Title
Digital Public Health Surveillance Tools for Alcohol Use and HIV Risk Behaviors.

Permalink
https://escholarship.org/uc/item/8n46699x

Authors
Garett, Renee
Young, Sean D

Publication Date
2021-03-17

DOI
10.1007/s10461-021-03221-z

Peer reviewed
Digital Public Health Surveillance Tools for Alcohol Use and HIV Risk Behaviors

Renee Garett1 · Sean D. Young2,3

Accepted: 8 March 2021
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2021

Abstract
There is a need for real-time and predictive data on alcohol use both broadly and specific to HIV. However, substance use and HIV data often suffer from lag times in reporting as they are typically measured from surveys, clinical case visits and other methods requiring extensive time for collection and analysis. Social big data might help to address this problem and be used to provide near real-time assessments of people’s alcohol use and/or alcohol. This manuscript describes three types of social data sources (i.e., social media data, internet search data, and wearable device data) that might be used in surveillance of alcohol and HIV, and then discusses the implications and potential of implementing them as additional tools for public health surveillance.

Keywords
HIV · Substance use · Social media · Wearables · Sensors

HIV/AIDS continues to be a critical global health issue, with more than 32 million cumulative deaths worldwide [1]. Several studies have characterized the influence of alcohol consumption (i.e., drinking alcohol) in the transmission of HIV [2] and the progression to AIDS [2, 3], making it important to study the intersection between these two public health issues. For example, among men who have sex with men (MSM) in the United States, heavy alcohol consumption was associated with unprotected anal intercourse [4, 5]. Similarly, for both male patrons [6] and female sex workers [7, 8], there was a significant association between drinking before intercourse and unprotected sex.

Analysis of “social big data” has been an evolving tool used by researchers to investigate chronic and infectious diseases [9–11]. There are discrepancies in the definition of social big data among researchers, and this definition will likely continue to change as new technologies and approaches are developed [12–15]. However, for the purpose of this manuscript, we define social big data as being large, near real-time data from technologies that are the result of social interactions and can be used to provide insights about people’s attitudes, behaviors, and social interactions. This would include data sources such as social media, internet search tools (e.g., Google searches), wearable devices, and blogs. Social data are being explored as new powerful tools for disease surveillance and information dissemination [16–21]. For example, a review by Bernardo et al. found that 65.5% of included studies showed social media data being correlated with traditional surveillance data (e.g., case reporting) [22]. Other studies have found similar correlations to health data using wearable device, social media, and internet search data [23–26]. Use of social big data as digital surveillance tools may help to improve the speed of surveillance and estimates of new cases. It may allow public health agencies to more efficiently deploy resources to launch prevention campaigns, inform healthcare providers of new patients, and prevent morbidity and mortality.

There is a need for improved surveillance on alcohol consumption, both broadly and specific to HIV. Traditional HIV and alcohol-related surveillance data, often suffer from lag times in reporting as they are typically measured from surveys, clinical case visits (such as emergency department data) and other methods that require extensive time for collection and analysis. Digital surveillance, or methods that
use social big data for surveillance, might help to address this problem and be used to provide near real-time assessments of people’s alcohol consumption and/or alcohol consumption during sexual encounters. These approaches can be tailored for specific at-risk populations, especially during times of an infectious disease outbreak (Charles-Smith et al.). However, there are very limited studies describing how these types of methods might be applied to the intersection between HIV and alcohol consumption, or alcohol consumption more broadly.

In this manuscript, we describe three types of social data sources (i.e., social media data, internet search data, and wearable device data) that might be further studied and used in surveillance of alcohol and HIV, and then discuss the implications and potential of implementing them as additional tools for public health surveillance. Because limited research has been conducted on this topic, we borrow from research approaches used in other fields and give example ideas of how they might be applied and studied in future research on alcohol and HIV.

Social Media

Investigators have already conducted studies on alcohol use and related content (e.g., images, texts, etc.) on social media, especially among youth and young adults. Alcohol content on social media has predominantly depicted the positive aspects of alcohol use behaviors [27, 28] and received positive responses and engagement from viewers [28]. This, in turn, has the capacity to promote positive perceptions about alcohol consumption [29]. For example, Nesi and colleagues examined social media usage and content among middle school aged youth and found that exposure to peers’ alcohol posts on Facebook was predictive of drinking initiation and binge drinking among this population [30]. The peer normative role of alcohol consumption on social media persists in young adults [29, 31, 32].

