SPECIAL ISSUE ON NOVEL PSYCHOACTIVE SUBSTANCES

Detecting a signal in the noise: monitoring the global spread of novel psychoactive substances using media and other open-source information[†]

Matthew M. Young[1,2]*, Chad Dubeau[3] and Ornella Corazza[4]

[1]*Senior Research and Policy Analyst, Canadian Centre on Substance Abuse, Ottawa, Ontario, Canada*
[2]*Adjunct Research Professor, Department of Psychology, Carleton University, Ottawa, Ontario, Canada*
[3]*Information Specialist, Canadian Centre on Substance Abuse, Ottawa, Ontario, Canada*
[4]*School of Life and Medical Sciences, University of Hertfordshire, Hatfield, UK*

Objective   To determine the feasibility and utility of using media reports and other open-source information collected by the Global Public Health Intelligence Network (GPHIN), an event-based surveillance system operated by the Public Health Agency of Canada, to rapidly detect clusters of adverse drug events associated with 'novel psychoactive substances' (NPS) at the international level.
Methods and Results   Researchers searched English media reports collected by the GPHIN between 1997 and 2013 for references to synthetic cannabinoids. They screened the resulting reports for relevance and content (i.e., reports of morbidity and arrest), plotted and compared with other available indicators (e.g., US poison control center exposures). The pattern of results from the analysis of GPHIN reports resembled the pattern seen from the other indicators.
Conclusions   The results of this study indicate that using media and other open-source information can help monitor the presence, usage, local policy, law enforcement responses, and spread of NPS in a rapid effective way. Further, modifying GPHIN to actively track NPS would be relatively inexpensive to implement and would be highly complementary to current national and international monitoring efforts. © 2015 The Authors. *Human Psychopharmacology: Clinical and Experimental* published by John Wiley & Sons, Ltd.

KEY WORDS—novel psychoactive substances; drug use epidemiology; monitoring drug use

INTRODUCTION

Sometimes referred to as "legal highs," "designer drugs," "research chemicals," or "herbal highs," the umbrella term novel psychoactive substances (NPS) is used to refer to psychoactive drugs that have not been approved for therapeutic use and that are not listed under the 1971 United Nations Convention on Psychotropic Substances. Although they might be natural substances (e.g., *Salvia divinorum* and *kratom*), they are frequently synthetic agents marketed as legal substitutes for more common illicit drugs. NPS are advertised and generally sold via the Internet or in "head shops" and are often uncontrolled (or were not controlled when they emerged) by relevant drug legislation. Information about the effects and any

associated short-term or long-term harms of these substances in humans is typically limited.

A recent report by the United Nations Office on Drugs and Crime describes the rapid emergence of these drugs as a serious threat to public health (United Nations Office On Drugs And Crime, 2013). As of 2013, the European Monitoring Centre for Drugs and Drug Addiction early warning system was monitoring over 350 new drugs of which almost 250 had been first identified since 2010 (European Monitoring Centre for Drugs and Drug Addiction 2014).

CHALLENGES OF MONITORING USE

Monitoring NPS poses a number of unique challenges. The rapid appearance of new substances on the market, the variety of brand names associated with the products, the assortment of chemicals frequently found in any one product, and the short life cycle of any specific product all contribute to the challenges of using conventional strategies for monitoring the emergence

*Correspondence to: M. M. Young, Senior Research and Policy Analyst, 500–75 rue Albert Street, Ottawa, Ontario, K1P 5E7, Canada. Tel: 613-235-4048 x 222; Fax 613-235-8101 E-mail: myoung@ccsa.ca
†Research conducted in Ottawa, Canada

of and harms associated with NPS use (for a review of the strategies that have been used to determine the epidemiology of NPS, see Sumnall, McVeigh, & Evans-Brown, 2013).

General population surveys or other self-reporting measures are limited in their ability to detect NPS because of the time it takes to develop and add appropriate questions on the survey, as well as to collect and analyze the data. By the time survey results are released, the product could have already caused a substantial amount of harm, the chemical composition of the product might have changed, or the product might have disappeared from the marketplace.

