What about drug checking? Systematic review and netnographic analysis of social media

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Abstract

Drug checking services have been operating worldwide as a harm reduction tool in places like festivals and nightclubs. A systematic review and netnographic analysis were conducted to explore the public's perception of drug checking. Although public perceptions of drug checking had not previously been evaluated in the literature, some positive and negative perceptions were captured. From Twitter, a total of 1316 tweets were initially identified. Following the removal of irrelevant tweets, 235 relevant tweets were identified of which about 95% (n = 223) tweets were in favour and about 5% (n = 12) were not in favour of drug checking as a harm reduction intervention. Tweets perceived the service as part of effective law reform, public health intervention that serves in raising awareness and countering the role of the internet, initiative to prevent harm and/ or potentially deaths, help in identifying novel trends related to drugs, enabling a scientific basis to capture data, reducing harm from risky drugs or risky consumption, reducing the economic and social burden on society and preventing young people from having criminal records and punitive fines. Drug checking was perceived to support engagement with treatment services and support individuals in making more informed decisions. Tweets against drug checking focussed on the concerns over the quality of drug checking particularly with false positive results, which may lead to punitive outcomes, discrimination and prejudice. The present study showed that Twitter can be a useful platform to capture people's perceptions on drug checking.

Keywords

Drug checking, Drug screening, Drug testing, Pill testing, Harm Reduction, Twitter

Introduction and Background

The growing increase in the severe harm caused by the use of illicit drugs places immense pressure on healthcare services [1-3]. As part of a public health initiative to tackle the harms associated with drug use, drug checking services (also known as drug or pill testing) have been made increasingly available worldwide as part of a harm reduction approach [4-5]. In 2017, a global review identified 31 drug checking services operating across 20 countries [6].

Various drug checking models have been established. These include on-site (also known as front-of-house testing) drug checking services such as The Loop, which is commonly found in nightlife economy like nightclubs and at festivals [7-8]. "Front-of-house testing" allows "face-to-face interactions and real-time exchange of information" between service users and service providers [5, 9-11]. Other models include off-site services such as the Welsh Emerging Drugs & Identification of Novel Substances (WEDINOS) project, a service that is funded by the Welsh Government. It allows submission of drug samples whereby individuals are provided with information on the chemical profile and harm reduction advice in addition to samples submitted from various organisations, services and nightlife economy venues from across the UK [12-13]. Another example of off-site services is MANDRAKE (Manchester Drug Analysis and Knowledge Exchange), which works in partnership with local police and other stakeholders in Manchester (UK), providing analytical results alongside harm reduction interventions in the city-centre [14]. Self-checking drug testing is another delivery method, which individuals can employ to assess their own products, and have been perhaps most commonly utilised to reduce the risk of fatal overdoses from potent drugs such as fentanyl derivatives [15-20].

The Drug Information and Monitoring System (DIMS) in the Netherlands is perhaps the longest running drug checking service [6]. DIMS have successfully operated their services for over 20 years [6, 10, 21], and have acted as a pharmacovigilance arm, which feeds into the European Early Warning System [22]. Following the Dutch initiative, other drug checking services began to set up across Europe, including CheckIt in Austria and WEDINOS in the UK. These drug checking services share common goals: reducing harm and inadvertent overdoses and pre-mature deaths [23-24]. DanceSafe was founded in 1998, in the United States. It provided a harm reduction service to the nightlife and electronic music community [7, 10]. More recently in the UK, The Loop introduced a "front-of-house" service known as Multi-Agency Safety Testing (MAST) to festivalgoers since 2016, which has claimed a 95% reduction in drug-related hospital admissions and identified numerous samples that were miss-sold [8].

In the UK, the first Home Office-licensed pharmacist-led drug checking service, within a drug and alcohol service, was piloted in 2019 in North Somerset. The pilot checked drug samples and provided holistic harm reduction interventions using a multi-disciplinary approach [25]. However, unlike the UK and the Netherlands, where drug

checking services are supported by government bodies and/ or through controlled drug licenses, other countries are often restricted as a result of national laws and regulations [6, 10, 21, 26]. In some services, where possession of drugs may be an offence, drug checking services' staff would ask the service user to conduct the testing themselves [27-28]. These services are dependent upon volunteer harm reduction organisations, where analysts may not have sufficient training [29]. Thus, despite the increasing use of drug checking services in a variety of settings, they may not be widely accepted and may be perceived as encouraging drug use [30-31]. Limited studies have been conducted to explore acceptability of drug checking whether the service was provided by specialised services or undertaken by the drug user [4, 19-20, 32]. An evaluation of DIMS has been undertaken to assess whether service provision has increased drug use. Evaluation results showed that drug use has remained unchanged since the initial set up of the service in 1992 in the Netherlands [33].