Alcohol-related content posted on social media not only influences viewers’ drinking behavior but might also be predictive of the users’ own alcohol use. A review by Curtis et al. looked at 19 studies on social media use and self-reported drinking and alcohol-related problems among adolescents and young adults. They found a correlation between the users’ social media engagement with their self-reported drinking and alcohol-related problems, with higher engagement leading to higher consumption and problems [33]. As an example, Litt et al. studied alcohol-related Twitter posts (tweets) among young adults to determine how these Tweets corresponded to the user’s self-reported alcohol use and behaviors. They found that having a higher proportion of alcohol-related tweets predicted willingness to drink, number of drinks a week, negative consequences of drinking, and problem drinking [34]. This effect is likely not unique to one particular social media site, such as Twitter, as studies on Facebook found similar results [35, 36].

In addition to analyzing data from individuals, population-level studies of the impact of social media content and alcohol use have also been conducted. Curtis and colleagues developed models to predict county-level alcohol consumption based on tweets. They found that tweet content was significantly associated with excess alcohol consumption (B. Curtis et al., 2018). Similarly, at the state level, the odds of recent alcohol use have been shown to have increased related to exposure to alcohol use tweets [37]. On a more local level, Hossain et al. compared alcohol consumption between a large urban area and a large suburban/rural area using geo-tagged tweets. They found a positive correlation between alcohol consumption and density of alcohol outlets as depicted in the tweets, which varied by geographic location [38].

Due to the recency of this field of study, there are limited studies looking at the intersection of HIV and alcohol risk behaviors on social media, making this an important area of need. Cornelius and colleagues examined three-months of tweets related among youth in Botswana. Alcohol-related tweets (i.e. wine, beer, Spirits) were the eighth most frequently tweeted content. They also identified alcohol consumption and unsafe sex practice (i.e. sex without a condom) as a trend in the tweets [39]. There have also been a small number of studies looking at the relationship between social media data and other substances (e.g., opioids), as well as studies looking at the relationship between social media data and HIV risk [40, 41]. For example, Cuomo et al. investigated tweets regarding intravenous drug use and HIV transmission risk pre and post an HIV epidemic. They found that Tweets about opioid use were significantly associated with HIV and opioid burden [42].

Although several studies on alcohol-related content on social media and its association with alcohol consumption focus on youth and young adults, limited studies exist among other age groups or high risk populations, especially in the context of HIV risk behavior, making this an important area of future study. Given the relationship between alcohol and HIV, it would be of interest to study the effects of alcohol-related social media posts and its subsequent impact on HIV risk behaviors. It has been shown that study participants not only post about alcohol while drinking, but even when intoxicated [43]. More research is needed to determine whether and how social media users post about sexual risk behaviors and related alcohol use.

Overall, there are a number of research (and ultimately, potential implementation) areas to study that could use social data as methods for surveillance on alcohol and HIV. Because social media data occur in real time, are publicly-available, and include personal health information shared
by users, social media data might provide insights about people’s alcohol consumption, including recent experiences consuming alcohol during sex. These data often provide targeted location information, which could help to inform public health efforts on how, where, and when people are engaging in alcohol use during sex. However, it is unknown how much data would be available on this topic, making it an area for future research.

**Internet Search**

Health researchers have used internet search trends (e.g., Google Trends data) to study a variety of topics including infectious diseases, mental health, substance use, and chronic conditions [18, 41, 44–46]. Compared to studies on the relationship between social media and alcohol use, fewer studies have looked at alcohol-related internet search trends. A study conducted by Parker et al. looked at the ability of internet search trends to forecast premature deaths and predicted an increase in state-level alcohol-induced deaths using the data [47]. Other investigators have examined the relative search volume of alcohol-related words on Google and state-level alcohol use, suggesting that alcohol-related query terms were associated with current alcohol use, and that the volume of search was affected by state alcohol policies [37]. Outside of health research, researchers have also studied the impact of economic conditions on alcohol search, finding that unemployment was positively associated with alcohol-related search queries [48].

