2016

A Study of Social Web Data on Buprenorphine Abuse Using Semantic Web Technology

Raminta Daniulaityte
Wright State University - Main Campus, raminta.daniulaityte@wright.edu

Amit P. Sheth
Wright State University - Main Campus, amit@sc.edu

Grant Number:	**R21 DA030571**
Project Title:	**A Study of Social Web Data on Buprenorphine Abuse Using Semantic Web Technology**
Grantee Org.:	**Wright State University**
Project Period:	**07/01/2011-06/30/2014**
PD/PIs:	**Daniulaityte, Raminta; Sheth, Amit**

FINAL PROGRESS REPORT

The Specific Aims of this application are to use a paradigmatic approach that combines Semantic Web technology, Natural Language Processing and Machine Learning techniques to:

1) Describe drug users' knowledge, attitudes, and behaviors related to the non-medical use of Suboxone and Subutex as discussed on Web-based forums.

2) Identify and describe temporal patterns of non-medical use of Suboxone and Subutex as discussed on Web-based forums.

The research was carried out by an interdisciplinary team of members of the Center for Interventions, Treatment and Addictions Research (CITAR) and the Ohio Center of Excellence in Knowledge-enabled Computing (Kno.e.sis) at Wright State University. The research team made significant progress advancing the application of information processing techniques, and identifying drug user knowledge, attitudes and behaviors to inform drug abuse epidemiology, including illicit use of buprenorphine products.

I. Application of advanced information processing techniques

The PREDOSE platform (Figure 1) was developed to semi-automate information extraction of data from Web forums on the illicit use of buprenorphine products. In the development of the PREDOSE platform, Semantic Web technologies were used to enhance traditional information processing techniques. We first developed a **Drug Abuse Ontology (DAO)** using Web standards such as Web Ontology Language as well as the Resource Description Framework. An **ontology** is a formal model of domain knowledge expressed as a set of concepts and relationships among them. The schema of the DAO was manually created at CITAR through technical guidance from the Kno.e.sis team. The DAO knowledge base was populated from the Web-based data (http://bit.ly/preDAO).

Figure 1. A Screenshot of the **PREDOSE** Trend Explorer.

Technological capabilities of the PREDOSE platform include an **Ontology-**

Driven Entity Identification module (e.g., identify "bupe" as buprenorphine or "WD" as withdrawal), generic sentiment extraction, and pattern-based search support that uses other relevant information **("Intelligible Constructs")** such as time intervals and quantitative descriptors. The PREDOSE interface contains various tools that support search by a single concept or a combination of concepts **(Content Explorer, Proximity Search, and Template Pattern Explorer)** and allow post retrieval by a specified time framework and unit (Figure 1). **While the PREDOSE platform has achieved early successes that move beyond current capabilities in the field, insights gained from our R21 also indicate a need for additional enhancements in our information extraction and automated data coding techniques.**

A documentation wiki page (http://bit.ly/prewiki) on the PREDOSE platform is available online. "Guest" version of PREDOSE interface is available for viewing at http://knoesis-hpco.cs.wright.edu/predose/ (guest log in name: guest; password: guest). A video demo of PREDOSE interface is available online (http://bit.ly/predemo).

II. Identification of drug abuse trends

Our collaborative work generated exciting results regarding our ability to detect emerging trends from social media content.

User knowledge, attitudes, and behaviors related to illicit buprenorphine use:

We employed the PREDOSE platform to explore Web-forum discussions about the use of buprenorphine to self-treat opioid withdrawal symptoms. The PREDOSE platform identified 1,217 posts containing discussions about buprenorphine and opioid withdrawal, covering a time period between 2005 and September, 2013. A random sample of 404 (33%) posts was selected and content analyzed using NVivo. The posts were about equally divided between those that expressed positive and negative views about the effectiveness of buprenorphine in relieving withdrawal symptoms. Web-forum participants emphasized that buprenorphine's effectiveness may become compromised because of the "size of a person habit', and/or when users repeatedly switch back and forth between buprenorphine and other illicit opioids. The majority of posts endorsed use of significantly lower amounts of buprenorphine (2 mg and lower) than typical doses used in standard treatment (16-24 mg/day). Concomitant use of other psychoactive substances was also commonly reported. Our findings highlight the usefulness of Web-based data in drug abuse epidemiology research. They add new information about lay beliefs about buprenorphine that may help inform prevention and policy measures, as well as further research with community recruited samples.

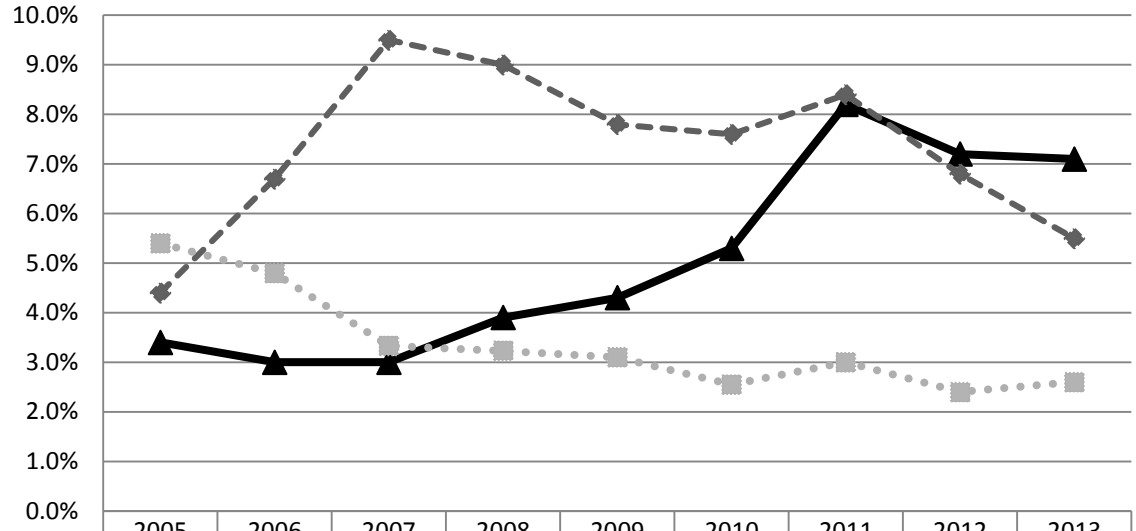
Discovery of an emerging trend of loperamide (Imodium) misuse:

