

Systematic review of surveillance by social media platforms for illicit drug use

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ABSTRACT

Background The use of social media (SM) as a surveillance tool of global illicit drug use is limited. To address this limitation, a systematic review of literature focused on the ability of SM to better recognize illicit drug use trends was addressed.

Methods A search was conducted in databases: PubMed, CINAHL via Ebsco, PsychINFO via Ebsco, Medline via Ebsco, ERIC, Cochrane Library, Science Direct, ABI/INFORM Complete and Communication and Mass Media Complete. Included studies were original research published in peer-reviewed journals between January 2005 and June 2015 that primarily focused on collecting data from SM platforms to track trends in illicit drug use. Excluded were studies focused on purchasing prescription drugs from illicit online pharmacies.

Results Selected studies used a range of SM tools/applications, including message boards, Twitter and blog/forums/platform discussions. Limitations included relevance, a lack of standardized surveillance systems and a lack of efficient algorithms to isolate relevant items.

Conclusion Illicit drug use is a worldwide problem, and the rise of global social networking sites has led to the evolution of a readily accessible surveillance tool. Systematic approaches need to be developed to efficiently extract and analyze illicit drug content from social networks to supplement effective prevention programs.

Keywords illicit drug prevention, social media surveillance, systematic review

Introduction

Illicit drug use is a foremost global public health issue facing individuals, families and society contributing to significant morbidity among youth and adults.¹ In 2014, over a quarter of a billion adults worldwide used drugs, and of these individuals 29 million are estimated to suffer from a drug use disorder and 12 million inject drugs. It is estimated that 14% of drug users are living with human immunodeficiency virus. In 2014, there were >207 000 drug-related deaths worldwide. Global regional differences exist in consumption patterns of illicit drug use; for example, recent trends indicate cocaine use is greater in western and southern European countries whereas amphetamine use is higher in Northern and Eastern Europe.^{1,2,3}

The prevalence of illicit drug use among US young adults was 21.5% and 22% among those transitioning into young

adulthood (18–25 years).⁴ In the USA, the most commonly used drugs are tobacco, alcohol, cannabinoids, opioids, stimulants, club drugs, dissociative drugs (Phencyclidine, Salvia divinorum, etc.), hallucinogens, inhalants and prescription medications (pain relievers).⁵ Cannabis is rated as the most preferred used drug globally with overall use not falling and increasing in some populations.¹ Adderall is also widely used by young adults.⁶ Among first-time illicit drug users, ~25% use non-medical prescription drugs, 6.3% use inhalants and 2% hallucinogens.⁵ Among young adults, there is also a high prevalence of polydrug use: i.e. a combination of

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prescription drugs and illicit drugs.⁷ The most commonly used substance is alcohol: 42% of young adults have indulged within the past 30 days.⁴ Prescription drugs are readily available in doctors' offices and home medicine cabinets and can be bought anonymously without a prescription from drug dealers and through the internet. Emerging new recreational drugs among young adults include synthetic cathinones 'bath salts,' synthetic cannabinoids and *Salvia divinorum*.^{6,8,9}

Globally, illicit drug use is highest among 18–25 year olds,¹ an age range shared by most active users of internet/social media (SM).^{9,10} Social networking sites (SNSs) are websites where users can share user-created content in an online community.¹¹ Users exchange ideas, personal news and photographs while also communicating with friends, family, strangers and with others who have similar interests.^{12,13} Twitter and Facebook are the most popular SNSs with over 1.2 billion monthly worldwide visitors.^{14,15,16} Young adults most often use SNS for communicating, entertainment, event planning, and to send and receive messages, meet people and obtain information.^{15,16,17} SNS provide a venue for both synchronous (e.g. Message Boards, Instant Messaging and Skype) and asynchronous (e.g. MediaWiki, Padlet and Popplet) communications that are low cost, private and hidden, which can make them difficult to monitor.^{18–20} Young people often discuss substance use on informal networks. Therefore, SNS could be a useful tool to monitor illicit drug use.¹⁴ Today SNS provide access to data enabling epidemiologists to detect credible public health threats such as geographic trends in disease outbreaks.^{21,22} Syndromic (symptom) surveillance collects and evaluates health data and clinical conditions that impact the public's health. Syndromic surveillance of social network sites is now used for tracking diseases such as the flu and drug safety monitoring. Common today is the use of SNS for tracking internet pharmacy pricing and illicit drug sales.^{23–27} Worldwide the demographics (age, gender, socio-economic status, geographic location, etc.) of those who use illicit drugs can fluctuate dynamically over time.^{1,4,28} Every year new types of drugs and drug combinations entice millions of young people to use drugs.^{7,8} Increasingly, epidemiological surveillance of websites such as blogs or Twitter messages are used as sources to collect global health data.^{29,30}