Similar to social media data/research at the intersection of alcohol and HIV risk, there is a need for more studies using internet search data at the intersection of alcohol and HIV risk. HIV studies have already shown promise using internet search data to predict HIV diagnoses in the US and China [19, 41, 49]. Though it has its limitations, modeling using internet search trend data may be a cost-effective HIV surveillance method [50]. These methods might be especially relevant and immediately implementable in low resource areas that lack surveillance tools [18, 45]. For example, in regions where there are no current methods available to track surveillance, internet search data might be used to provide initial estimates and/or changes in trends in cases without incurring costs. These approaches are therefore immediately implementable in low resource settings where the current alternative to these digital surveillance approaches is to not collect any information. However, it remains important to continually study and gain support of the citizens to ensure proper ethical implementation.

It is important to note that while search data are collected and reported in aggregate (i.e., aggregate number of searches for “alcoholism” within a certain region is reported), social media data can be collected at the individual level. There are therefore trade-offs in the utility of social media versus internet search data, suggesting that approaches integrating both of these data sources could be useful.

**Wearable Devices, Apps and Sensors**

Smartphone applications (apps) are increasingly being used for monitoring alcohol consumption [51, 52] and broader health promotion [52]. For example, smartphone apps are used as a data collection tool for alcohol consumption [53] and for intervention delivery [54, 55]. A recent HIV study by Trang et al. tested the feasibility of an ecological momentary assessment application (EMA) and wearable device among MSM to monitor HIV related risk behaviors. They collected information about physical (ambulatory heart rate and physical activity) and mental health, risk behaviors, social environment, and geographic locations. Overall, study participants had positive feedback about their experience citing preferences for a more tailored experience (i.e., providing feedback on mood and behavior, MSM-friendly messaging) in the future. Additionally, participants stated the ability for telemedicine and locations of HIV service providers nearby as desirable features for future apps [56]. However, a limiting factor of using data from EMA’s and other apps is that they would require typically individuals to download the app. If a sufficient number of individuals did not download or use the app/EMA frequently, then there would not be sufficient data to provide meaningful results. Although these issues affecting amount of sensor data (e.g., user ability/willingness to download an app and/or share data) currently limit the utility of data science approaches, we expect in the future that these types of data will be increasingly available and able to analyzed based on trends in technology development and data sharing [57].

The use of technology to determine alcohol intoxication has evolved from breath analyzers to include electrochemical biosensors that can detect biofluids such as sweat, interstitial fluid, tears, and saliva [58]. Kai-Chin et al. developed a device designed to measure ethyl glucuronide in sweat and were successful in detecting alcohol consumption after one, two, and three dinks within one hour. This non-invasive approach would allow researchers to study light to moderate drinking among study participants [59]. Other researchers have developed software systems that could allow collection of alcohol consumption data in a more naturalistic setting using a wearable device [60].

There are also studies on the feasibility of using mobile apps as intervention tools to reduce alcohol consumption [61] or minimize relapse [62]. Chih et al. developed a predictive model to provide targeted feedback to study participants using a smartphone app to prevent relapse. After data about alcohol consumption were analyzed by the model,
if the participant was predicted to relapse, the smartphone would send a text message to participant and also alert the participant’s counselor [63]. These novel studies provide support for health researchers to incorporate technologies into HIV and alcohol interventions to test efficacy.

What is needed in Future Research?

Both excessive alcohol consumption and HIV are significant public health concerns. They also have overlapping health risks/comorbidities and stigma, making it important to study them together as well as separately [64–67]. Early detection and immediate response, including the use of new technologies and data surveillance methods, are crucial for the prevention of morbidity and mortality. Social media, internet search, and wearable device/sensor data might be used to serve as an early warning system. Even with a warning of a couple of weeks in advance, these types of tools might greatly assist public health preparation and response. To supplement, or even in place of, manual coding, investigators could use machine learning [68] and deep neural network analysis [69] to comb through social media posts to analyze content for potential outbreaks and predictive risk behaviors in a timely manner [70]. Importantly, due to the changing use of and perceptions of use around technologies, ongoing ethical studies need to be conducted to ensure safety and proper ethical use [71–76].

