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Assessing Characteristics and Compliance of Online Delta-8 Tetrahydrocannabinol Product Sellers

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## ORIGINAL RESEARCH

# Assessing Characteristics and Compliance of Online Delta-8 Tetrahydrocannabinol Product Sellers

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### Abstract

**Introduction:** The debate over the legal status of many cannabis- and hemp-derived products, including delta-8 tetrahydrocannabinol (THC), is in question. Although low concentrations of delta-8 THC are legal at the Federal level, many states have implemented their own regulations to both allow and restrict its use and sale. Of concern, sellers with unknown legal credentials have appeared online and are actively selling this product.

**Materials and Methods:** We characterized the marketing, sale, and compliance of online delta-8 THC sellers using (1) data collected from the Twitter Application Programming Interface with delta-8 THC-related keywords; (2) unsupervised topic modeling using the Biterm Topic Model to identify clusters of tweets involved in marketing and selling; (3) inductive coding to identify marketing and selling characteristics; and (4) web forensics and simulated shopping to determine compliance with state restrictions for delta-8 THC sales.

**Results:** In total, 110 unique hyperlinks associated with 7085 tweets that included marketing and selling activity for delta-8 THC were collected. From these links, we conducted simulated purchasing in January 2021 to identify compliant and noncompliant websites. Among the vendors, age verification was not found in over half of websites (59, 53.63%); 60 (54.55%) did not report a physical address; and 74 (65.45%) sold delta-8 products direct-to-consumer. Sixty-seven (90.54%) of detected vendors shipped delta-8 products to addresses in states that prohibit sales. Forty-three (64.18%) of Internet Protocol addresses were located within the United States; all others were international.

**Conclusion:** Our analysis suggests that online storefronts are illegally selling and shipping cannabinoid derivatives to U.S. consumers. Further research is needed to understand downstream health and regulatory impacts from this unregulated access.

**Keywords:** Twitter; THC; delta-8; delta-8 THC; Federal Law; cannabis; tetrahydrocannabinol

### Introduction

In 2019, cannabis, also known as marijuana, was the most commonly used drug substance in the United States; 48.2 million Americans have used it at least once during the prior year.<sup>1,2</sup> Although some states have legalized its use, only 22 states permit recreational use; others have limited its use to medical patients, while still others have completely prohibited both recreational *and* medical use.<sup>3,4</sup>

Among the states that have legalized cannabis use, there are different state requirements to purchase (e.g., a minimum age requirement 18–21 years for the user; oversight and regulatory filings for the vendor).<sup>5</sup> However, it should be emphasized that under the Federal Control Substance Act (CSA), cannabis remains a Schedule 1 controlled substance. This means that cultivation, distribution, and/or possession of any or all of the 426 related chemical entities of

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cannabis, and more than 60 cannabinoid compounds, including hemp-derived cannabidiol (CBD), delta-9 tetrahydrocannabinol (THC), and, of interest here, delta-8 THC, are federal drug offenses.<sup>6–8</sup>

However, given recent changes to state legislation surrounding cannabis, the legal status of delta-8 THC cannabis is currently under debate. U.S. Federal legislative decision making may have also contributed to the confusion. In 2018, the Agricultural Improvement Act (the Farm Bill) was signed into law.<sup>9</sup> The Farm Bill removed hemp, or cannabis and cannabis derivatives at concentrations of no more than 0.3% THC, from inclusion in the CSA, excluding these products from the Schedule I definition of cannabis.<sup>9</sup>

However, this statute became commonly misinterpreted as wholesale *legalization* of all *non*-delta-9 THC products, notably, delta-8 THC.<sup>10</sup> As a result of this perceived legal “loophole,” a rapid increase in the unregulated sale of delta-8 THC products in various storefronts and across the internet throughout the United States has been observed.<sup>10</sup> Three states, Delaware, North Dakota, and Utah, attempted to address this issue by explicitly prohibiting delta-8 THC from being shipped within and from other states. However, other states have not followed suit. This situation has alarmed federal regulators, such as the U.S. Food and Drug Administration (FDA). It has expressed concerns about the psychoactive and potential adverse effects of delta-8 THC, as well as illegal online marketing of unapproved and unsafe versions of products in an uncertain regulatory environment.<sup>11</sup>