US government surveillance systems have evolved to monitor illicit drug use. The purpose of existing government surveillance systems is to examine population trends in use regarding types of illicit drugs, overdose, deaths, and to identify health-risk behaviors, and gaps in prevention health practices.^{4,6,23,28,31–35} Traditional surveillance methods in the USA have relied on mandatory and voluntary reporting by

physicians, the National Poisoning Data System and laboratories of governmental agencies.^{23,31,32} Healthcare providers and diagnostic laboratories report the data either by legal mandate or voluntary agreement.³¹ Other indirect methods of surveillance include vital statistic reports from hospital emergency departments (EDs), substance abuse treatment centers, poison centers, medical examiners and police departments.^{33,36} Current surveillance methods for illicit drug use also include national surveys such as the National Survey on Drug Use and Health (NSDUH) and the Behavioral Risk Factor Surveillance System (BRFSS).^{4,34} NSDUH provides both national and state data on the use of tobacco, alcohol and illicit drugs. BRFSS collects data on illicit drug use, health-risk behaviors and preventive health practices. The surveys are delivered to adults through random digit dialing and administered through state health departments in collaboration with the Centers for Disease Control and Prevention (CDC).^{4,37} The Monitoring The Future (MTF) study (sponsored by the National Institute on Drug Abuse (NIDA)) and the Youth Risk Behavior Survey (YRBS; sponsored by the CDC) survey high school students using the US mail system and provided data on the availability of illicit drugs to youths. The MTF study found that 90% of study participants indicated that it was 'fairly easy' or 'very easy' to obtain illegal substances.³⁵ These large population-based surveys, e.g. MTF, NSDUH are conducted annually with results reported 1–2 years after collecting the data. Furthermore, these cross-sectional surveys rely on participant self-report; as a result, they lack the ability to track immediate and emerging drug trends. These may include different routes of administration (e.g. marijuana vaporizers), new substances (e.g. synthetic cathinones 'bath salts') or unique drug combinations intended to entice more users.³⁸

Established in 1972 in the USA, Drug Abuse Warning Network (DAWN) was operated by the Substance Abuse and Mental Health Services Administration (SAMHSA) and the Department of Health and Human Services (HHS). DAWN collected data on substance use and abuse from non-federal hospital EDs' from 37 metropolitan states.³⁹ DAWN was discontinued in 2011, in the last year DAWN estimated that 2.5 million illicit drug ED visits occurred.³⁹ The Research Abuse Diversion and Addiction-Related Surveillance (RADARS) is a monitoring system operated by the Center for Applied Research on Substance Use and Health Disparities (ARSH) and the National Drug Control Strategy (NDCS). RADARS collects quarterly and annual data from multiple police agencies, poison centers, pharmaceutical boards and health departments in 49 US states. Data collection includes field surveys, personal interviews, telephone and mail surveys, computer-assisted interviews

and focus groups, as well as operations that involve tracing hard-to-find interviewees.⁴⁰ The internet makes the sale of illegal drugs very easy and provides anonymity for both dealers and users.⁴¹ In 2014, RADARS started a web monitoring program that conducts surveillance via the Web Monitoring program.⁴⁰ The Web Monitoring system tracks posts on the internet, which are then organized by trained team coders to review and code the data on illicit drug use.⁴² Such data may also be useful as early warnings of specific illicit drug outbreaks.

Despite recent efforts toward more sophisticated web-based monitoring (e.g. RADARS), many of the current surveillance methods have limitations, including difficulties linking data, reliance on retrospective cross-sectional surveys, delayed reporting, inadequate notification system and an inefficient detection of new or emerging illicit drug use.^{21,31,36,43} As a result, regional illicit drug use may remain unknown to healthcare professionals until overdoses or deaths are encountered in the emergency room. Table 1 provides a summary of the US national surveillance systems.

Objective

Current knowledge of the use of SM as a surveillance tool for illicit drug use remains very limited. To address this limitation, we examined studies that focused on how social media has

been used to identify illicit drug use. We conducted a review of the SNS literature using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.⁴⁴ Specifically, we examined studies that collected illicit drug data from internet web forums (e.g. Tweets, Twitter, Facebook and YouTube)^{45–51} and evaluated each study design, methods used, results, limitations and implications for an illicit drug surveillance system. Also, we provide recommendations for promising strategies for collecting, analyzing and interpreting SNS data to monitor illicit drug use. Our effort to systematically review studies examining communications about illicit drug use that occur in public dialogs on SNS may potentially uncover trends and patterns in illicit drug use that can inform the development of intervention and prevention programs designed to reduce illicit drug use among youth and adults.

Method

Data sources

A search for articles related to SM surveillance in illicit drug use was performed using the following databases: PubMed, CINAHL via Ebsco, PsychINFO via Ebsco, Medline via Ebsco, ERIC via Ebsco, Cochrane Library, Science Direct, ABI/INFORM Complete and Communication and Mass Media Complete via Ebsco. Boolean combinations of keywords

Table 1 Summary of US surveillance methods

<i>Surveillance method</i>	<i>Administering agency or organization</i>	<i>Overview</i>
BRFSS	CDC	Collects data on health-related behaviors (including drug use), chronic health conditions and preventive health practices Collects data in all 50 US states, the District of Columbia and 3 US territories
DAWN	SAMHSA, an agency in the USA Department of HHS. Discontinued in 2011	Monitors drug-related visits to hospital EDs and drug-related deaths in the USA
MTF	Funded by investigator-initiated competing research grants from the NIDA, a part of the NIH and conducted at the Survey Research Center in the Institute for Social Research at the University of Michigan	Studies the behaviors, attitudes and values of secondary school students, college students and young adults in the USA
NSDUH	SAMHSA, an agency in the USA Department of HHS	Provides national and state-level data on the use of alcohol, tobacco and illicit drugs (including non-medical use of prescription drugs) in the USA
RADARS	Center for ARSH and NDCS	Measures rates of abuse, misuse and diversion of prescription drugs in the USA
YRBS	CDC	Monitors six types of health-risk behaviors that contribute to the leading causes of death and disability among American youth and adults, including alcohol and other drug use

This information was adapted from: <https://nsduhweb.rti.org/respweb/homepage.cfm>, <http://www.cdc.gov/brfss/>; <http://www.monitoringthefuture.org/>, <http://www.cdc.gov/healthyyouth/data/yrbs/index.htm>, <http://www.radars.org/>.