Data from medical monitoring systems have also been used to monitor use of NPS and are particularly effective at assessing harms: for example, emergency department visits to hospitals (Substance Abuse and Mental Health Services Administration, 2012) and calls to poison control centers (American Association of Poison Control Centers, 2014). However, not all countries have medical monitoring systems that assess morbidity related to the use of psychoactive drugs.

The emergence of NPS can also be monitored through forensic analysis of samples seized by law enforcement, acquired via test purchases, or donated during amnesties or in response to harm reduction strategies. This method of monitoring the emergence of NPS is invaluable as it is the only reliable way to know with certainty what substances are present in the marketplace. However, these methods can be expensive, and laboratories can have difficulty determining the chemical compounds contained in a product because of the novelty of the active ingredient and the lack of a reference substance to make a reliable identification or because of the various mixtures of compounds the sample might contain.

These monitoring strategies help to provide information that can be pieced together to understand the epidemiology of NPS. However, not all countries have the resources and capabilities to implement some or all of them. Because the approaches vary from one country to another, estimates regarding the prevalence of use and harms associated with use are problematic, and it is currently not possible to make international comparisons (Sumnall et al., 2013).

Given the rapid emergence of NPS as well as limited capabilities for monitoring their emergence, those seeking to monitor NPS have had to innovate and look to new data sources that could, in combination with existing sources, help to provide a better understanding of the epidemiology of NPS (e.g., Corazza, Assi, Simonato, & the ReDNet group, 2014; Deluca et al., 2012). These data sources have included Internet monitoring strategies.

The Internet has played an important role in the development, marketing, and sale of NPS. Similarly, Internet monitoring has quickly become an important source of information on NPS. Internet monitoring has been used predominantly to identify and track new substances by examining websites that sell NPS (Bruno, Poesiat, & Matthews, 2013). In addition to monitoring online sales of NPS, another rich source of information has come from online message boards or discussion forums where anonymous users discuss drug use (Davey et al., 2012; Deluca et al., 2012; McNaughton et al., 2012).

Although used to track the spread of infectious diseases since 2002, media reports and other open-source information have yet to be appropriated to monitor NPS.

THE GLOBAL PUBLIC HEALTH INTELLIGENCE NETWORK

Operated and developed by the Public Health Agency of Canada for the World Health Organization, the Global Public Health Intelligence Network (GPHIN) monitors news sources and websites across the globe 24 h a day, 7 days a week, in nine languages (English, French, Farsi, Portuguese, Arabic, Russian, Spanish, and Chinese, simplified and traditional) to provide alerts about international events of public health significance to both domestic and international partners (Mawudeku & Blench, 2005; Keller et al., 2009). The GPHIN has been shown to effectively detect rumors of unusual disease events. These rumors (i.e., open-source media reports) are then verified by the appropriate authorities. Of the 578 disease outbreaks verified by the World Health Organization between July 1998 and August 2001, 324 or 56% were initially detected by the GPHIN (Heymann et al., 2001).

The GPHIN monitors open-source media automatically as well as manually. Filtered via a series of queries, the GPHIN application automatically retrieves articles from news feed aggregators that contain keywords indicating the article might be relevant to public health security. When the article enters the GPHIN system, it is also automatically assigned a "relevancy score." Highly relevant articles are retained while highly irrelevant articles are excluded. In addition to automatic filtering and relevancy assessment, the GPHIN also relies on human analysts. Articles that are not deemed to be either highly relevant or irrelevant by the automated process are reviewed by a GPHIN analyst. The analyst employs his or her

linguistic, interpretive, and analytical expertise to determine inclusion or exclusion from the GPHIN database. Articles retained in the GPHIN database are categorized into one or more of the GPHIN's taxonomy categories (animal or human infectious diseases, plant diseases, natural disasters, chemical incidents, radiological incidents, nuclear incidents, and unsafe products).

USING MEDIA TO MONITOR CLUSTERS OF ADVERSE DRUG EVENTS ASSOCIATED WITH NPS

As part of its mandate to gather information on unsafe products, information on some NPS and new drug use trends are retained in the GPHIN database (e.g., synthetic cathinones and caffeinated alcoholic beverages). The objective of the current study was to determine the feasibility of using this information to monitor and detect clusters of adverse drug events associated with NPS. To do so, we pilot-tested the methodology by examining English media reports on synthetic cannabinoid receptor agonists from 1997 to June 2013.