Previous studies have conducted content analysis of online vendors in states that have comprehensive product bans to assess compliance with federal and state rules, for example, tobacco and nicotine vendor mandates.<sup>12,13</sup> Other studies have analyzed illicit cannabis cryptocurrency markets and compliance with regulations in other countries, and performed limited social media surveillance, yet few have examined compliance of online vendors with state and local laws relating to CBD or THC compounds.<sup>14,15</sup> Specifically, no existing research to our knowledge has assessed or characterized the connection between social media and direct-to-consumer sale of delta-8 THC, while also assessing online vendor compliance with state laws that specifically prohibit delta-8 THC sales.

To address this research gap, we conducted a structured social media and simulated shopper study to identify specific characteristics of delta-8 THC product sellers and assess their compliance with state sales bans,

building on earlier methodologies.<sup>16,17</sup> We characterize how online cannabis vendors are marketing and selling delta-8 THC using social media and online store fronts and assess if they are in potential violation of state-specific sales bans.

## Materials and Methods

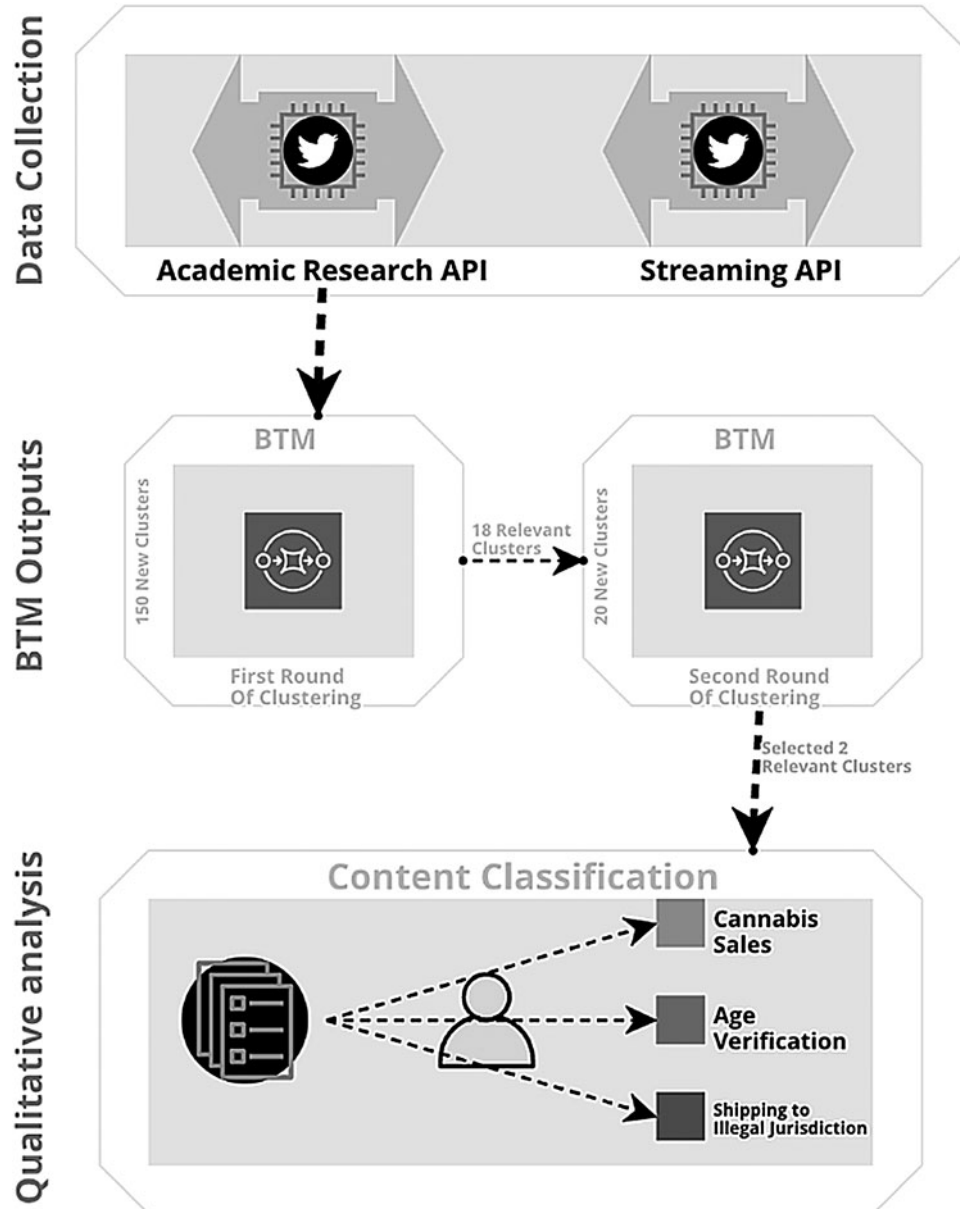
We carried out data analysis in four phases: (1) data collection using multiple Twitter Application Programming Interfaces (APIs); (2) natural language processing to identify topic clusters of tweets with selling activity using the Biterm Topic Model (BTM); (3) inductive content coding and analysis to identify marketing and selling-related characteristics from social media posts through Twitter; and (4) simulated shopping from online vendors (derived from hyperlinks to websites associated with social media posts) to determine selling characteristics and compliance with state regulations. A summary of the methodology is provided in Figure 1.