NIH, National Institutes of Health.

used were variations of SM (social network, Facebook, Twitter, tweet), surveillance (infoveillance, infodemiology) and substance abuse (illicit/illegal drug use, drug overdose, substance dependence).⁵² Manual searches of letters to the editor and technical reports were also performed. We also conducted ancestry (i.e. obtaining documents that are cited in an eligible or relevant manuscript) and descendancy approaches (i.e. obtaining documents that cite an eligible or relevant manuscript) in the studies obtained.

Inclusion and exclusion criteria

To be included in the review, studies had to meet the following criteria: (i) original research published in peer-reviewed journals, (ii) primary focus on collecting data on young illicit drug users from SM platforms (Twitter, Facebook and WebForums) to analyze or track trends in illicit drug use and (iii) publication between January 2005 and June 2015. We began our search in January 2005 because the use of SM has dramatically increased since that time.⁵³ Excluded were studies with a primary focus on purchasing prescription drugs from illicit online pharmacies. Gray literature such as dissertations and theses, review papers, reports, newspaper articles, abstracts, letters to the editor and commentaries were excluded.⁵⁴

Data extraction and data synthesis

The initial search yielded 159 704 citations. After applying filters and removing duplicates, the articles were reduced to 27 869. Next, three members of the research team reviewed the papers' titles and abstracts for relevance, duplication and the selection criteria. A total of 295 citations were considered relevant, but 276 did not meet the inclusion criteria; 19 articles were identified for full review. Each article was then independently reviewed, and five studies were removed from the pool because they did not meet the inclusion criteria. The final 14 articles were subjected to full content analysis. The final articles were independently reviewed by three researchers. The researchers evaluated the studies and reached consensus on inclusion for the analysis. Interrater reliability between them for yes/no inclusion decision was 0.90, indicating strong agreement.⁵⁵ Discrepancies in the selection of articles for review were discussed until consensus was reached (see Fig. 1).

Results

Overview of major findings

The heterogeneity among the 14 studies examined precluded a meta-analytic integration. Instead, we provide a comprehensive summary of the 14 studies' design, methodology, major findings and limitations.

Study design

The majority of studies were exploratory, providing descriptive analyses of SM content.^{56–68} Only one study used a qualitative study design,⁶⁹ the others used content analysis of data from SM.

Social media platforms

Two studies analyzed web forums or message boards.^{61,62} Two analyzed data from YouTube.^{60,68} Morgan *et al.*⁶⁰ analyzed more than one SNS, reviewing data from Myspace, YouTube and Facebook.⁶⁰ Five studies analyzed data from Twitter.^{57,63–66} Other SNSs that were analyzed included Facebook and LiveJournal.^{58,67}

Participants

The studies' participants were from the general public, college students, young adults, adolescents, and Myspace and Twitter users. SM users ranged from school-aged children to young adults, with the majority reported between ages 17 and 24 years.^{56–60} One study reported the youngest participant was 11 years of age.⁶⁹ Many participants were college students between 17 and 19 years old who followed musicians, with 43% African American.⁵⁶

Illicit drugs used

A range of illicit drugs were discussed, but the most frequently reported were alcohol, marijuana, tobacco and prescription drugs. Two studies analyzed the illicit use of any prescription drug, and others focused on particular prescription drugs like opioids or Adderall.^{61,66}

Methodology

The selected studies used a broad range of SM tools/applications, including message boards, web forums, Twitter, Facebook, Myspace and blog/forums/platform discussions. A detailed description of each study reviewed is provided in Table 1. Most of the reviewed studies followed a two-step process to track illicit drug trends.^{56–61,63,65–67,69} In the first step, data were collected from the SM chosen for study and prepared for analyses. In the second step, researchers used the data to analyze trends with the help of software or techniques like SPSS⁶¹ and STATA,⁵⁸ Machine Learning Algorithms^{63,64} or Hadoop framework.⁶⁷ In one study, Cameron *et al.*⁶² developed a software application called PREDDOSE, which is a publicly available web forum to collect data and identify emerging trends in drug abuse. The software also helped mechanize the mining of semantic data from web forum content to enable illicit drug abuse research using SM.⁶²

