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Short report

Evidence of the emergence of illicit benzodiazepines from online drug forums

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Illicit or 'designer' benzodiazepines are a growing contributor to overdose deaths. We employed natural language processing (NLP) to study benzodiazepine mentions over 10 years on 270 online drug forums (subreddits) on Reddit. Using NLP, we automatically detected mentions of illicit and prescription benzodiazepines, including their misspellings and non-standard names, grouping relative mentions by quarter. On a collection of 17 861 755 posts between 2012 and 2021, we searched for 26 benzodiazepines (8 prescription; 18 illicit), detecting 173 275 mentions. The rate of posts about both prescription and illicit benzodiazepines increased consistently with increases in deaths involving both drug classes, illustrating the utility of surveillance via Reddit.

Introduction

Nonmedical benzodiazepine use and related harms are a global public health concern[1] and are on the rise in the USA.[2] Benzodiazepine-involved overdose deaths have been increasing in recent years.[1,3] These overdose deaths have been attributed to benzodiazepine nonmedical use alone or in combination with other substances such as alcohol or opioids.[2,3] Both prescription benzodiazepines and illicit (i.e. those not marketed in the USA for medical purposes) have been involved in overdose deaths.[4]

The availability and use of illicit benzodiazepines (a.k.a., 'designer' benzodiazepines) is a growing trend in the USA, and recent studies have reported on the harms associated with illicit benzodiazepines such as etizolam, clonazolam, diclazepam, and flualprazolam.[3,5,6] Recent toxicology data from emergency department visits and post-mortem studies have confirmed increases in overdoses involving illicit benzodiazepines.[4,7] However, there has been limited attention to this growing aspect of the overdose crisis as health practitioners and public health officials may be unfamiliar with illicit benzodiazepines given the limited inclusion of these substances in traditional substance use surveillance systems such as the National Survey on Drug Use and Health. It is difficult to detect emerging designer benzodiazepines and quantify trends in the availability of these substances.[8] Consequently, we utilized large-scale online data from drug forums to assess the most frequently discussed benzodiazepines and explore trends over time.

Methods

Data

We analyzed data from Reddit, a leading social media platform that hosts many online drug forums and has been used previously in drug use epidemiology.[9] We included data from 270 Reddit drug forums or 'subreddits' (Supplementary table A1). These subreddit names were curated from related literature and past work and reviewed by experts from the Centers for Disease Control and Prevention (CDC). We collected all publicly available data from these subreddits that were retrievable via the Python Reddit API Wrapper (PRAW) (available at: https://praw.readthedocs.io/en/latest/, 19 March 2022, date last accessed).

Following data collection, we searched each post for the presence of benzodiazepine keywords. These keywords included generic names (e.g. alprazolam), and common trade names (e.g. Xanax®). Additionally, since medication/drug names are often misspelled on social media, we used a validated tool to automatically generate common misspelled versions for the medication keywords (e.g. '*klonazepam*', '*colnazepam*' and '*clonozepam*' for clonazepam).[10] Finally, where appropriate, we also included street names curated by collaborators from CDC for specific substances (e.g. '*zannies*' and '*z-bars*' for alprazolam). We identified both prescription and illicit benzodiazepines. An initial list of known illicit benzodiazepines was provided by CDC based on toxicology testing from mortality samples. To augment this list, we searched all Reddit posts retrieved for any word ending with '*zepam*' and '*zolam*', manually reviewed each term retrieved, and added those that represented benzodiazepines to our list. Ultimately, we analyzed 26 benzodiazepines, including 8 prescription benzodiazepines and 18 illicit benzodiazepines (Supplementary table A2). We also included counts for unspecified benzodiazepine mentions.