### Data collection

We first conducted manual searches of delta-8-related posts on Twitter to identify keywords and hashtags associated with delta-8 THC conversations and mentions. Twitter was chosen as the social media platform to conduct this study due to the availability of data access and based on prior studies that have identified illegal drug sales on the platform.<sup>18,19</sup> From this initial search, we identified a set of keywords that Twitter users commonly used in delta-8-related posts (Supplementary File).

Both the Twitter public streaming API and Twitter academic research API were used to collect Twitter delta-8 posts. This approach was used to collect a more representative sample of tweets associated with delta-8 THC by using both retrospective and prospective data over a prescribed time period between January and March 2021. This broad timeframe was split into five different time periods (January 7–February 27, January 28–February 21, February 22–March 18, March 19–April 8, and April 8–April 28) for five sets of BTM modeling. Note for the academic API data collection, the API had a limit of 300 queries per 15-min window, so the “next\_token” feature was used to collect data continually between all queries to ensure that all available data in the given time period were collected.

The Twitter data field categories analyzed for this study primarily consisted of text, including the



**FIG. 1.** Methodology visual representation of data collection, BTM outputs and qualitative analysis. BTM, biterm topic model.

following fields: Text, Link, ID associated with the tweet, username (de-identified and not disclosed in this study), user link, author ID, API type, and tweet creation time and date.

#### Analysis

To analyze large volumes of data collected from Twitter, we utilized an unsupervised machine learning ap-

proach that leverages natural language processing to generate distinct topics and word groupings from a large corpus of tweets. Specifically, the BTM is a commonly used topic modeling approach that has shown a high degree of efficiency when analyzing short text documents, especially for Twitter, given that tweets are often short and limited to 280 characters.<sup>20,21</sup> With a given number  $k$ , BTM analyzes word pairs in each

text to build  $k$  topic models, and then assigns one of the  $k$  topics to each short text. In BTM modeling, the coherence score is typically used to measure how similar the outputted topics are to each other. For each set of our BTM results, the coherence scores were calculated and checked to ensure that the topics are interpretable to human coders.

### Content coding

The second phase of the study involved conducting inductive content coding of tweets outputted by the data analysis phase using BTM. Specifically, we manually coded all tweets using an inductive coding approach to identify themes related to delta-8 THC user marketing and selling discussions. Characteristics of interest that were coded included (1) posts using Twitter as an online modality to market and sell delta-8 THC products; (2) identification of type of cannabis product being marketed/discussed (i.e., THC, delta-8, etc.); (3) sentiment toward products based on user interaction with marketing/selling posts; and (4) discussion of other specific topics related to cannabis and delta-8 THC use.