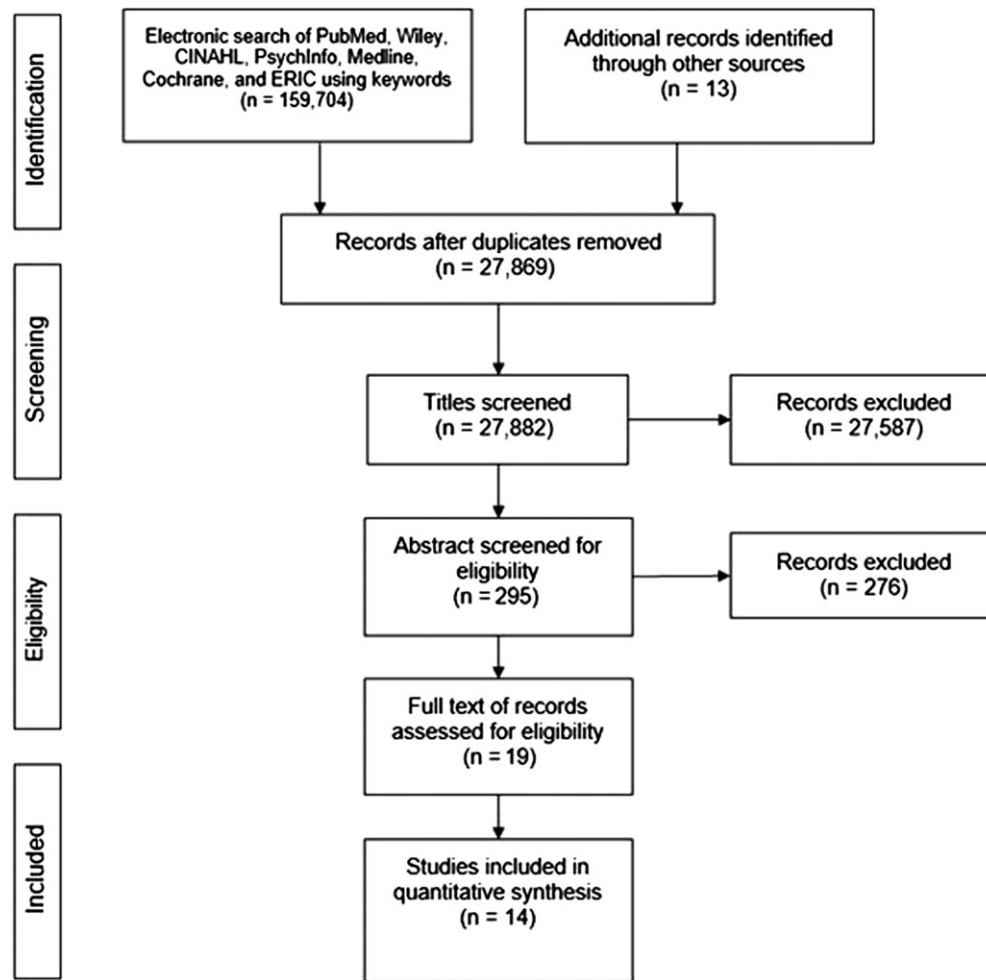


Fig. 1 A systematic review of the literature.

Major findings

All studies reported illicit drug surveillance from SMS sites (e.g. tweets, twitter, LiveJournal and Facebook profiles) was a positive pursuit. However, 57% of the studies ($n = 8$) lacked demographic filters and indicators due to privacy restrictions, presenting issues of sampling bias and limiting generalizability.^{56,57,61–64,67,68} Convenient small samples also limited generalizability.^{60,68,69} Hanson *et al.*⁶⁵ noted their inability to observe actual behavior made it impossible to determine which public tweets corresponded with actual illicit drug use.⁶⁵ Two studies did observe behavior by analyzing storytelling videos on YouTube.^{60,68} However, Moreno *et al.*⁵⁹ questioned the validity of information on Myspace since the studies were examining alcohol reference, which may have been exaggerated.⁵⁹

In the last decade, SM has been used to assess the motivations behind the posting of images and videos of substance use.^{60,67,68} Five of the 14 studies reviewed here used Twitter to track trends in substance use.^{57,63–66} Cavazos-Rehg *et al.*⁵⁶

found that African Americans and Hispanics disproportionately follow @stillblazingtho.⁵⁶ Cavazos-Rehg *et al.*⁵⁷ investigated Twitter sources and found that offline and online social networks influenced health behaviors.⁵⁷ Another SNS, Facebook, was found to have a potential impact on perceptions of peer alcohol use.⁵⁸ A qualitative study of focus groups showed similar results; i.e. SNSs may influence adolescents' positive attitude toward alcohol consumption.⁶⁹ One of the studies suggested that the information in SM can be used by teachers and parents to track how youths interact relative to alcohol use.⁵⁹

Limitations

Our review revealed several overarching limitations of illicit drug surveillance today: (i) information extracted is not always examined for relevance related to illicit drug use and is not always disseminated in the most efficient way, (ii) there is a lack of standardized system or updates and (iii) algorithms to

isolate important data from streaming SM are not well developed.