Synthetic cannabinoids

Synthetic cannabinoids are a large and diverse group of psychoactive drugs that, since approximately 2008, have been marketed for recreational use as legal alternatives to cannabis. This group of drugs is more correctly referred to as cannabinoid receptor agonists or cannabimimetics. However, they have also been referred to as Δ9-tetrahydrocannabinol (THC) homologues, synthetic marijuana, legal weed, and so on. Synthetic cannabinoids are functionally similar to THC, the main psychoactive ingredient in cannabis. As of May 2013, there have been over 84 different synthetic cannabinoids identified internationally (European Monitoring Centre for Drugs and Drug Addiction, 2013). Synthetic cannabinoids are typically purchased online or via the black market. They are then dissolved and sprayed on dried plant material (e.g., marshmallow, mullien, or damiana leaves) so that the end product appears less synthetic and more "herbal" or "natural." The sprayed plant is then placed in small packets, branded with names such as "Spice," "K2," "IZMS," and so on, and sold as "herbal incense" or "herbal smoking blends."

METHODS AND RESULTS

Search strategy

To identify media reports in the GPHIN database that referred to synthetic cannabinoids or other similar synthetic preparations, we developed a specific search query. The GPHIN database contains or references articles from January 1997, so the query spanned January 1997 to July 2013; it employed the following search string:

> "synthetic cannabinoids" OR "synthetic cannabis" OR "synthetic marijuana" OR "synthetic weed" OR "synthetic pot" OR "synthetic grass" OR "synthetic THC" OR "fake cannabis" OR "fake marijuana" OR "fake weed" OR "fake pot" OR "legal weed" OR "legal pot" OR "legal blends" OR "cannabimimetics" OR "legal highs" OR "herbal highs" OR "herbal blends" OR "herbal incense" OR "herbal mixtures" OR "herbal smoking blends" OR "synthetic cannabinoid" OR "legal blend" OR "cannabimimetic" OR "legal high" OR "herbal high" OR "herbal blend" OR "herbal mixture" OR "herbal smoking blend."

Relevance screening and data extraction

The search yielded 840 media reports. Each report was examined for relevancy by a member of the research team. Specifically, the following question was asked of each media report: "Is this a media report that refers to synthetic cannabinoids or other similar synthetic preparations?" Reports for which the question was answered in the negative were excluded. This stage of screening excluded 36% (317 reports; see Figure 1). Following screening, two reviewers extracted the following information from the remaining reports: (1) headline; (2) publication date; (3) whether the report was a repetition of another included story; (4) topic of the media report; and (5) if the report referred to a specific event, the location of the event. When it was not possible to determine the specific location of the event, the location of the media outlet was recorded. As illustrated in Figure 1, after removing duplicates, data was extracted from 490 unique reports related to synthetic cannabinoids.

When determining the topic of the media report, researchers manually coded each report into one only of the following categories:

- **Seizure/arrest**: reports covering arrests or seizures of synthetic cannabinoids.
- **Morbidity/mortality involving the drug**: reports of direct or indirect harms associated with synthetic cannabinoid use.
- **General report of presence**: reports that did not refer to a specific event, but instead contained anecdotal information from local sources about the presence of synthetic cannabinoids in the community.
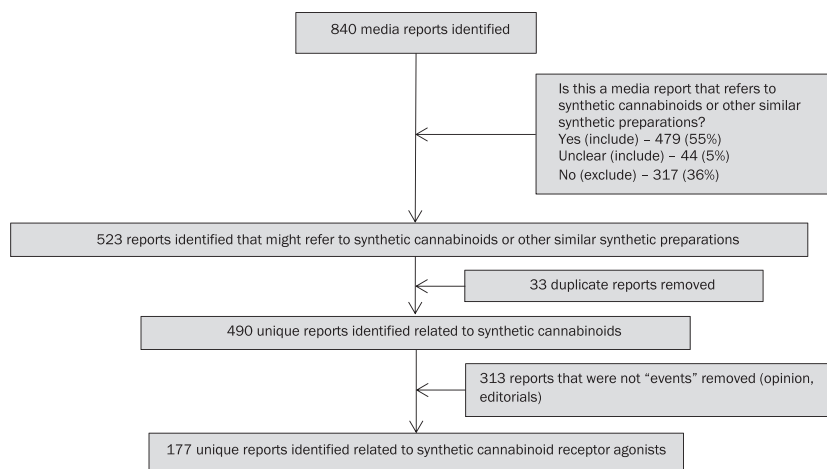
Figure 1.   Diagram illustrating the reports yielded by the query and how they were screened for relevancy