Language of the tweet was also assessed for any potential regional or country variation associated with the post. First and second authors coded all Twitter posts independently and achieved a high intercoder reliability ( $\kappa=0.92$ ). In case of inconsistent results, authors reviewed and conferred on the correct classification with the last author.

### Website characteristics and simulated shopping

The final phase of the study involved manually annotating tweets to identify posts and sellers who advertised the direct-to-consumer sale of delta-8 THC and other cannabis products through external online websites and e-commerce platforms. While prior studies have focused on social surveillance on Twitter and other social media platforms for cannabis-related behavior, this study sought to identify the linkage between marketing and selling activity on Twitter and how it directly connects to online or e-commerce sites that further enable sales transaction.<sup>12,17,22</sup> Following identification of tweets with a hyperlink or URL that connected to an online cannabis vendor, we used the Internet Corporation for Assigned Names and Numbers WHOIS look-up tool (a directory of domain registrant information) to obtain the website domain name, registrar name, registrant name, registrant country, registrant address, Internet Protocol (IP) or-

ganization, IP server location, and creation date for all identified websites.

Following website identification and WHOIS characterization, simulated online purchases (which terminated upon request for confirmation of payment) were conducted to assess if it was possible to advance through the ordering process for the purpose of buying and shipping delta-8 THC products to a prohibited jurisdiction. Delta-8 THC products (Edibles, Vapes, and Plant) were selected and placed in the shopping cart to simulate online orders, followed by advancing through the account registration process, entering shipping information with addresses where delta-8 THC products are explicitly prohibited under state law, with the order information confirmed without issuing payment.

For the purposes of our simulated shopper approach, we focused on the states of Delaware, North Dakota, and Utah, as they explicitly prohibit the shipping of delta-8 THC to their state, whether through interstate or intrastate commerce. Although the exact legislative language and requirements vary state-to-state, generally, these state laws do one of the following: (1) prohibit any possession or distribution; (2) regulate delta-8 THC specifically as a controlled substance; or (3) consider all forms of THC product illegal under a state's controlled substance laws. Online vendors who allowed shipping to one or more of these prohibited jurisdictions were categorized as noncompliant and those who enabled controls to restrict the sale and/or shipment to prohibited areas were categorized as compliant.

### Results

A total of 1,291,346 twitter posts comprising 399,706 unique Twitter user accounts were collected from the Twitter public API and academic API based on the cannabis and delta-8 THC keywords utilized. From this Twitter corpus, after removing all retweets and duplicated tweets, 698,494 tweets were used for BTM modeling. After applying BTM to identify specific topic clusters associated with marketing and selling queues, we identified 122,000 tweets that were highly correlated with these topic clusters and manually reviewed them using our inductive coding scheme. The coherence score of generated 20 topics ( $k=20$ ) was  $-1628$ , making  $k=20$  the most suitable option for providing detailed and discrete topical clusters.

Within the 150 topics in total outputted, we then chose 18 clusters containing word groupings associated with drug-related marketing and sales (i.e., topics that address the objective of the study). Specifically, these word

groupings tended to include words associated with transactions (e.g., “buy,” “sell,” “discount”) and specific drugs (e.g., “thc,” “weed,” “cannabis,” “delta”). A second round of BTM modeling was done for this specific corpus, generating a second round of 20 more distinct topic clusters. Two of these clusters (clusters 5 and 6) contained relevant topics related to marketing and selling activity of delta-8 THC product, resulting in a final dataset of 7085 (0.55%) tweets that were then manually annotated for characteristics of interest.