There are a number of potential ways to incorporate social data analyses at the intersection of alcohol-related behaviors and HIV risk among high risk populations. For example, artificial intelligence models might be incorporated to combine current (traditional) case reporting data on alcohol and HIV risk behaviors with social data. As there are limitations with every type of data source, models would likely combine traditional data with as multiple novel data sources (e.g., combining social media, internet search, and/or sensor data rather than using just one of these sources) as possible to address the limitations of each. When combined, models might be able to assist public health departments and epidemiology researchers in their surveillance efforts by providing more timely data that address lag times in reporting traditional data, as well as to provide greater insights into psychological and demographic predictors of alcohol and HIV risk behaviors. Importantly, these models and approaches should be collaborative efforts between scientific researchers, industry, and public health agencies to most rapidly, safely, and effectively address public health needs.

The approaches discussed in this manuscript are becoming increasingly relevant as a result of the COVID-19 pandemic. Due to COVID-19 policies and people’s increased time online, it is likely that an even larger amount of digital data are currently being created and can mined to learn about people’s health behaviors. For example, our team has already conducted some of this work, including studying how mobility data (i.e., movement data acquired from smartphone devices) can be used to inform COVID-19 transmission, use of Instagram/image data to inform adherence to COVID-19 social distancing orders, and to more broadly monitor the effects of internet and social media use on mental health, HIV, and substance use during the pandemic. Future research may focus on how the COVID-19 impacts the use of these approaches for alcohol and HIV research and surveillance.

Acknowledgements We wish to thank Romina Romero for assistance in drafting this manuscript.

Funding This study was funded by National Institute of Mental Health, National Institute on Drug Abuse, National Center for Complementary and Integrative Health and National Institute of Allergy and Infectious Diseases.

Declarations

Conflict of interest The authors have no conflicts of interest to report.

Ethical Approval No IRB approval or consent was required as this manuscript did not collect data.

References

1. HIV/AIDS. World Health Organization. 2019. Available from https://www.who.int/news-room/fact-sheets/detail/hiv-aids. Accessed 31 May 2020
2. Shuper PA, Neuman M, Kanteres F, Balunus D, Joharchi N, Rehm J. Causal considerations on alcohol and HIV/AIDS — A systematic review. Alcohol Alcohol. 2010;45(2):159–66.
3. Hahn JA, Samet JH. Alcohol and HIV disease progression: weighing the evidence. Curr HIV/AIDS Rep. 2010;7(4):226–33.
4. Koblin BA, Chesney MA, Husnik MJ, Bozeman S, Cemul CL, Buchbinder S, et al. High-risk behaviors among men who have sex with men in 6 US cities: baseline data from the EXPLORE study. Am J Public Health. 2003;93(6):926–32.
5. Washington TA, Patel SN, Meyer-Adams N. Drinking patterns and HIV risk behaviors among black and Latino men who have sex within Los Angeles county. Am J Mens Health. 2017;11(4):834–44.
6. Madhivanan P, Hernandez A, Gogate A, Stein E, Gregorich S, Setia M, et al. Alcohol use by men is a risk factor for the acquisition of sexually transmitted infections and human immunodeficiency virus from female sex workers in Mumbai, India. Sex Transm Dis. 2005;32(11):685–90.
7. Chersich MF, Bosire W, King’ola N, Temmerman M, Luchters S. Effects of hazardous and harmful alcohol use on HIV incidence and sexual behaviour: a cohort study of Kenyan female sex workers. Global Health. 2014;10(1):22.
8. Wang B, Li X, Stanton B, Zhang L, Fang X. Alcohol use, unprotected sex, and sexually transmitted infections among female sex workers in China. Sex Transm Dis. 2010;37(10):629–36.
9. Eysenbach G. Infodemiology: tracking flu-related searches on the web for syndromic surveillance. AMIA Annu Symp Proc. 2006;2006:244–8.

10. Eysenbach G. Infodemiology and infoveillance: framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the internet. J Med Internet Res. 2009;11(1):e11.

11. Young SD. Behavioral insights on big data: using social media for predicting biomedical outcomes. Trends Microbiol. 2014;22(11):601–2.