Benzodiazepine mentions

We searched all posts retrieved for the above benzodiazepine keywords and mapped any matches to the generic name of the substance. For each benzodiazepine, we grouped counts of mentions by quarter. Since the number of Reddit subscribers and posts has steadily increased over the years, it was unsurprising that mentions of these substances have also increased over time. To obtain relative rates of benzodiazepine mentions, for each substance, we normalized

the post count of mentions by the total number of posts from all chosen subreddits within the same period. We analyzed the trends in rates of benzodiazepine mentions over the 10-year period from January 2012 to December 2021 via visualization of the quarterly data points (figure 1). We did not perform any statistical testing. We compared the trends between individual benzodiazepines and also between prescription and illicit benzodiazepines. All analyses were conducted in Python (Version 3.8).

Results

We collected 17 861 755 posts from the 270 subreddits between January 2012 and December 2021; 173 275 mentioned any benzodiazepine, including non-specific references such as '*benzo*' and '*tranq*', which could not be mapped to specific substances. Across all years, alprazolam had the highest number of mentions among prescription benzodiazepines (36 318), while etizolam had the highest number of mentions among illicit benzodiazepines.

Figure 1a shows the rates of mentions over time for prescription and illicit benzodiazepines. The rate of posts mentioning both classes consistently increased over the years, and rates were higher for prescription compared to illicit benzodiazepines. However, illicit benzodiazepine mentions experienced a larger percentage increase over time—the average mention rate for 2021 (0.99 per 1000 posts) was almost 16 times higher than that of 2012 (0.06 per 1000 posts); for prescription benzodiazepines, this increase was ∼4-fold.

Among posts mentioning benzodiazepines, illicit benzodiazepines on average comprised 15% of total mentions, and remained relatively consistent between July 2018 and December 2021 (figure 1b). Supplementary table A3 shows the annual distribution of individual illicit benzodiazepines among all illicit benzodiazepines. The 5 most frequently mentioned benzodiazepines account for at least 80% of all illicit benzodiazepines, with the top 3, etizolam, clonazolam, and flualprazolam, accounting for ∼70% of mentions. Among the top 5, etizolam and diclazepam experienced a gradual decrease in proportion among all illicit mentions over time, while flualprazolam and clonazolam experienced gradual increases.

Discussion

The pattern of increase in the rate of posts about prescription and illicit benzodiazepines is similar to that of increases in benzodiazepine-involved overdose deaths in the USA. Furthermore, leading illicit benzodiazepines that we identified from online forums—etizolam, flualprazolam, clonazolam and flubromazolam—were also the leading illicit benzodiazepines identified in overdoses from CDC and state surveillance systems based on toxicology data.[4] These findings add to the body of literature that suggests online data, particularly from social media, may aid in early detection of emerging substance use patterns of concern and could be used to help inform toxicological testing and the development of assays for new substances of concern. Continued development of NLP methods to