### Delta-8 Twitter advertising

Inductive content coding detected a final corpus of 2023 ( $n=28.55\%$  of the final data generated from our BTM phase) posts that were advertising various products on Twitter. These tweets were associated with content marketing or selling cannabis and delta-8 THC products directly to the consumer using different methods, including providing contact information (e.g., phone number, email, encrypted communication account username, etc.) and redirecting users to other Internet sites and platforms to shop for products using e-commerce tools (see Fig. 2 for examples). Breakdown of selling by product was 34.7% delta-8 ( $n=1309$ ), 21.7% THC ( $n=439$ ), 11.27% cannabis vaping ( $n=228$ ), 1.13% synthetic ( $n=23$ ), 1.08% CBD ( $n=22$ ), 0.05% Delta-10 ( $n=1$ ), and 13.39% products not related to cannabis or hemp-derived products ( $n=271$ ).

Written language of tweets revealed that the majority of delta-8 THC advertisement was written in English ( $n=1303$ ; 99.54%), whereas relatively few were written in Greek ( $n=3$ ; 0.15%), Japanese ( $n=2$ ; 0.1%), and Arabic ( $n=1$ ; 0.05%). Advertisements included co-occurring themes of discussing the legal status of delta-8 THC, providing discount codes, and claims about legal allowable 0.3% THC limit for products.

### Website characteristics and simulated purchases

In total, 110 unique hyperlinks were identified and reviewed from the 7085 tweets that specifically marketed the sale of delta-8 THC direct-to-consumer. Simulated orders were conducted in January 2022, to identify websites that were noncompliant by allowing ordering and shipping of a delta-8 THC product to a consumer address in a prohibited jurisdiction. Of all the websites reviewed for products marketed and sold on their website, 65.45% ( $n=73$ ) specifically offered the sale of a delta-8 THC product at the time of review.

Stores that were reviewed, but did not specifically offer a delta-8 THC product, often marketed and advertised

other addictive products such as nicotine vaping devices and cannabis flower and edibles. Among the identified online delta-8 THC online vendors, only 46.36% ( $n=51$ ) used any form of age verification when clicking on the homepage/hyperlink for the site (e.g., entering a birth date or binary age classification for over 18/21 years old). Another potential concern detected was that the majority of websites (54.55%,  $n=60$ ) did not report a physical address on their website.

Once a website was confirmed as offering a delta-8 THC product, a representative product was placed in the website’s e-commerce shopping cart and authors progressed through the ordering process (e.g., account creation, confirmation of products to purchase, shipping information, and request for payment). Different simulated orders were placed for three distinct state addresses in Delaware, North Dakota, and Utah at different instances. Based on this approach, we observed that 91.78% ( $n=67$ ) websites were noncompliant, 5.48% ( $n=4$ ) were fully compliant (prohibited sale to all three jurisdictions), and 2.70% ( $n=2$ ) were partially compliant (prohibited sale to less than all the three jurisdictions). Furthermore, only 11.94% ( $n=8$ ) of noncompliant websites used a form of ID verification (i.e., requiring proof of age or identity to finalize order) during point-of-sale.

All vendors who restricted the sale of delta-8 THC products to Delaware, North Dakota, or Utah had specific online restriction measures that included a form of messaging, informing the customer that the address they entered was prohibited for shipping of delta-8 THC products. In addition, for those websites that used a third party ID verification system ( $n=2$ ), this additional control also restricted delta-8 THC from being purchased after a prohibited address was already entered during the simulated order, ensuring the vendor exercised compliance in preventing the order from taking place. Figure 3 is a screenshot of an example of an online e-commerce control that restricted online sales of delta-8 THC to prohibited jurisdictions. Delta-8 THC vendors who were categorized as partially compliant generally included a nonunanimous restriction on the location of shipping addresses among the three states.

Cross-referencing WHOIS data, the geographical location for compliant, noncompliant, and partially compliant vendors was also recorded based on the IP address information (including both U.S. and international IP locations). IP server locations for the 67 noncompliant websites comprised 64.18% ( $n=43$ ) located in the United States and 35.82% ( $n=24$ ) in international

Get #Delta8THC online now at the best prices online with this 15% OFF Direct Delta 8 coupon! Legal #vape, #gummies, #tinctures and more.

SHOP >

#coupons #discounts #promos #cannabis #marijuana #hemp #weed #shopping #plantlife #herbs #fun #SaveOnCannabis



Y'all ready for the RIFT?