Discussion

Main finding of this study

In spite of the limitations noted, the current review elicits data that supports the salient role of SNS in providing health professionals the public voice and influences that need to be addressed in programs to combat illicit drug use. The 14 studies selected investigated how SMS and, in particular SNS (e.g. Tweets, Twitter, Facebook, YouTube), have been used to identify illicit drug data acquisition. The research indicates clear implications for SM potential as a useful tool for tracking illicit drug use. If properly analyzed, these publicly available dialogs (e.g. tweets on Twitter) provide a unique and powerful way to understand substance use among young adults, who make up the largest group of users on SNS. For example, Twitter tweets extracted by Hanson *et al.*⁶⁵ include contemporary keywords which identify risk/abusive behaviors e.g. pop, crush, steal, inhale and mimosa among others. Other publicly available tweets provide insight into substance use patterns and the influence of SM. For example, this tweet provides insight into marijuana use: 'Those who don't understand the beauty of weed, purchasing weed, rolling and sharing of weed are outsiders and have no business in our world.' Similarly, this tweet elucidates prescription drug use effect: 'Adderall + Benadryl has put me in a weird awake/tired haze. Relatively certain that I'm saying things i wont [sic] remember in the morning.'^{56,65} (Table 2).

More timely and adequate findings on illicit drug use from SM could help health professionals design early and effective programs to address substance use/abuse. According to Butler *et al.*⁶¹, examining chatter on message boards could lead to a new surveillance model.⁶¹ Also, Cavazos-Rehg *et al.*⁵⁷ concluded that Twitter has useful information that needs to be explored.⁵⁷ Every day new SMS surveillance approaches are being developed, using different resources. For example, Chary *et al.*²³ have proposed techniques to leverage SM to identify patterns of drug usage. Natural language processing can be used to discover statistical structures in the data. Further, Chary *et al.*²³ suggest that machine learning can isolate items from streams of SM and discover the relationships between variables that change over time.²³

What is already known on this topic

The research on SM surveillance suggests many promising directions for future investigations. In all of this research, it

is vital to educate SM users about privacy policies and the potential negative consequences of posting illicit drug use behaviors online using publicly available media. First, sophisticated techniques are being developed in machine learning (triaxial classification scheme, latent Dirichlet allocation and Naïve Bayes) and cloud computing (Hadoop MapReduce Model) that allow researchers to track trends in substance use.^{63,64,67} The Naïve Bayes algorithm, a popular text classification technique, is relatively simple and computationally efficient.⁶³ Second, the influences on illicit drug abuse chatter on the Internet remains largely unknown.⁶¹ Butler *et al.*⁶¹ identified the need for studies on Internet chatter to compare the use of pharmaceutical medications with abuse rates of these drugs found by hospital EDs and poison control centers. This approach would provide valuable information on the association between Internet chatter and levels of illicit drug use in the community.⁶¹ Facebook may be a useful tool to distribute information about alcohol prevention programs, counseling services or alcohol-free events to college students.⁵⁸ Further, research could examine whether SNS can be used to reduce the adverse consequences of alcohol use.⁵⁸ Finally, it would also be valuable to determine which SM platforms are used most for discussions of illicit drug use. This information could potentially lead to the development of a platform to capture discussions about drugs use asynchronously on multiple SM sites. Future research could then lead to a web-based SM monitoring system for tracking illegal drug use.

What this study adds

In order to address research limitations, this review provided a comprehensive evaluation of a number of current studies focused on SMS's role in surveillance of illicit drug use. The results of the current review indicated that there is a clear need to incorporate data mining methods (the process of finding patterns for data sets to predict outcome) into comprehensive surveillance systems to enhance communities', law enforcements' and healthcare agencies' responses to drug use and emerging drugs. However, several methodological concerns are evident in the current literature. First, SM surveillance for prevention of illicit drug use is in its infancy of scientific-technological development. The current focus is primarily on collecting observational and descriptive data similar to other early efforts in health technical services such as, neuro-imaging and computed tomography scanners.⁷⁰ Second, SM surveillance technology is advancing faster than current knowledge as relates to the relationship of human motivation and SM. This is not unexpected in light

Table 2 Review of studies tracking illicit drug trends through SM

References	SM/user/drugs	Design	Method/analysis	Results	Limitations	Implications
Butler <i>et al.</i> ⁶¹	Message Boards that promoted discussion of psychoactive drugs/ NF/ Opioids, Prescription drugs	6 month OCA of three message board posts. Systematic approach to analyze Internet chatter for monitoring potential abuse of opioid drugs	Harvested topics for keywords (e.g. Kadian) Searched with message board search engine. Coders determined if post was abuse-related. Data websites entered into Atlas.ti to identify unique individuals contributing	Captured 48 293 posts, 53% from unique contributors. 78.6% were abuse related and 62.0% encouraged abuse. 1813 posts (4%) contained at least one mention of OxyContin, 940 posts contained mention of Vicodin and 27 posts contained mention of Kadian	50% of visitors to the message boards did not post. Message boards were not randomly sampled	Monitoring internet discussions may relate meaningfully to real-world diversion and abuse. Early warning system for possible trends
Cameron <i>et al.</i> ⁶²	Web forums were cited as Site X, Site Y, Site Z/ NF/ (i) allows discussion of psychoactive drug use; (ii) contains information on illicit drug use	OCA of the use of the PREDOSE platform to analyze SM to find drug abuse practices	Created PREDOSE platform to collect data, automatically code, analyze and interpret the web data	Developed PREDOSE platform to facilitate web-based research on the illicit use of pharmaceutical opioids. Extracted 1066 502 posts of 35 974 users from three different sites	Lack of demographic indicators due to privacy restrictions from web-forum administrators. Practices in general. Geographical location of the users was not considered	PREDOSE Platform is capable of extracting entities, relationships, triples and sentiments from unstructured texts. Platform facilitates web-based research on the illicit use of pharmaceutical drugs
Cavazos-Rehg <i>et al.</i> ⁵⁶	Followers of @stillblazingtho/ NF. Individuals 17–19 years old (54.05%), 42.55% African American, 12% Hispanic, 27.93% students, 21.47% musicians/ Marijuana	OCA of tweet engagement, sentiment, content and demographics of followers of a popular pro-marijuana Twitter handle	2590 tweets from @stillblazingtho were collected for 8 months and analyzed for engagement, sentiment, content and demographics of its followers. Used crowdsourcing. Each tweet was coded by at least three coders	82.06% of tweets were positive about marijuana, 17.64% neutral, and 0.31% negative. Of the positive, 58.72% were jokes or humorous. Of the neutral, 17.4% were inspirational or motivational quotes or messages. Most tweets were alike in their overarching positive sentiment toward marijuana use	Demographics were inferred based on usage/ behavior, not reported. Only analyzed tweets from one twitter handle. Did not examine Twitter marijuana discourse in a general way	Demonstrates the use of Twitter to find and target a more appropriate audience in marijuana prevention
Cavazos-Rehg <i>et al.</i> ⁵⁷	Twitter/ NF. Demographics were 82%	OCA of Twitter. Examined sentiment and themes of	A total of 7 653 738 tweets were collected for	77% of tweets were pro-marijuana, 5% against	Tweets were from only 1 month period. Cannot	Approximately 1 of every 2000 tweets was about