12. Olshannikova E, Olsson T, Huhtamaäki J, Kärkkäinen H. Conceptualizing big social data. J Big Data. 2017;4(1):3.

13. Olteanu A, Castillo C, Díaz F, Kıcıman E. Social data: biases, methodological pitfalls, and ethical boundaries. Front Big Data. 2019. https://doi.org/10.3389/fdata.2019.00013/full.

14. Evans BM, Chi EH. Towards a model of understanding social search. In: Proceedings of the 2008 ACM conference on Computer supported cooperative work. New York, NY, USA: Association for Computing Machinery; 2008. p. 485–494. doi: https://doi.org/10.1145/1460563.1460641.

15. Young SD. A “big data” approach to HIV epidemiology and prevention. Prev Med. 2015;70:17–8.

16. Barros JM, Duggan J, Rehbolz-Schuhmann D. The application of internet-based sources for public health surveillance (infoveillance): systematic review. J Med Internet Res. 2020;22(3):e13680.

17. Brownstein JS, Freifeld CC, Madoff LC. Digital disease detection — Harnessing the web for public health surveillance. N Engl J Med. 2009;360(21):2153–7.

18. Young SD, Torrone EA, Urra J, Aral SO. Using search engine data as a tool to predict syphilis. Epidemiology. 2018;29(4):574–8.

19. Zhang Q, Chai Y, Li X, Young SD, Zhou J. Using internet search data to predict new HIV diagnoses in China: a modelling study. BMJ Open. 2018;8(10):e018335.

20. Young SD. Recommended guidelines on using social networking technologies for HIV prevention research. AIDS Behav. 2012;16(7):1743–5.

21. Young S, Dutta D, Dommety G. Extrapolating psychological insights from Facebook profiles: a study of religion and relationship status. Cybersysthych Behav. 2009;12(3):347–50.

22. Bernardo TM, Rajac A, Young I, Robiadek K, Pham MT, Funk JA. Scoping review on search queries and social media for disease surveillance: a chronology of innovation. J Med Internet Res. 2013;15(7):e147.

23. Liu S, Zhu M, Yu DJ, Rasin A, Young SD. Using real-time social media technologies to monitor levels of perceived stress and emotional state in college students: a web-based questionnaire study. JMR Hyg. 2017;4(1):e2.

24. Liu S, Zhu M, Young SD. Monitoring freshman college experience through content analysis of tweets: observational study. JMR Public Health Surveill. 2018; 4(1). Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5785682/. Accessed 18 Sep 2018

25. Garett R, Li S, Young SD. The relationship between social media use and sleep quality among undergraduate students. Inf Commun Soc. 2018;21(2):163–73.

26. Nuti SV, Wayda B, Ranasinghe I, Wang S, Dreyer RP, Chen SI, et al. The use of google trends in health care research: a systematic review. PLoS ONE. 2014;9(10):e109583.

27. Cavazos-Rehg PA, Krauss MJ, Sowles SJ, Bierut LJ. “Hey Everyone, I’m Drunk.” An Evaluation of drinking-related twitter chatter. J Stud Alcohol Drugs. 2015; 76(4):635–43.

28. Hendriks H, Van den Putte B, Gebhardt WA, Moreno MA. Social drinking on social media: content analysis of the social aspects of alcohol-related posts on Facebook and Instagram. J Med Internet Res. 2018; 20(6):e226.

29. Young SD, Jordan AH. The influence of social networking photos on social norms and sexual health behaviors. Cybersysthych Behav Soc Netw. 2013;16(4):243–7.

30. Nesj J, Rothenberg WA, Hussong AM, Jackson KM. Friends’ alcohol-related social networking site activity predicts escalation in adolescent drinking: mediation by peer norms. J Adolesc Health. 2017;60(6):641–7.

31. Bergman BG, Dumas TM, Maxwell-Smith MA, Davis JP. Instagram participation and substance use among emerging adults: the potential perils of peer belonging. Cybersysthych Behav Soc Netw. 2018;21(12):753–60.

32. Boyle SC, LaBrie JW, Froidevaux NM, Witkovic YD. Different digital paths to the keg? How exposure to peers’ alcohol-related social media content influences drinking among male and female first-year college students. Addict Behav. 2016;57:21–9.