Is DELTA 8 THC LEGAL? 🌿

Yes, it is legal and was passed in 2018 with the Farm Bill.

Help me CELEBRATE my new LAUNCH. 🎉

Use code "dgi" for \$5 off your first purchase!



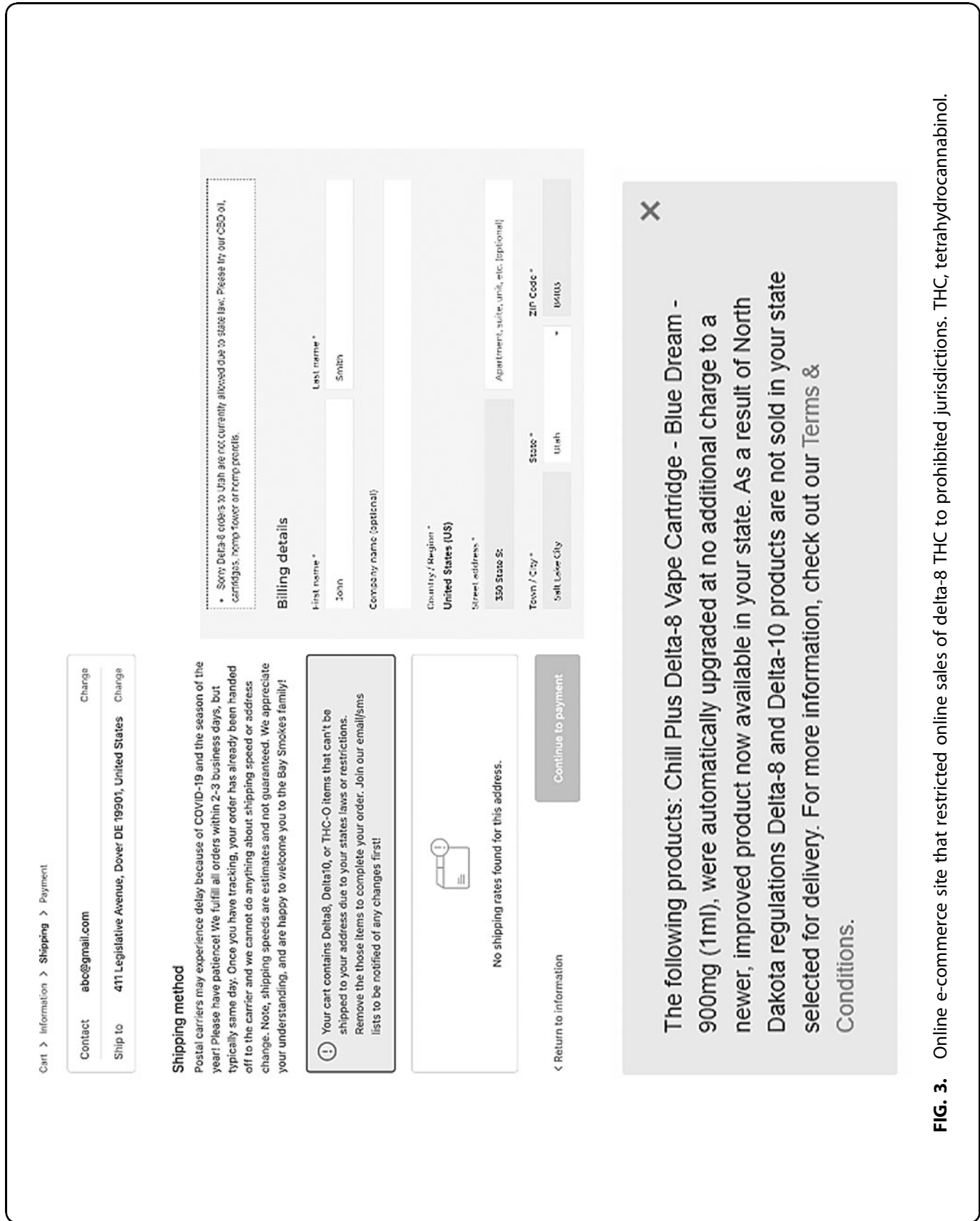
EFFEX Delta 8 Disposable Device: Guava Purp (Indica), Insane Punch (Hybrid), Watermelon Zkittlez (Indica)

Features: Disposable Vapor System, Battery: 280mAh | Rechargeable, Delta 8 Distillate & Terpenes

These Products Contains Less Than 0.3% THC Content



FIG. 2. Example delta-8 product advertising found on Twitter.