Due to the limited published literature available on the general public's perception of drug checking, in this research, we aimed to explore this further via social media. "Social media mining" may provide some understanding of the acceptability of the use of drug checking services within a harm reduction context and potential for use in a wide range of settings. The growing popularity of social media in recent years has provided a platform for users and suppliers to interact and communicate and is frequently used by providers of drug checking services to communicate findings, particularly pertaining to substances, which carry significant levels of risks if consumed.

A netnographic method, where qualitative data is obtained from information that is already publicly available can be used to identify the needs and decision influences of online consumer groups [34]. "Social media mining" has been shown to be an effective public health tool that can support disease surveillance, pharmacovigilance particularly with respect to behavioural medicines, etc. [35]. However, "Social media mining" can be limited by technical literacy and subjective analysis [35]. In fact, many research papers have used social media as a source of big data that is generated by users [35- 46]. This approach has been used to explore various aspects of substance misuse via Twitter [38-46]. Unlike other social media platforms such as Facebook, Twitter's Application Programming Interface (API) is easily and openly accessible, allowing large publicly made available datasets to be retrieved [47]. Twitter users create posts known as "tweets", which are limited to 280 characters and reports having 326 million monthly active users in 2018 [48] with 500 million tweets posted daily [49]. Re-tweets are posts re-tweeted by other users. Furthermore, the creation of "Hashtags" allows tweets to be categorised [50], which is useful for classifying major themes and current understanding trends.

By using Twitter, user-generated data has been commonly collected manually or via a web crawler [36]. The duration of data collection in various studies varied from seven

days up to a year [39, 44]. Some of these research papers collected tweets, whilst others identified social circles of main users [39, 41]. The number of tweets varied with the popularity of the topic. For example, 2100 tweets were collected about the use of prescription drugs in just seven days [44]. This is in comparison 2.3 million tweets collected over six months on diversion of prescription medicines [40].

To our knowledge, there are no published papers to date, which explored the public's perception of drug checking or drug testing via Twitter.

Aims

The aim of this study was to explore the public's perception of drug testing as a harm reduction intervention in the literature and via Twitter.

Methodology

The public's perceptions of drug testing as a harm reduction intervention was explored in the literature. Engagement in discussions related to drug testing was investigated by collecting real-time data using a netnographic methodology via Twitter.

Literature Review

A literature review was carried out using the scientific databases PubMed, Scopus and Google Scholar using the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [51] (Figure 1). The search was completed during 2019 and the following search terms were used: "public perception" AND "drug testing" OR "drug checking" OR "drug screening" OR "pill testing"; a combination of all four search terms: "drug testing" AND "drug checking" AND "drug screening" AND "pill testing". All types of publications up until 18th July 2019 were included. Articles that were not written in English were excluded from this study. Duplicate articles were removed using Zotero V.5.0.69. A grey literature search was also conducted on Google to explore the public's perception of drug testing at festivals using the same search terms.