- **Health alert/warning of new product**: reports covering local alerts by public health or law enforcement about the presence of synthetic cannabinoids.
- **New law/policy announcement**: reports of new legislation or policy pertaining to the sale or possession of synthetic cannabinoids.
- **Opinion/editorial**: reports that included opinions, commentary, or other editorial material.
- **Results of research report**: reports that referred to recent results of research involving synthetic cannabinoids.
- **Prevention/harm reduction initiative**: reports referring to a new or ongoing prevention or harm reduction initiative.
- **New method/test to detect**: reports describing a new method to detect synthetic cannabinoids.
- **Report of trial**: reports of a trial for possession or trafficking of synthetic cannabinoids. These categories emerged from the data and were not specified *a priori*. The most frequently occurring reports were those announcing new policies or laws followed by reports of seizures or arrests (see Table 1).

Table 1.   Frequency of media report topics

Report Topic	Frequency	Percentage (%)
New law/policy announcement	190	39
Seizure/arrest	54	11
Opinion/editorial	50	10
Morbidity involving the drug	48	10
Results of research report	43	9
General report of presence	43	9
Health alert/warning of new product	33	7
Prevention/harm reduction initiative	16	3
Method/test to detect	8	2
Report of trial	5	1

After reports were categorized, reports that did not refer to a specific adverse drug event that could be linked to a specific time and place (i.e., opinion/editorials, results of research reports, prevention/harm reduction initiatives, or reports of new method/test to detect) were removed. There were 177 unique reports referring to specific events (see Figure 1).

Number and category of media reports over time

To begin, we plotted the number of reports referring to synthetic cannabinoids in the English media over time (see Figure 2). The first media reports emerged in late 2009, early 2010, and there were very few (<10 per month). The number of reports increased in early 2012, peaking in April 2013.

Comparison with other indicators of synthetic cannabinoid use

In an effort to determine if the number of media reports about synthetic cannabinoids is a valid indicator of synthetic cannabinoid-related adverse drug events, we next compared our results with other indicators to determine whether they had concurrent validity. If the number of media reports about synthetic cannabinoids is a valid measure of synthetic cannabinoid-related adverse drug events, then the resulting pattern or curve when plotted over time should resemble that of other indicators of use or harms associated with use. To assess the extent to which the pattern of media reports of synthetic cannabinoid use resemble other indicators, we compared the pattern to the number of U.S. poison control center exposures and the volume of discussion regarding synthetic cannabinoids in the online harm reduction discussion forum Bluelight (now moved to www.bluelight.org).
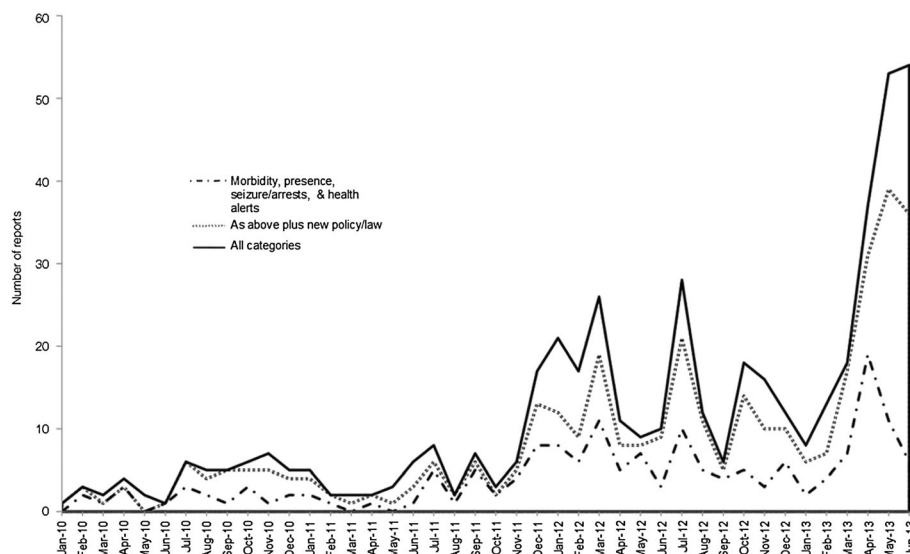
Figure 2. Number of reports referring to synthetic cannabinoids in English media between January 2010 and June 2013