**FIG. 3.** Online e-commerce site that restricted online sales of delta-8 THC to prohibited jurisdictions. THC, tetrahydrocannabinol.



**Table 1. Store Count by Compliance, Internet Protocol Server Location, Age Verification, and Hosting Company**

Testing date	Compliance	Number	Internet protocol server location		Age verification homepage		Hosting company	
			United States	International	Yes	No	GoDaddy.com	Other
January 25	Non-compliant	67	43	24	31	36	29	38
	Compliant	4	1	3	2	2	1	3
	Partial compliant	2	1	1	1	1	0	2
	Other*	37	26	11	17	20	12	25

jurisdictions. Country breakdown for international IP server locations included 20 (83.33%) from Canada, and 1 (4.17%) each from Belgium, Bulgaria, Germany, and Singapore. Of the four fully compliant delta-8 THC vendors, IP server locations were exclusively from the United States ( $n=1$ ) and Canada ( $n=3$ ). Two partially compliant vendors were split between the United States and Canada (see Table 1 below).

### Discussion

To our knowledge, this is the first study that used a multiphase methodology examining social media posts, websites, and e-commerce sellers to assess the characteristics of online marketing, selling, and compliance of hemp-derived cannabinoids. Using our data mining and unsupervised machine learning approach, this study detected thousands of tweets marketing the sale of delta-8 THC, leading to unique hyperlinks directly enabling direct-to-consumer purchasing opportunities for delta-8 THC.

Greater than 90% of these online delta-8 vendors were found to be noncompliant with regulations in states with bans at the time of the study. Simply put, online vendors we observed appeared to actively market and sell delta-8 THC, to consumers in states prohibiting the substance, using both social media marketing and e-commerce platforms. It is apparent that there is a substantial need for further research and evaluation of enforcement of state and federal cannabis laws in the United States for online sales.

Specifically, patchwork legislation across the federal and state level has created uncertainty for consumers about the legal status of cannabinoids and “loopholes” for online vendors. While federal laws prohibit the cultivation, distribution, and consumption of cannabis products, a large portion of states are rapidly legalizing cannabis for both medical and recreational purposes. Some states mirror federal laws and prohibit cannabis, including Delaware, Utah, and North Dakota, the states chosen for analysis in this study. These conflictual and ambiguous controlled substance laws have implications due to their interpretations, both for consumers and professionals, whether law enforcement or retailers.<sup>23</sup>

Importantly, it provides incentives for selling both licitly and illicitly, or diverting product from legitimate sources to states that prohibit its use, a situation similar to other case studies of pharmaceutical diversion across country lines, which can lead to public safety concerns.<sup>24,25</sup> This situation can therefore result in the illegal sale of unregulated cannabis products. This puts into jeopardy legitimate access approaches for patients and vendors and also introduces challenges for the legal cannabis system that may be undermined by illicit sales.

The situation is not simply one of regulatory comity. Regulators such as the U.S. FDA have expressed safety concerns about the psychoactive and intoxicating effects and potential adverse effects of delta-8 THC.<sup>11</sup> Indeed, manufacturing of delta-8 THC under Farm Bill mandates may not exceed the 0.3% THC limit set, yet alarmingly high levels of the main cannabis psychoactive substance delta-9 have been found inside tested product (e.g., more than 23% delta-9 in a review of 52 different Delta-8 THC products).<sup>26</sup> Further, the FDA recently issued warning letters to five companies illegally marketing and selling unapproved delta-8 THC products online, which claimed therapeutic uses.<sup>11</sup> Hence, poor policy clarification has resulted in the proliferation and sale of unregulated delta-8 THC products, thereby increasing the potential for adverse health impacts associated with this and other unregulated cannabis use.<sup>27,28</sup>