Continued

Table 2 Continued

References	SM/user/drugs	Design	Method/analysis	Results	Limitations	Implications
	ages 17–24, 41% male, 78% African Americans, 73% income <\$20k, 62% single, 17% musicians and 15% students/Marijuana	marijuana-related chatter on Twitter sent by influential Twitter users	1 month in 2014 using Simply Measure—a SM analytics company. An inclusive list of marijuana-related terms from Urban Dictionary/Topsy. 7000 tweets analyzed	and 18% neutral or unknown. For pro-marijuana tweets 10 themes were identified. Most common theme, 77%, was intent to use or craving for marijuana, 17% frequent/heavy/regular use of marijuana	verify degree to which tweets correspond with marijuana use. African American tweeters who sent pro-marijuana messages were overrepresented	marijuana implying that Twitter is a SM platform that facilitates chatter about marijuana. Tweets against marijuana use were comparatively low
Egan <i>et al.</i> ⁵⁸	Facebook/male undergraduates between ages 18–23, mean = 19.8, 68% under 21, 62% single, 35% in a relationship/alcohol	OCA Facebook profiles from for references to alcohol use, including timing and content of alcohol references	225 Facebook profiles were analyzed. Used codebook to find key terms in status updates and posts. Used Stata 9.0. to determine associations between alcohol, age, grade level and Facebook usage	Reference to alcohol in 85.33% of profiles. Number of references increased by year in college. Students who were of legal drinking age (21 years or older) had an average of 4.5 more references per profile than underage students ($P = 0.003$; confidence interval [CI] = 1.5, 7.5)	Sample was limited to one university and only limited to Facebook	Facebook has the potential to have an impact on perception of peer alcohol use, behavior related to alcohol use, Facebook could help screen users for high-risk alcohol behavior and target users with information to help with alcohol awareness
Hanson <i>et al.</i> ⁶⁵	Twitter/users ($n = 25$), and 100 people in their social network, who had discussion about prescription drugs/ Prescription drugs	OCA of Twitter users selected who discussed topics indicative of prescription drug abuse	Twitter statuses mentioning prescription Drugs within social circles of 100 people were examined around each of these Twitter users using an algorithm	Mean number of the people in the social circle with tweets matching at one abuse category was 33.2. 3 389 771 mentions of prescription drug terms were observed	May have excluded misspellings of keywords. Can only observe discussion not behavior. May have underestimated the number of prescription drug abuse tweets	Twitter is used as a platform for discussion about prescription drug abuse within social circles. Strong correlation was found between the kinds of drugs mentioned by the index user and his or her network
Hanson <i>et al.</i> ⁶⁶	Twitter/users Likely college students/ Adderall	OCA Messages pertaining the term 'Adderall were monitored.' Variations in volume during periods of exams on college campuses were observed	Tweets were examined for mention of side effects and other commonly abused substances. Tweets from same region were clustered together	213 633 tweets from 132 099 unique user accounts mentioned 'Adderall.' Most common substances mentioned with Adderall were alcohol	Not all tweets were about Adderall use. Only used public tweets. Only colleges and Universities of 10 000 or more students were examined	Geographical findings can provide practitioners with evidence necessary for prioritizing intervention resources to target priority populations. Side effects