Poison control center exposures. Figure 3 includes a graph of the number of U.S. poison control center calls about synthetic cannabinoids between January 2010 and June 2013, and a graph of the number of media reports during the same time. A visual comparison of the juxtaposed graphs indicates that poison control center calls began increasing slowly in January 2010, peaked in July 2011, and then gradually decreased. Media reports appear to lag poison control center calls by 6–8 months, then gradually decrease in number (when specifically examining morbidity presence, seizure/

arrest, and health alerts). This comparison indicates that while media reports of synthetic cannabinoids might not be as sensitive as poison control center calls, there is a comparable pattern in the time frame examined.

Volume of discussion on bluelight.ru. To further assess the extent to which the frequency of media reports was comparable with other indicators of synthetic cannabinoid use, we compared the number of media reports with the volume of discussion referring to
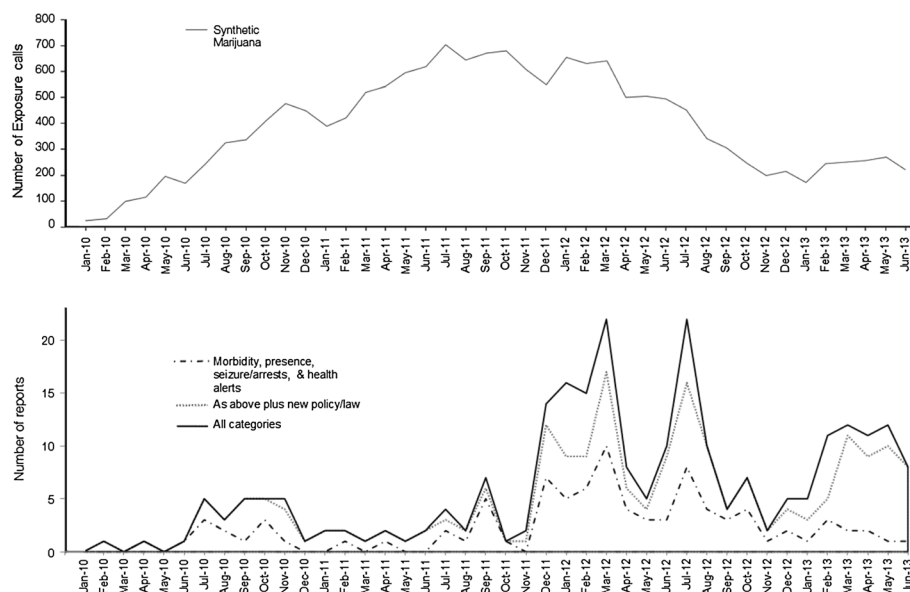

Figure 3. Comparison of number of US poison control center exposure calls (reproduced and adapted with permission from University of Maryland, Center for Substance Abuse Research, 2013) and number of US media reports regarding synthetic cannabinoids between January 2010 and June 2013

synthetic cannabinoids on the harm reduction forum, Bluelight. Among other roles (e.g., summarizing information on drugs), Bluelight is an online discussion forum in which users discuss recreational drug use. Plahuta (2013) analyzed approximately 1.2 million posts on the discussion forum and produced a customizable chart that permits users to plot, over time, the proportion of discussions containing reference to over 100 different drugs.

Figure 4 includes the proportion of discussion posts referring to synthetic cannabinoids relative to all monthly posts. In the succeeding text is a graph of the number of reports about synthetic cannabinoids in the English media. A visual comparison reveals great similarity in the curves. Both charts indicate low levels of activity, until December 2011–January 2012. Both graphs contain two time periods where the level of activity peaks, the first around March 2012, the second in July 2012.