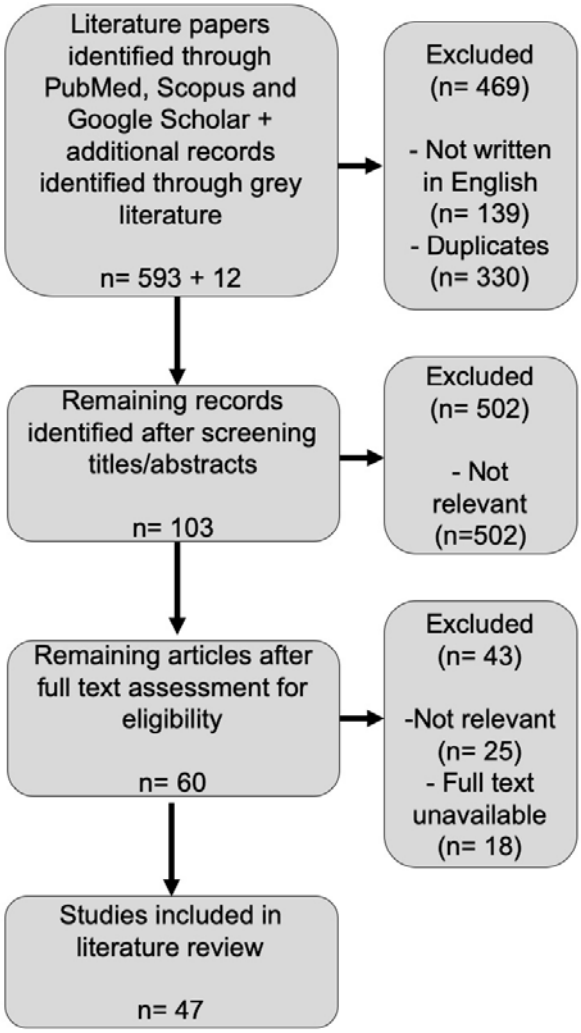

Figure 1: PRISMA flow chart

Twitter Data

RapidMiner Studio (2018) V.9.0. (Germany), a data-mining software, was employed to extract tweets over a one-month period (23rd October 2018 - 23rd November 2018) from Twitter users as outlined in Figure 2. A "Search Twitter" operator was selected to allow access to Twitter and establish a connection with a Twitter account. The following keywords were individually searched: “drug testing”, “drug checking”, “drug screening” and “pill testing”, with separate connections being established. Access tokens were then produced, which provided authentication and allowed RapidMiner to connect to the Twitter account.

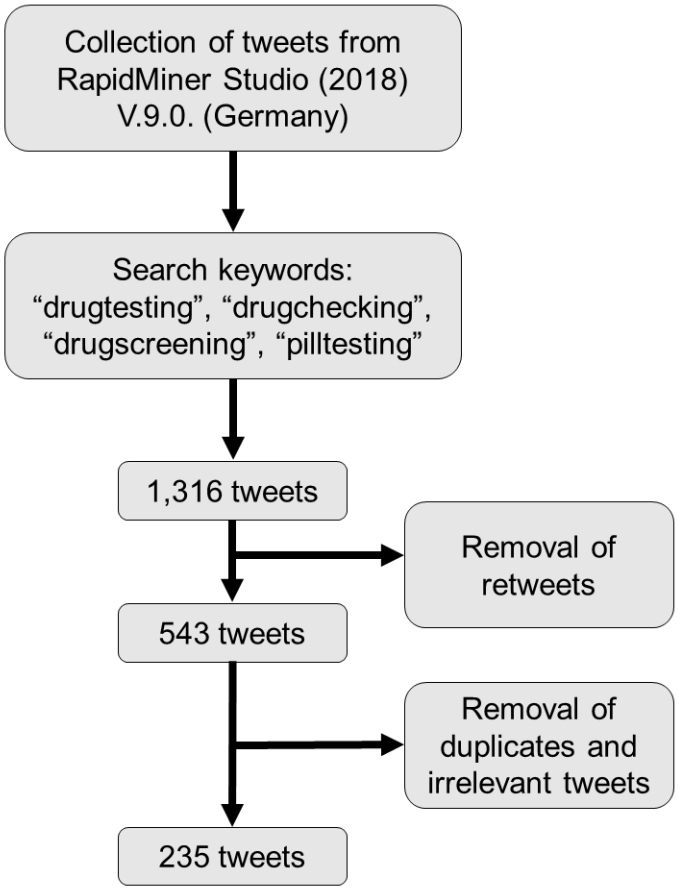

Figure 2: A schematic flowchart outlining the process of extracting tweets from the data mining software RapidMiner Studio (2018) V.9.0. (Germany).

Method optimisation and data cleaning

Following the initial set up, additional parameters were added (e.g. exclude non-English tweets) to restrict the search and ensure relevance of the original tweets as highlighted in Table 1. Raw data were then imported into a Microsoft Excel (2018) spreadsheet (Table 2). The software could only identify tweets that were most recent or popular (up to 10 days). This led to old tweets being automatically deleted from the spreadsheet as more recent tweets became available. As a result, new spreadsheets had to be created daily in order to keep the data intact and ensure tweets were being obtained through the software. Due to a large volume of raw data generated, RapidMiner was used to clean the dataset e.g. remove retweets and duplicates. For this purpose, a second spreadsheet was created with reposted tweets (re-tweets) removed, undertaken using the same parameters described in Table 2 with the addition of “(-rt)” after each keyword. Tweets related to workplace drug testing were not aligned with the objectives of this study and hence, were also removed.