33. Curtis BL, Lookatch SJ, Ramo DE, McKay JR, Fein R, Kranzler HR. Meta-analysis of the association of alcohol-related social media use with alcohol consumption and alcohol-related problems in adolescents and young adults. Alcoholism Clinical and Experimental Research. 2018;42(6):978–86.

34. Litt DM, Lewis MA, Spiro ES, Aulick L, Waldron KA, Head-Corllis MK, et al. #drunktwitter: examining the relations between alcohol-related Twitter content and alcohol willingness and use among underage young adults. Drug Alcohol Depend. 2018;1(193):75–82.

35. Marczinski CA, Hertzgen H, Goddard P, Maloney SF, Statemates AL, O’Connor K. Alcohol-related Facebook activity predicts alcohol use patterns in college students. Addict Res Theory. 2016;24(5):398–405.

36. Moreno MA, Cox ED, Young HN, Haeland W. Undergraduate college students’ alcohol displays on Facebook and real-time alcohol behaviors. J Adolesc Health. 2015;56(6):646–51.

37. Weitzman ER, Magane KM, Chen P-H, Amiri H, Naimi TS, Wisk LE. Online searching and social media to detect alcohol use risk at population scale. Am J Prev Med. 2020;58(1):79–88.

38. Hossain N, Hu T, Feizi R, White AM, Luo J, Kautz H. Inferring fine-grained details on user activities and home location from social media: detecting drinking-while-tweeting patterns in communities. arXiv:1603.03181. 2016; Available from http://arxiv.org/abs/1603.03181. Accessed 5 Jun 2020

39. Cornelius J, Kennedy A, Wesslen R. An examination of twitter data to identify risky sexual practices among youth and young adults in Botswana. Int J Environ Res Public Health. 2019;16(4):656.

40. Young SD, Shoptaw S. Stimulant use among African American and Latino MSM social networking users. J Addict Dis [Internet]. 2013;32(1). Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3825678/. Accessed 22 Feb 2019

41. Young SD, Zhang Q. Using search engine big data for predicting new HIV diagnoses. PLoS ONE. 2018;13(7):e0199527.

42. Cuomo RE, Cai M, Shah N, Li J, Chen WH, Obradovich N, et al. The use of Google Trends in health care research: a systematic review. PLoS One. 2014;9(10):e109583.

43. Litt DM, Lewis MA, Spiro ES, Aulick L, Waldron KA, Head-Corllis MK, et al. #drunktwitter: examining the relations between alcohol-related Twitter content and alcohol willingness and use among underage young adults. Drug Alcohol Depend. 2018;1(193):75–82.

44. Hossain N, Hu T, Feizi R, White AM, Luo J, Kautz H. Inferring fine-grained details on user activities and home location from social media: detecting drinking-while-tweeting patterns in communities. arXiv:1603.03181. 2016; Available from http://arxiv.org/abs/1603.03181. Accessed 5 Jun 2020

45. Cornelius J, Kennedy A, Wesslen R. An examination of twitter data to identify risky sexual practices among youth and young adults in Botswana. Int J Environ Res Public Health. 2019;16(4):656.

46. Young SD, Shoptaw S. Stimulant use among African American and Latino MSM social networking users. J Addict Dis [Internet]. 2013;32(1). Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3825678/. Accessed 22 Feb 2019

47. Cuomo RE, Cai M, Shah N, Li J, Chen WH, Obradovich N, et al. Characterising communities impacted by the 2015 Indiana HIV outbreak: a big data analysis of social media messages associated with HIV and substance abuse. Drug Alcohol Rev. 2020; Doi: https://doi.org/10.1111/dar.13091

48. Ceballos NA, Howard K, Dailey S, Sharma S, Grimes T. College binge drinking and social media use among Hispanics and non-Hispanics. J Stud Alcohol Drugs. 2018;79(6):686–75.

49. Nuti SV, Wayda B, Ranasinghe I, Wang S, Dreyer RP, Chen SI, et al. The use of Google Trends in health care research: a systematic review. PLoS One. 2014; 9(10):e109583.

50. Young SD, Mercer N, Weiss RE, Torrone EA, Aral SO. Using social media as a tool to predict syphilis. Preventive Medicine. 2017; Available from http://www.sciencedirect.com/science/article/pii/S0091743117305030. Accessed 22 Jan 2018
46. Young SD, Zheng K, Chu LF, Humphreys K. Internet searches for opioids predict future emergency department heroin admissions. Drug Alcohol Depend. 2018;190:166–9.