DISCUSSION

To the best of our knowledge, this study is the first to employ media reports and other open-source information to monitor NPS. The purpose of the study was to determine the feasibility of using information collected by GPHIN to detect adverse drug events associated with NPS. To do so, the number of media reports about synthetic cannabinoids captured by GPHIN was plotted over time. The pattern of results was then compared with other indicators of synthetic cannabinoid presence, namely, US poison control center exposures and discussion about synthetic cannabinoids on the harm reduction discussion forum Bluelight. That the appearance of media reports on synthetic cannabinoids in the U.S. appears to lag poison control center calls is not surprising. Poison center calls are a leading edge indicator of harms associated with new drugs (American Association of Poison Control Centers, 2014). However, not all countries or regions have timely access to data from poison centers. In the absence of access to other early warning indicators, it could be that media reports are one of the first indicators available to local public health authorities of significant harms arising from psychoactive substance use.

Further use of media reports to monitor NPS has a number of advantages. First, it could be especially helpful in identifying clusters of drug use that are associated with great harm. Although media reports can have many limitations (e.g., often sensationalist and can frequently include incorrect information regarding substances involved), they can be valuable in identifying clusters of harms related to substance use that warrant further investigation. Therefore,
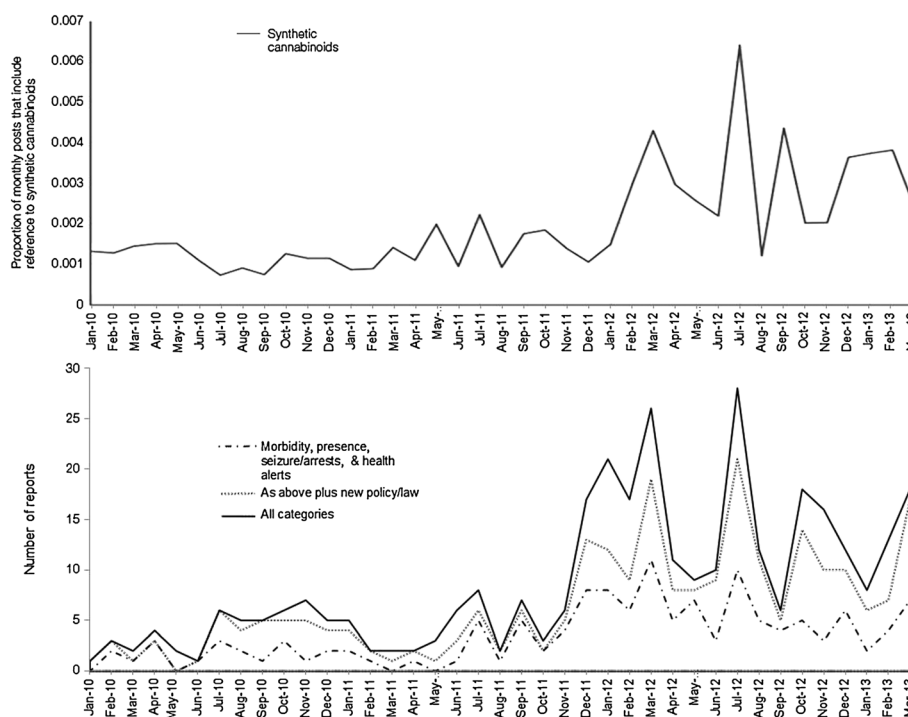

Figure 4. Comparison between the proportion of posts referring to synthetic cannabinoids relative to all monthly posts on the drug forum Bluelight.ru (data from Plahuta, 2013), and the number of reports regarding synthetic cannabinoids in the English media between January 2010 and June 2013

media reports could provide a vitally important early signal that could be used in an event-based surveillance system to monitor and report on significant clusters of morbidity or mortality related to psychoactive substance use.

Event-based surveillance is used to monitor infectious disease outbreaks (World Health Organization, 2008). However, we are unaware of any such system that has been developed to monitor drug-related harms. Such a system would be highly complementary to existing national drug early warning systems. In addition to being a valuable early indicator of clusters of harms related to substance use, the proposed system would also require relatively little investment of resources. Because GPHIN already has the infrastructure in place for monitoring other public health threats, modifying the system to actively track NPS would be relatively inexpensive. Another possible advantage of this system would be that countries participating in such a system could monitor substance use-related harms occurring outside their borders. The implementation of such a system could facilitate rapid knowledge exchange between authorities who have experience regarding a specific NPS or new drug use trend and those who are first encountering it.