Table 1: Outline of searches for tweets and additional search restrictions

Parameter	Description	Search Restrictions
Search Query	The term that should be searched	drugtesting, drugscreening, drugchecking, pilltesting
Result Type	The preferred search result type	Recent or popular
Limit	The limit on the number of tweets to return	1,000
Language	Specifics the language of the query	English

Table 2: Output data generated on a Microsoft Excel (2018) spreadsheet

Parameter	Description
Created-At	Date and time tweets were created
From-User	Username of Twitter account holder
From-User-Id	Username Id of Twitter account holder
To-User	User of which tweet is directed to
To-User-Id	User Id of which tweet is directed to
Language	Language of tweet
Source	Source of tweet
Text	Tweet created by user
Geo-Location-Latitude	Geographical location and latitude of the tweet
Retweet-Count	Number of re-tweets
Id	Id of tweet

Re-tweets, duplicated and irrelevant tweets were excluded and manually removed from the data set. The dataset collected from raw data was manually compared to clean data, to ensure no tweets were missed during removal of re-tweets. Keywords and phrases were also searched within the document using the sidebar search to confirm the removal of duplicated tweets. Keywords were manually identified assigned and themes were analysed by searching for common words or phrases present within the tweets. A colour coding system was then used to categorise these tweets to their relevant themes. The Excel spreadsheet was manually reviewed by IM and independently reviewed by AG to ensure appropriate tweets had been identified. Categorisation was then independently reviewed, the findings were discussed and no differences were identified.

In this study, original tweets were only included. Re-tweets may indicate that a user is in favour of a tweet. They were however removed from the dataset as there is no clear indication whether the tweet is, in fact, an opinion of the tweeter. For example, some users may choose to re-tweet a tweet, which resonates with their followers, but this may not represent their personal opinion. Duplicates were also removed from the dataset. Duplicates differ from re-tweets as users may duplicate an original tweet by re-writing the same tweet. Organisations may also use this method by tweeting the same tweet multiple times during the day to increase the chances of followers viewing the tweet. The latter is not considered a duplicated as they have been tweeted by different users and hence, were not removed from the dataset.

Results

Literature Review

Search results from Scopus and PubMed identified a total of 139 papers. The search from Google Scholar identified 923 papers. Seventeen published papers over the period 2015 - 2019 were identified as relevant. Duplicate articles were removed and relevant papers were identified resulting in 47 papers. Due to the limited published data available on the public's perception of drug testing at festivals in the UK; therefore, a grey literature search was conducted on Google to provide an overview of the public's perception of drug testing at festivals in the UK.

The literature review identified two main authors Barratt and Brunt who have carried out comprehensive global evidence reviews to compare various drug checking services [52]. The literature review also showed the lack of benchmarking to evaluate these services [52]. It has also showed mixed views relating to perceptions of drug checking services. Some views expressed that these services were found to positively influence users' behaviour and allow informed decisions to be made [8, 53-54], whilst, others expressed their concerns about the potential of these services to encourage or endorse drug use [8-10, 55-57]. Limited studies have been conducted in the UK to explore the public's perceptions of drug checking in the UK [8, 25]. A number of research papers explored various aspects of substance misuse on Twitter [38-42, 44-46], however, none of them explored the public's perceptions on drug checking.

Twitter

This research explored the views and perceptions of the general public using real-time data collected employing a netnography method, where data was collected from Twitter. Themes "in favour" or "not in favour" of drug checking were identified from keywords, hashtags and full tweets.

A total of 1316 tweets were initially identified. Following the removal of retweets, 543 original tweets were identified: 274 tweets on drug testing, 50 on drug screening, 50

on drug checking and 169 on pill testing. Following the removal of duplicates and irrelevant tweets (n = 56), 235 relevant tweets were identified of which about 95% (n = 223) tweets were in favour and about 5% (n = 12) were not in favour of drug testing as a harm reduction intervention. The most common keyword that attracted relevant tweet was “pill testing”.