Many other areas of policy confusion exist, complicating oversight and increasing safety risks of an absent oversight system. For example, U.S. Supreme Court rulings provide the federal government the power to criminalize the production and use of homegrown cannabis, regardless of state law for medicinal purposes,<sup>29</sup> currently in direct conflict with state-based measures that allow for the possession, cultivation, or distribution of cannabis under local laws. However, then, U.S. Congressional action prohibited the Department of Justice from taking any action intended to interfere with state implementation of procannabis legislation.<sup>30</sup> Finally, federal enforcement of the CSA has been

inconsistent across administrations, further confusing appropriate implementation of cannabis laws.<sup>31,32</sup>

One critical area of policy is a major obstacle in safety policy. All social media and other Internet platforms (such as Twitter) are currently protected by the federal Communications Decency Act of 1996; specifically, Section 230(c)(2) “provides immunity from civil liabilities for information service providers that remove or restrict content....”<sup>33</sup> This allows platforms, such as Twitter, which may host harmful user-generated content or content that promotes illegal products, to shield themselves from any liability that arises from said content.

In this regime, platforms self-police (or not) content on the platform, including uneven application of their own terms and conditions that prohibit sales of contraband goods and services (that explicitly include “drugs and controlled substances”). This has led to inadequate content moderation and lack of proactive elimination of illicit content, and enables illegal sellers to continue their product sales. These deficiencies are evident in prior studies that have identified Twitter as a source of advertising and direct-to-consumer access to other illegal health-related products, including opioids, illicit drugs, and unproven COVID-19 products.<sup>19,34</sup>

Results of this study provide early evidence that the unregulated sale of novel cannabis and hemp-derived cannabinoid products (such as delta-8 THC) is likely to continue. Unregulated markets of recreational and medicinal drugs pose unique concerns to public health, particularly in the context of products that are untested, unregulated, and make specific health claims.<sup>35</sup> Delta-8 THC, which fits these categories, is no exception and requires more coherence on policy, monitoring, and enforcement to avoid potential harms associated with a digitally enabled unregulated market.<sup>36</sup>

### Limitations

A limitation during the data collection process is the use of Twitter academic research API to collect data retrospectively for a subset of the sample, as this may impact the internal reliability of data collection approach over time. In particular, the streaming API collects Tweets as they are being posted, thereby capturing a sample of all Tweets with the given keywords. The academic research API is used to collect Tweets for specified time periods and may have different results.

However, this approach was taken to achieve more comprehensive coverage of tweets on the topic. It is also possible that some users deleted or hid their Tweets, some users got suspended, and some tweets were deleted

by Twitter due to content violation, so the academic research API would not be able to capture these data compared to the streaming API. A further limitation is the incompleteness of the simulated shopping methodology, as the methodology did not involve actual purchases of delta-8 THC product to confirm they would be physically shipped to a requested location. In addition, in the event a prohibited delta-8 THC product purchase was completed, and payment went through, it is also possible that the order could be refunded or remain unfulfilled due to other compliance steps taken by the vendor. These limitations limit the generalizability of study results that focus on measuring compliance of online vendors examined.

### Data Availability

The raw data supporting the conclusions of this article will be made available by the authors in a de-identified and aggregated format.

### Ethical Compliance

Not applicable/not required for this study. All information collected from this study was from the public domain and the study did not involve any interaction with users. Any user identifiable information was removed from the study results.

### Authors' Contributions

M.C.N., T.J.M., and V.P. conducted data analyses. All authors contributed to the design, formulation, drafting, completion, and approval of the final article.

### Author Disclosure Statement

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## Supplementary Material

### Supplementary File

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### Abbreviations Used

APIs = Application Programming Interfaces  
 BTM = bitern topic model  
 CBD = cannabidiol  
 CSA = Control Substance Act  
 FDA = Food and Drug Administration  
 IP = internet protocol  
 THC = tetrahydrocannabinol