The GPHIN system is also complimentary to and offers a number of advantages over other web analytical software that are increasingly being used in health research. One prominent example is Google Trends (Nuti *et al.*, 2014). Analyses obtained from a tool such as Google trends are a useful indicator of the public's interest in a specific topic, as represented by the volume of specific keywords or search terms used over time. However, the utility of the strategy in determining prevalence of or harms associated with NPSs is limited because search engine query data simply reflects public interest in a topic/drug. While in some circumstances this may be a reliable proxy for drug use or harms associated with use, there are many situations when it may not. For example, in June 2012, there was a dramatic increase in searches for the string "bath salts" (a slang term used in Canada and the United States to refer to a mixture of various synthetic cathinones) among Canadians. However, this sudden increase in interest was not associated changes in use or harms associated with use of "bath salts" (Canadian Community Epidemiology Network On Drug Use, 2012). Instead, the sudden increase in public interest in the drug was more likely the result of a sensational story out of Miami, Florida, of a man who cannibalized another man on a public freeway who was reportedly on "bath salts" (these reports were never confirmed). In contrast to public interest in a drug,

the GPHIN system tracks media stories about events (e.g., seizures/arrests, morbidity/mortality involving the drug, and health alert/warning of new product) and thus provides more information that could be used along with Google Trends data to monitor NPS.

Limitations

Limitations of the design. The GPHIN system is currently not designed or configured to be sensitive to NPS-related media. It is unknown to what extent media reports on synthetic cannabinoids were filtered out before entering into the GPHIN database. In an attempt to approximate how many reports might have been filtered out, GPHIN staff ran the same query on the unfiltered source data from the news aggregator, Factiva. This query returned 35 342 records. If we assume a similar rate of relevance to what was found in the pilot data (i.e., approximately 50%), there could be up to 17 000 potentially relevant records.

Limitations of language. Although the GPHIN system operates in nine languages (English, French, Farsi, Portuguese, Arabic, Russian, Spanish, and Chinese, simplified and traditional), for this study, only English reports were included. Additional languages would likely increase the volume of relevant reports and could improve timeliness of detection where NPS use is associated with non-English countries or communities

Query limitations. The query we used to identify media reports in the GPHIN database that referred to synthetic cannabinoids or other similar synthetic preparations did not include street names (e.g., "Spice" or "K2") or specific chemical names (e.g., "JWH-018"). However, we argue that the proposed system is not designed to detect mentions of specific chemicals or drug brands as these will frequently be unknown at the time of the event. Instead, the strength of the proposed system lies in its capacity to detect clusters of adverse drug events associated with larger categories of new drugs (e.g., cathinones and phenethylamines) as they appear on the market. Media reports would be another indicator for drug use epidemiologists to examine in conjunction with other early warning indicators to help validate the reports (e.g., poison control center data, emergency room data, wastewater drug analysis, and Internet monitoring of sites selling NPS). Ideally, clusters of adverse drug events would be followed up with more reliable methods to determine the exact chemicals involved such as urine screens, analysis of seized samples, and so on. Although search queries would undoubtedly require updating on an ongoing basis, queries would not need to include specific terms

for specific new chemicals or brands introduced into the market in order to detect and alert the user of the system to clusters of adverse drug events.

Despite the limitations, the pilot study indicates the proposed system is worth further investigation. Work must be conducted to make the network more sensitive to NPS and ensure all media reports about NPS are entered into the GPHIN database. In addition, a multilingual taxonomy must be developed that is sensitive to emerging NPS in real time. A multilingual taxonomy could map the terms across languages so a search in one language only (e.g., English) would be able to capture occurrences in all languages. To be an effective complement to existing monitoring efforts, it is essential that the methods be tested in multiple languages and across multiple substances as well as new, possibly yet unknown, substances.

CONCLUSIONS

The results of this initial pilot study indicate that using media and other open-source information shows great promise for rapidly tracking the presence, usage, local policy, law enforcement responses, and spread of NPS. Further, modifying GPHIN to actively track NPS would be relatively inexpensive to implement and could be highly complementary to current national and international monitoring efforts.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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