Keywords were identified to explore a user’s behaviour and the emotions they are trying to convey. For example, positive emotions are often associated with words such as “good” and “amazing” whereas negative emotions are associated with words such as “bad” and “poor” [58]. Examples of positive sentiments identified within the tweets include “*pleased”, “happy”* and *“grateful”.* Negative sentiments identified. Include “*sad”* and “*disappointing”.*

Results from the present study are in good agreement with findings from other twitter studies:

“Of 87 respondents 53% supported #pilltesting at all youth music events in Australia, 46% supported pilltesting at GroovinTheMoo and 1% opposed pill testing https://t.co/Mci67vjX8e”

Tweets in favour of drug checking listed various benefits of those services including raising awareness and countering the role of the internet:

“having that discussion face-to-face with health professionals means more young people can stay safe and healthy”.

“This is about listening to experts & giving people non-judgmental info about their #drugs that will prevent overdose & save lives”.

“Impact of speaking with a professional on dangers of drugs, without fear of persecution”.

“it is overseen by medical professionals with expertise in drug overdose, with forensic chemists performing the analysis on lab grade kit, & peer groups providing context”.

Tweets identified in favour of drug checking highlighted tweeter’s opinions that drug checking could prevent harm and/ or potentially deaths:

“After significant struggle>80 countries allowed legal needle syringe programs to reduce HIV spread among & from people who inject drugs as less worse option. #Pilltesting another less worse option compared to more deaths & hospital admissions of young people at music events”.

“Tragedy averted by naloxone by paramedics”.

"I'd much prefer to see benefit of doubt go to trying to save lives, prevent hospital admissions of young people than go to theoretical concerns maybe this/that. Let's get on with it!"

"Pill testing would be beneficial to save lives & expenses. Whilst having drug tested, users could've been educated on dosage to reduce OD."

"Save lives first, questions later #PillTestingSavesLives #pilltesting #votereason!"

"There are concerns Premier Berejiklian's policy of ramping up police operations and refusing to adopt harm minimisation measures such as pill testing will lead to the loss of more young lives. #sydneydruglawyers #pilltesting #musicfestivals #drugpossession https://t.co/SCgdBbkHvt"

"What we know is that at the #Canberra trial - yes, just one the one so far - at least two potentially fatal substances were identified. Punters threw them out".

#PillTesting won't end all harm, but it can make a real difference. We can keep more young lives safe. #Greens https://t.co/7TD0OwKdmI"

"I'm tired of #pilltesting debate. If there's still doubt where should that benefit of doubt go? I'd much prefer to see benefit of doubt go to trying to save lives, prevent hospital admissions of young people than go to theoretical concerns maybe this/that. Let's get on with it!"

In this study, a number of tweets highlighted that drug checking helps engaging people in services and capturing individuals who are not in treatment, influences and alters their drug-taking behaviours and habits:

"Offering #drugchecking at services provides an opportunity to engage with young people who may otherwise never present to a traditional drug service. Looking forward to seeing @profhrs work on #prevention and #briefintervention at festivals #nationaldrugsforum2018 https://t.co/q7mNsPk1oC"

Some views see that drug checking being part of drug policy:

Harm minimisation, supply reduction and demand reduction = effective drug law reform. The Federal Government's own Drug Strategy backs this approach. #pilltesting https://t.co/kX5OIzHHNr"

"Posession of illicit drugs is still illegal (it's kind of implied in the word ??), and #pilltesting doesn't change that."

#PillTesting offers users opportunity to know from responsible figures that drugs/substances could be dangerous, without fear of persecution. Mostly, 'Fear of persecution' has never been a reason to stop indulging in addictive behaviour".

"This is not endorsing drug use, just like injection rooms & needle exchanges".

Opinions in the present study highlighted that drug checking can support individuals in making more informed decisions:

"They are told the contents so they can make a more informed, safer decision. No ticks. #PillTesting saves lives, a good thing".

"That's the evidence pill testing shows, pills with known harmful contents are thrown out & not taken. Need #pilltesting to learn the contents".

Some tweets shared outcomes of drug checking services:

"Pills with known content are thrown and not taken".

"Benschop et al. clearly shows that where #pilltesting is offered, consumers use less drugs, & use fewer varieties".

"Sharing knowledge and information for young people on what to do if test is positive".