Continued

Table 2 Continued

References	SM/user/drugs	Design	Method/analysis	Results	Limitations	Implications
Lange <i>et al.</i> ⁶⁸	YouTube/NF/ Salvia Divinorum	OCA of YouTube. Examined effects of salvia use through the systematic observation of YouTube videos	for regional comparison. ArcGIS 10 was used to create maps of rates for GPS Adderall tweeters Three coders conducted observations and developed an observation checklist, <i>t</i> -test to examine the difference in the mean duration of the effects by pipe type	(4.8%) and stimulants (4.7%). Most common side effects were sleep deprivation (5.0%) and loss of appetite (2.6%) Mean duration of the videos was 5.8 min with users taking an average of 1.71 hits while holding the smoke in their lungs on an average of 25.4 s	Videos were randomly selected for the study. Through videos only small amount of salvia users can be captured	and reasoning behind the co-ingesting of drugs was commonly mentioned Provides only some possible risk areas for Salvia Divinorum. Further research must be conducted to identify the risks more accurately
Moreno <i>et al.</i> ⁶⁹	SNS Websites/ adolescents between the ages of 11 and 18/ alcohol	Examined adolescents' interpretations of alcoholic references on SNSs. Eight focus groups were conducted	Focus groups were 45–90 min, moderated and followed semi structured format. Recorded and transcribed, coded, and analyzed	Three themes emerged: (i) References to alcohol use on SNS profiles represents real use of alcohol. (ii) References to alcohol use represent efforts to appear 'cool.' (iii) References to alcohol use on SNSs have risks associated with them	Convenience sampling. IRB limited how much demographic information could be gathered. Small sample size, therefore lack of generalizability	SNSs may influence adolescents' attitudes toward alcohol use. Trends could reflect patterns that are seen in male alcohol use on college campuses, with alcohol consumption increasing throughout college
Moreno <i>et al.</i> ⁵⁹	MySpace/users (<i>n</i> = 400) 17–20 years old representing urban, suburban and rural communities in one Washington county. 54.2% male and 70.7% white/alcohol	Theoretical content analysis of MySpace accounts of older adolescents displayed alcohol references on a social working website	Randomly selected public MySpace profiles were evaluated for alcohol references suggesting (i) explicit versus figurative alcohol use and (ii) alcohol-related motivations, associations and consequences	Of 400 profiles, 225 (56.3%) contained 341 references to alcohol. Profile owners who displayed alcohol references were mostly male (54.2%) and white (70.7%). The most commonly displayed motivation for alcohol use was peer pressure (4.7%)	Validity of information on MySpace is unknown. Display of references to alcohol use may represent alcohol use, consideration of alcohol use, boastful claims or nonsense. Only analyzed public profiles. Analyzed profiles from one website and one county	Information could be used by providers, teachers, as well as parents in considering new venues to interact with youth regarding alcohol use. Providing media literacy training to youth may help them to interpret alcohol messages received in media
Morgan <i>et al.</i> ⁶⁰	MySpace, YouTube, and Facebook/Users (<i>n</i> = 314). Undergraduate college	OCA. Examined young adults' postings of public images and videos of	MySpace image search produced 14 145 results and the YouTube video	Images and videos showed known effects of alcohol. Alcohol	Content analyses addressed a very small sample of such images	Need to examine SM users to assess frequency, content and motivations

Continued

Table 2 Continued

References	SM/user/drugs	Design	Method/analysis	Results	Limitations	Implications
	students. 157 men and 157 women. Ages ranged from 18 to 25/alcohol and marijuana	themselves depicting alcohol and marijuana consumption	search produced 26 000 results. Participants completed a series of questions assessing social networking use, alcohol and marijuana use	consumption habits—68% reported that they currently consumed alcohol 0.33% of participants reported that they have smoked marijuana	and videos available for public access online	behind posting images and videos of substance use online. Also explore interventions that could help SM users be aware of privacy policies and the potential negative outcomes of posting publicly accessible of health-risk behaviors online
Myslin <i>et al.</i> ⁶³	Twitter/NF/tobacco	OCA. Created a content and sentiment analysis of tobacco-related Twitter posts and built machine learning classifiers to detect relevant tobacco posts	Collected 7362 tobacco-related Twitter posts at 15-day intervals. For 6 months Classified using a triaxle scheme, Naïve Bayes Algorithms were used to identify the phrases most associated with tobacco-related tweets	Most prevalent genres were first and second hand experience and opinion. Most frequent themes were hookah, cessation and pleasure. Sentiment toward tobacco was overall more positive	Tweets were harvested from free 1% feed, not the full Twitter. Number of keywords for smoking was limited. Exclusively analyzing tobacco-related tweets using natural language processing rather than the social network aspect of Twitter	Content analysis allows for a general pulse or snapshot of tobacco-related discussion on Twitter. New insight can be gained into causes for positive and negative sentiment toward Tobacco, especially with respect to hookah and e-cigarettes
Prier <i>et al.</i> ⁶⁴	Twitter/NF Georgia, Idaho, Indiana, KS, Louisiana, Massachusetts, Mississippi, Oregon and Pennsylvania/ tobacco	OCA of Twitter to model and discover public health topics and themes in tweets. Data were gathered from Twitter API for a 14 day period	Data were prepared by removing all non-Latin characters from messages and all the links are replaced with the term link. Used Latent Dirichlet Allocation (LDA) unsupervised machine learning model, to generate a topic mode to analyze	Querying the comprehensive data set with these terms resulted in a subset of 1963 tweets. The subset was ~0.1% and contained topics related not only to tobacco use but also terms that are related	LDA process of removing irrelevant information is limited. Need human intervention to query terms and analysis of themes	LDA has potential to extract valuable topics from large data sets. Twitter has been identified as a potentially useful tool to better understand health-related topics such as tobacco. Twitter analysis enables public health researchers to better monitor and survey health status in order to solve community health problems. Research is needed to automate the extraction process

