of online information.

These findings must be considered in the context of a number of limitations. A primary limitation is that we do not have demographic or geographic information about individuals who posted in this online community, so we are not able to make any claims as to what

degree posting is happening in states with medical or recreational cannabis legalization, or even within the United States. However, limited data on Reddit users in general indicates that they tend to be male, young, and in the United States (Alexa, 2017; Pew, 2016). We believe the decrease in overall post volume to this subreddit after 2012 was due to people going to other more specific but smaller cannabis-related subreddits, which were not examined in this study. Post counts are based on key words and not on a thorough hand-coding, as this would have been prohibitively resource intensive for 2.26 million posts. While we did inspect a subset of posts to prevent capturing false positives, we may have misclassified some posts or missed some misspellings or novel keywords as terminology is constantly evolving. One way to address this limitation in future work is to use natural language processing, methods that are automated but use more linguistic context than only keywords. Finally, while we found very few mentions of adverse effects, this may be an indication that this is a very pro-cannabis community and individuals experiencing and wishing to share adverse effects were posting elsewhere or in the comments section, or it may simply reflect a low frequency of acute adverse effects experienced by cannabis users. Similarly, as people were not explicitly asked about products or methods of use, subjective highness, or adverse health effects, all information is based on what people decide to include in their post*s*.

Findings indicate that a large volume of discussions of emerging cannabis forms of use occur online and have been increasing over time. Online community discussion platforms are a novel complementary tool for understanding temporal trends and user experiences in real time that may not be captured in traditional surveillance methods. As U.S. states and other countries increasingly decriminalize and legalize medical and recreational cannabis use, these findings should be combined with others (Fischer et al., 2017) and taken as a call for more research to understand the relative harms and benefits of different forms of cannabis use and to inform clinical, public health, and regulatory and industry practices to reduce potential adverse effects related to cannabis use.

Acknowledgements:

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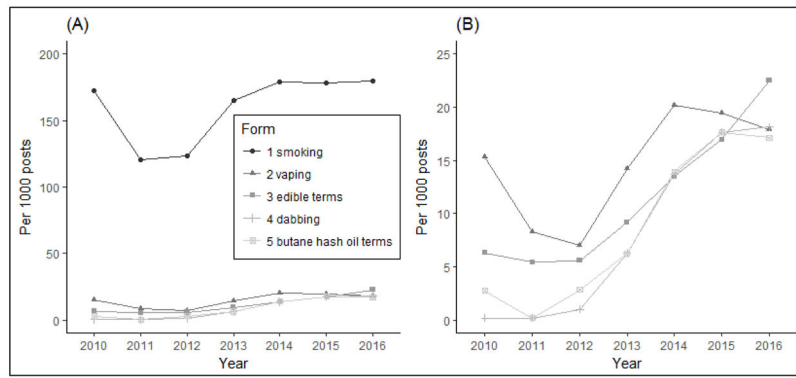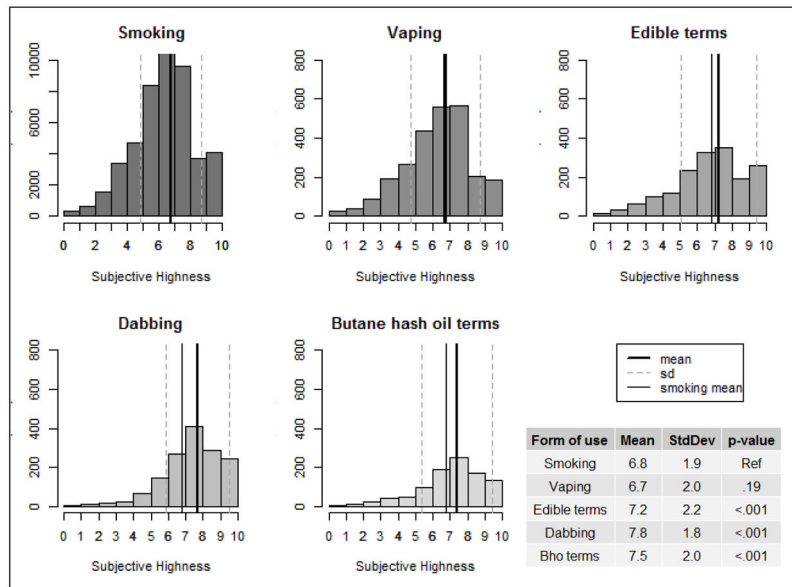
Figure 1: Relative post volume over time for different cannabis forms of use 2010 to 2016
(A) All forms of use (B) Only non-smoking forms of use on zoomed-in scale