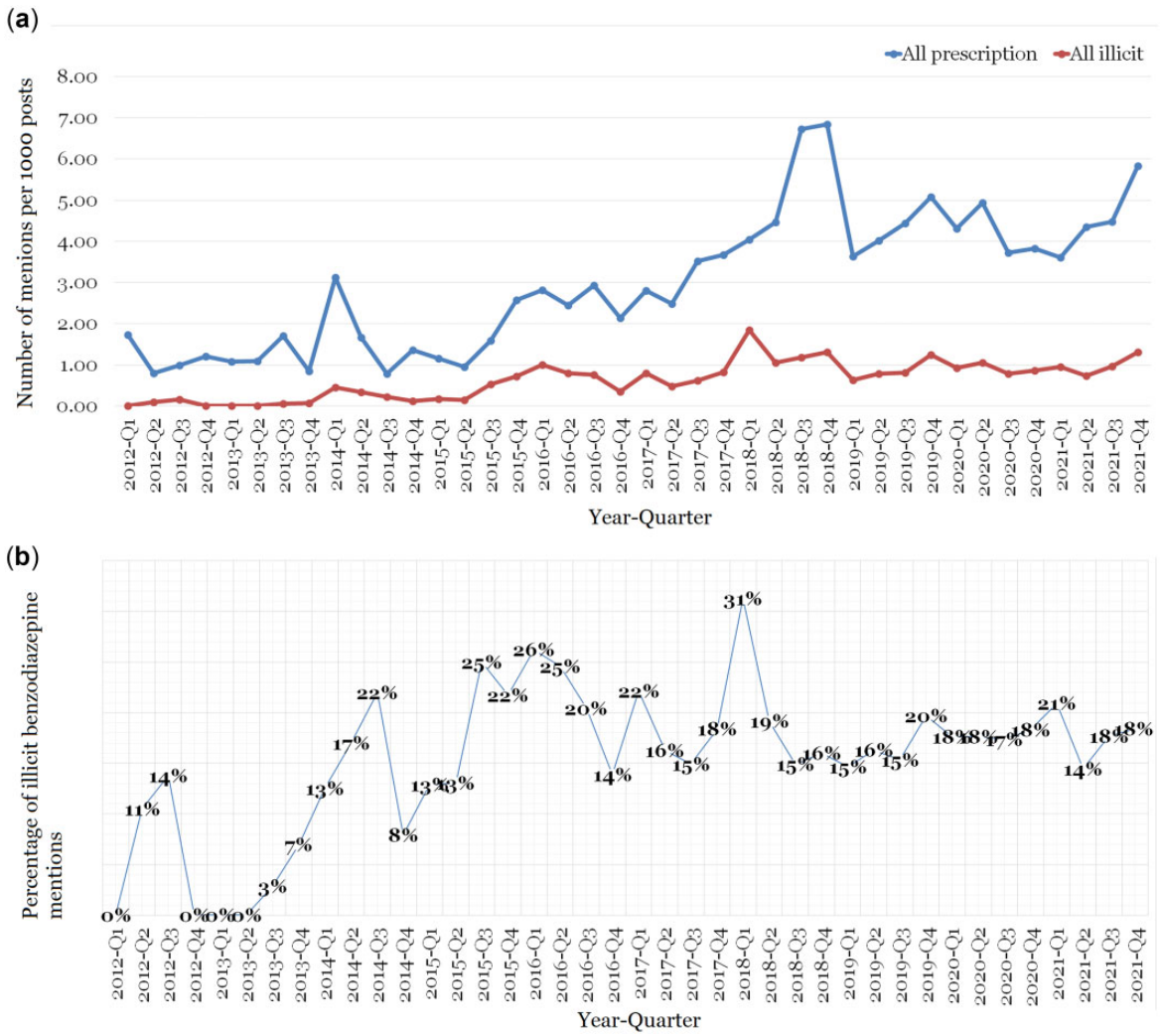

Figure 1 (a) Quarterly rates of mentions for prescription and illicit benzodiazepines. (b) Percentage of illicit benzodiazepines among all benzodiazepine mentions by quarter

identify relevant terms, mis-spellings, colloquial variants will further enhance the utility of these approaches. These early warning signals can also be used by public health, substance use, and clinical practitioners to help tailor prevention, treatment, and response efforts to evolving substance use patterns. Given increasing opioid involvement in benzodiazepine overdoses, these findings have relevance to prevention strategies to address the opioid overdose epidemic including improved naloxone availability and access to medication for opioid use disorder.[4]

Limitations

Some important limitations of this work include that it was not possible to capture all potential drugs mentioned, due to either exclusion of potentially relevant subreddits or imperfect capture of benzodiazepine mentions. Our study attempted to minimize this limitation by including a broad list of subreddits and incorporating methods designed to identify brand, generic and street names of substances. Additionally, the user base of social media platforms such as Reddit may not be representative of the US population and the data do not contain location information. Furthermore, the users of such platforms may change over time, particularly as such forums grow in size. Thus, conclusions derived from online data, however large-scale, should be confirmed and compared with traditional data sources where available.

Nonetheless, our results and their concurrence with known public health trends related to benzodiazepines, demonstrate potential for earlier identification of drug-related trends. Early awareness is a challenging but critical initial step in enabling a more robust and timely public health response to better address rising overdose rates.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Disclaimer

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Conflicts of interest: None declared.

Data availability statement

All data used in this study were publicly available at the time the data was collected. All the data from the mentioned subreddits can be collected via the API described in the paper as long as the data is still publicly avaialble at the time of collection.

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