We identified an emerging trend among illicit opioid users of "mega-dosing" with loperamide (Imodium) to self-treat opioid withdrawal symptoms. The timeliness and significance of these findings were subsequently corroborated by clinical toxicologist reports of patients presenting with heart arrhythmias due to abuse of high doses of loperamide.

Temporal patterns of buprenorphine-related discussions:

The overall number of buprenorphine-related posts increased from 46 in 2005 to 1,012 in 2009, peeked to 4,376 in 2011, and then decreased to 3,546 in 2012. These numbers include all posts that contain at least one mention of buprenorphine or its slang/brand names.

Figure 2. Percentage of buprenoprhine, oxycodone, and hydrocodone-related posts on a Web-forum discussing illicit drug use



	2005	2006	2007	2008	2009	2010	2011	2012	2013
Buprenorphine	3.40%	3.00%	3.00%	3.90%	4.30%	5.30%	8.20%	7.20%	7.10%
Oxycodone	4.40%	6.70%	9.50%	9.00%	7.80%	7.60%	8.40%	6.80%	5.50%
Hydrocodone	5.40%	4.80%	3.33%	3.23%	3.10%	2.55%	3.00%	2.40%	2.60%

Figure 2 displays changes in the occurrence ratio of buprenorphine-related posts over time in comparison to two other commonly abused pharmaceutical opioids—oxycodone and hydrocodone. As shown in the figure, initially buprenorphine was less commonly discussed than hydrocodone or oxycodone. In 2008, buprenorphine-related posts increased and became more common than hydrocodone-related posts, but still were significantly less common than oxycodone-related mentions. However, the frequency of buprenorphine-related post increased substantially in 2011, and overtook oxycodone in 2012 (Figure 2). These changes coincided with the release of tamper-resistant formulation of OxyContin in late 2010. Prior studies have shown that the introduction of tamper-resistant products contributed to decreases in the non-medical use of OxyContin, but was associated with increases in non-medical use of other opioids. These trends in Web-based mentions of buprenorphine are consistent with other data sources showing rising rates of illicit buprenorphine use. Conversely, they also indicate that due to buprenorphine's complex pharmacological profile, or as Web-forum participants suggested, "weird" and "counterintuitive" properties, individuals may have more questions and concerns about how to use it to increase its effectiveness and minimize unpleasant side effects.

III. Continued work

Building on the successes of our R21, our research team submitted an R01 application in response to NIDA RFA-CA-14-008. The R01 (DA039454-01; Daniulaityte/Sheth) application, entitled "Trending: Social media analysis to monitor cannabis and synthetic cannabinoid use," was funded in 08/2014. The key goal of the project is develop and deploy a comprehensive software platform, **eDrugTrends**, for semi-automated processing and visualization of thematic, sentiment, spatio-temporal, and social network dimensions of social media data (Twitter and Web forums) on cannabis and synthetic cannabinoid use.

IV. Conference presentations and publications

Conference presentations:

Daniulaityte, R., Carlson, R., Falck, R., Cameron, D., Udayanga, S., Chen, L., Sheth, A. "A web-based study of self-treatment of opioid withdrawal symptoms with loperamide." Presented at the College on Problems of Drug Dependence 74th Annual Scientific Meeting in Palm Springs, California, June 9-14, 2012.

Daniulaityte, R., Carlson R, Cameron D, Smith A and Sheth A. When less is more: A web-based study of user beliefs about buprenorphine dosing in self-treatment of opioid withdrawal symptoms. 2014. To be presented at the College on Problems of Drug Dependence 76th Scientific Meeting in San Jose, Puerto Rico, June 9-14, 2014.

Manuscripts in preparation:

Daniulaityte, R., Carlson R., Brigham, G., Cameron D., Sheth A. "Sub is a weird drug:" A Web-based study of lay attitudes about use of buprenorphine to self-treat opioid withdrawal symptoms. (Being revised) *The American Journal on Addictions*

Cameron, D., Sheth, A., Jaykumar, N., Anand, G., Thirunarayan, K., Smith, G. A. A Hybrid Approach to Finding Relevant Social Media Content for Complex Domain Specific Information Needs. (Resubmitted with minor revisions) *Journal of Web Semantics*

Published papers:

Daniulaityte, R., Carlson, R., Falck, R., Cameron, D., Perera, S., Chen, L., Sheth, A. (2013). "I Just Wanted to Tell You That Loperamide WILL WORK": A Web-Based Study of Extra-Medical Use of Loperamide. Drug and Alcohol Dependence, 130 (1-3), 241-244.
PMCID: PMC3633632

Cameron, D., Smith, G.A., Daniulaityte, R., Sheth, A.P., Dave, D., Chen, L., Anand, G.,Carlson, R., Watkins, K., Falck, R. (2013). PREDOSE: A semantic web platform for drug abuse epidemiology using social media. Journal of Biomedical Informatics: Special Issue on Biomedical Information through the Implementation of Social Media Environments, 46, 985-997.
PMCID: PMC3844051 [Available on 2014/12/1]