Continued

Table 2 Continued

References	SM/user/drugs	Design	Method/analysis	Results	Limitations	Implications
Yakushev et al. ⁶⁷	LivJournal/ NF/multiple illicit and prescription drugs. Opioids, Cannabinoid, Cocaine, Psycho stimulants	OCA of LivJournal. Approach for mining and analysis of data from SM which is based on using MapReduce model and CLAVARE, distributed cloud computing platform to perform analysis	A three stage process was used. The first and second stages were data mining from SM. Data mining was performed by a crawler which is based on MapReduce model	Data were mined from SM using a crawler and stored into Hadoop cluster. The large volume of data was filtered and clustered into small data sets of useful information	Not all society groups are presented equally in SM and their main consumers are young people. Criticisms about trustworthiness and reliability of using data from SM	Several macro factors can be estimated based on official data sources but the level of interest in drugs is much easier to estimate using data from SM. But estimation of factors based on the data from SM as well as modeling with these factors is a potential future direction

NF, No Filter for demographics and unrestricted membership; SM, Social Media; OCA, observational content analysis.

of the lack of training and experience health service professionals have with SM. Third, SM can potentially be a useful tool for tracking data relevant to epidemiological and clinical utility. This is a limited view since tracking is just one factor in its role of contributing to health service intervention and prevention in particularly as relates to illicit drug use. In addition, the internet is an important source of information, which can be gathered from many WorldWide Web forums (Twitter, Facebook and forums). Potential biases exist when relying on a particular social platform selected for surveillance. Specifically, users of the platform may not be representative of the population and questions will always exist regarding the intent, identity or accuracy of self-representation of the contributors to internet discussion on SM. Therefore, a need exists to identify which social platforms are used most by the public to share their illicit drug use. Also, the development of a dictionary of common words used by illicit drug users would facilitate the surveillance of internet platforms (Twitter, Facebook and forums).

Ethical issues in the surveillance of illicit drug use are a long-standing concern. In light of current innovative technological advances as seen on the internet (websites or SM) ethical issues about surveillance of illicit drug in SM is a new challenge for all professional health service practices. The benefits for health professionals are evident since the data retrieved could serve as public health warning and the need for interventions. There are many limitations related to the validity and reliability of information retrieved from surveillance systems. For example, several questions arise regarding the data extracted, (i) who retrieved and interpreted the information e.g. professional, epidemiologist, (ii) was the information extracted from an official or 'public' unofficial source (iii) with the high volume and real-time surveillance, the data may be obsolete by the time it reaches the health professionals and (iv) extraction methods are not well developed relative current standardized procedures.

The use of SM for illicit drug surveillance is a new concept. Although social networks are in public domain, there are also ethical issues related to privacy protection when using these sites for public health surveillance. Privacy laws can prevent free access to illicit drug use data, which would prevent formal analysis of data by structured institutions e.g. government agencies. Legal additions/revisions of privacy laws are required to address the ethical dimension of the surveillance method by SM. A cooperative effort by professional health services organization, governmental agencies such as SAMHSA and the Department of HHS, community health agencies, concerned citizen groups and ethical, legal and technological expertise is required to address these issues.

Limitations of this study

Findings in the current literature should be considered in the context of some limitations. The studies examined here were carried out only with publicly available data, which may not include some crucial data like geographical location, post, comment, tweet and other personal information like age, sex and race. This may limit the accuracy of the results obtained. Another limitation is that when a keyword-based approach was used to find the data, misspelled words were not considered, nor were synonyms for the keyword.^{60,61,65,66,68} Restricting the search to a few drugs without considering the most prevalent drugs is a major drawback.^{60,63,68} Another issue found was that when a selected model is applied to a small data set, there is always the risk of the model to over fit. For example, Butler *et al.*⁶¹ failed to address this critical issue, and, therefore, their results may be inconsistent with reality.

Conclusion

The rise of the internet and SNS has led to the evolution of readily accessible information on a global scale regarding illicit drug use. Current illicit drug surveillance methods have significant limitations including being slow and costly, unable to detect new or emerging illicit drugs trends and often dependent on retrospective data.^{4,28,34,37,71} The development and worldwide use of SM, particularly by young adults, suggests that people may prefer informal networks such as SM and message boards for discussing their drug use.^{14–17} Thus, worldwide social network data can identify patterns of emerging drug use, and data mining tools can complement current surveillance methods.²³ National and International health and government organizations including the World Health Organization need to focus on the potential impact of SM for prevention and treatment of illicit drug use. Training of health service providers on the role of SM and its evolving technology should be a primary focus for national and global international organizations.

A vast trove of information with clear real-time updates and identification of new and emerging drugs seems to be untapped. Therefore, worldwide systematic approaches need to be developed to efficiently extract and analyze content from social networks. This important work would best be accomplished by a global multi-disciplinary collaboration to include health service providers, computer scientists, mathematicians, internet technical specialists, government/community services and public citizens.

Conflicts of interest

DMK declares that she has no conflict of interest. BB declares that he has no conflict of interest. MJL declares that

she has no conflict of interest. BD declares that he has no conflict of interest.

Ethical approval

This article contains no studies performed by the authors using human participants or animals.

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