47. Parker J, Cuthbertson C, Loveridge S, Skidmore M, Dyar W. Forecasting state-level premature deaths from alcohol, drugs, and suicides using Google Trends data. J Affect Disord. 2017;213:9–15.

48. Frijters P, Johnston DW, Lordan G, Shields MA. Exploring the relationship between macroeconomic conditions and problem drinking as captured by Google searches in the US. Soc Sci Med. 2013;1(84):61–8.

49. Jena AB, Karaca-Mandic P, Weaver L, Seabury SA. Predicting new diagnoses of HIV infection using internet search engine data. Clin Infect Dis. 2013;56(9):1352–3.

50. Nan Y, Gao Y. A machine learning method to monitor China’s AIDS epidemics with data from Baidu trends. PLoS One. 2018;13(7). Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6040727/. Accessed 31 May 2020

51. Hoeppner BB, Schick MR, Kelly LM, Hoeppner SS, Bergman B, Kelly JF. There is an app for that – Or is there? A content analysis of publicly available smartphone apps for managing alcohol use. J Subst Abuse Treat. 2017;1(82):67–73.

52. Weaver ER, Horyniak DR, Jenkinson R, Dietze P, Lim MS. “Let’s get wasted!” and other apps: characteristics, acceptability, and use of alcohol-related smartphone applications. JMIR mHealth uHealth. 2013;1(1):e9.

53. Dulin PL, Alvarado CE, Fitterling JM, Gonzalez VM. Comparisons of alcohol consumption by timeline follow back vs. smartphone-based daily interviews. Addict Res Theory. 2017;25(3):195–200.

54. Gajecki B, Berman AH, Sinadinovic K, Rosendahl I, Andersson C. Mobile phone brief intervention applications for risky alcohol use among university students: a randomized controlled study. Addict Sci Clin Pract. 2014;9(1):11.

55. Gonzalez VM, Dulin PL. Comparison of a smartphone app for alcohol use disorders with an Internet-based intervention plus bibliotherapy: a pilot study. J Consult Clin Psychol. 2015;83(2):335–45.

56. Trang K, Sullivan PS, Hinton DE, Worthman CM, Le MG, Jovanovic T. Feasibility, acceptability, and design of a mobile health application for high-risk men who have sex with men in Hanoi, Vietnam. Lancet Global Health. 2020;15(7):1040–9. https://doi.org/10.1080/17441692.2020.1724314.

57. Lim S, Tucker CS, Kumara S. An unsupervised machine learning model for discovering latent infectious diseases using social media data. J Biomed Inform. 2017;1(66):82–94.

58. Chiu CJ, Menacho L, Fisher C, Young SD. The association between age and stigmatization of alcohol use among people receiving antiretroviral therapy for HIV infection, Cape Town, South Africa. Glob Public Health. 2020;15(7):1040–9. https://doi.org/10.1080/17441692.2020.1724314.

59. Bonar EE, Koocher GP, Benoit MF, Collins RL, Cranford JA, Walton MA. Perceived risks and benefits in a text message study of substance abuse and sexual behavior. Ethics Behav. 2018;28(3):218–34.

60. Chiu CJ, Menacho L, Fisher C, Young SD. Ethics issues in social media-based HIV prevention in low- and middle-income countries. Camb Q Healthc Ethics. 2015;24(3):303–10.

61. Chiu CJ, Menacho L, Young SD. The association between age and ethics-related issues in using social media for HIV prevention in Peru. Ethics Behav. 2016;26(2):99–109.

62. Chiu CJ, Menacho L, Young SD. Ethical issues in using social media to deliver an HIV prevention intervention: results from the HOPE Peru study. Prev Sci. 2017;18(2):225–32.

63. Golden S, Ahmed S, Norman G, Booth A. Attitudes toward the ethics of research using social media: a systematic review. J Med Internet Res. 2017;19(6):e195.

64. Young SD, Garrett R. Ethical issues in addressing social media posts about suicidal intentions during an online study among youth: case study. JMIR Mental Health. 2018;5(2):e33.