Figure 2: Distributions of subjective highness ratings across forms of cannabis use mentioned in online posts

p-value for t-test comparing form of use post mean ratings to smoking post mean rating

Table 1:

Relative post volume and frequently used terms for posts mentioning cannabis forms of use 2010-2016

Form of use	Post Volume				Subjective Highness			Most Common Words in Posts
	Number of posts	Relative post volume (out of 2.26 million posts)	Rate of increase (per 1,000 posts per year)[1]	Unique usernames posting (out of 432,726)	Number of 1–10 rating posts (with 1 or more forms of use mentioned)	Number of 1–10 ratings posts (with *only 1* form of use mentioned)	Unique usernames posting a rating (with *only 1* form of use mentioned)	Top 10 words in post titles
Smoking	353,850	0.152	6.88	145,044	50,618	47,373	26,846	spot, weed, today, time, first, tree, day, ent, buddi, just
Vaping	29,799	0.132	1.54	18,239	4,275	2,562	1,677	pen, smoke, question, best, new, first, help, get, buy, weed
Edible terms	23,217	0.010	2.84 **[2]	15,042	2,726	1,700	1,184	first, question, browni, make, time, edibl, pot, help, weed, eat
Dabbing	16,125	0.007	3.63 ***	9,846	2,461	1,474	1,042	first, time, rig, take, just,hit, like, question, new, smoke
Butane hash oil terms	18,185	0.008	3.16 ***	11,359	2,002	972	681	wax, shatter, bho, oil, concentr, help, question, budder, first, make

[1] p-value for linear regression F-test

** p<.01

*** p<.001

[2] quadratic time term fit the data better but linear effect is presented for ease of interpretation

Table 2:

Counts of adverse health effect terms mentioned in post titles across cannabis forms of use

Adverse Health Effect Terms	Smoking	Prop.	Vaping	Prop.	Edible terms	Prop.	Dabbing	Prop.	Butane hash oil terms	Prop.
anxiety, anxious, panic, nervous [1]	836	0.0051	14	0.0010	37	0.0028	15	0.0014	18	0.0017
throw up, barf, vomit, puke [1]	120	0.0007	0	0.0000	10	0.0007	4	0.0004	0	0.0000
pass out, passed out	121	0.0007	4	0.0003	11	0.0008	9	0.0009	1	0.0001
too high	132	0.0008	4	0.0003	16	0.0012	11	0.0010	5	0.0005
cough [2]	300	0.0018	30	0.0022	4	0.0003	30	0.0028	11	0.0010
injury, injure	20	0.0001	2	0.0001	1	0.0001	0	0.0000	4	0.0004
memory, can't remember, couldn't remember	189	0.0011	4	0.0003	4	0.0003	5	0.0005	1	0.0001
paranoia, paranoid, psychotic	312	0.0019	8	0.0006	10	0.0007	0	0.0000	0	0.0000
Sum of adverse effect term occurrences	2030	0.0123	66	0.0048	93	0.0069	74	0.0070	40	0.0037
Total possible post titles with cannabis form	165,185		13,647		13,390		10,574		10,686	

Prop. = Proportion of total possible post titles also mentioning cannabis form of use key search terms

No significant differences across forms of use when compared to smoking proportion

[1] May include posts where cannabis was used to address feelings of anxiety or nausea prior to use

[2] Does not include mentions of "strawberry cough," a cannabis strain