Tweets in favour of drug checking also highlighted the fact that with decriminalisation or not, people will continue to take drugs and hence, harm reduction as exemplified by drug checking is key:

"drug use will always prevail"
"young people will continue to take drugs"
"people have and will always use drugs".

"We know young people consume recreational drugs both inside and outside major music events".

More work must also be done to ensure on-site and offsite #pilltesting services are realised".

"I don't support decriminalisation of illegal drugs but I do support #PillTesting People will always take drugs & studies show that if you test pills & tell users what's mixed with the drug i.e. bleach-draino-ketamine-petrol ect the majority will throw them away #BetterThanDeath"

"Pilltesting policy is in transition from contentious to widely supported & unremarkable.

Think about it the other way: knowing young people will continue to take drugs at music events, what are the arguments for ensuring those drugs are untested?".

Tweets in favour of drug checking have sometimes included a harm reduction message to potential drug users. These included:

"if you're taking a #drug obtained anywhere other than a pharmacy, get it tested".

"Discard if you can, don't use alone, take a test shot, have naloxone nearby".

"Test your drugs! Spread the word- everyone needs to know that #harmreduction tools are available! #drugchecking can save lives of your friends and loved ones. Check for #fentanyl and other adulterants- test it before you ingest it! #testit https://t.co/Vo4QOxVSDD https://t.co/aeXv3Fo4nT"

In the present study, tweets highlighted barriers where drug checking may not be legal in some countries e.g. Sydney.

"She said those handling illicit substances as part of a pilltesting service could be liable to prosecution under current laws".

Views not in favour of drug checking perceived drug checking as a way to legalise all drugs without educating on harms from drugs or how to deal with peer pressure, which leads to more arrests for under 18 years of age.

"Hi! I respectfully disagree!??Im from #Michigan & it thrived with jobs until they began #DrugTesting. I tested 99% on the tests to work at GMC and the ONLY test I failed was for #Cannabis. Also a friend just bought a house & got fired due to random test. Resulted in #Suicide ??"

"Look how often field drug tests send innocent Georgians to jail https://t.co/V9e1UcJWVC #drugtests #drugtesting".

"#Pre-employment #drugtesting can limit turnover, by detecting which applicants are likely to miss work, raise insurance premiums, have performance issues, and ultimately have a higher separation rate. https://t.co/kYAo8gfjQt".

"You get what you pay for and a $2 drug test is almost to good to be true. Sad that innocent people had to pay the price. Hopefully they can right some wrongs. #drugtesting….. police used faulty drug testing tool that sent people to jail. https://t.co/MtPz74WhjO https://t.co/5Zjer5xrAA".

Discussion

This is the first paper to explore public's perceptions of drug testing as a harm reduction intervention. Engagement in discussions related to drug testing was investigated by collecting real-time data using a netnographic methodology via Twitter. This research explored people's perceptions and views about the use of drug checking

services as a harm reduction tool in settings such as festivals and nightclubs. From the literature, some studies have explored the design features of a publicly accepted service: in Australia, Barratt et al. (2018) found that 94% of people would use on-site drug checking services located at festivals or clubs; however, they would not use the service if there was a likelihood of arrest. Recently, Alex Ross-King, 19 years old, overdosed on MDMA and lost her life as a result of trying to avoid being arrested at the Fomo music festival in Parramatta (New South Wales, Australia) [59]. This finding is consistent with other studies where research suggested that users are receptive towards using drug checking services [55, 60], however, obstacles to using these services include fear of being detained by the police, loss of privacy, criminalisation and loss of anonymity [16, 60]. Furthermore, users may choose not to use these services unless they were using a new substance, batch and/ or dealer [61].

Published views from the public of drug testing at festivals in the UK showed mixed perceptions of drug checking [62-64]:

"There were two people killed yesterday, so if [The Loop's work] stops two people dying. It has to be a good thing".

"It just gives you peace of mind. I know tomorrow I'll be alright rather than worrying about what's in my drugs".

"Legalise and regulate them. That'll make people much safer".

"Drug testing services offer an illusion of safety…drugs are illegal because they are unsafe and that is the message that the police ought to be giving"

Views in favour of drug checking at festivals showed that the public considers drug checking services at festivals as being important in preventing deaths and reducing harm to users. Many in favour of drug checking services, appreciated the service being provided and the potential reduction in harms that they may have otherwise experienced. Some believed that the government should not be responsible for providing funding for drug checking services and feel that it would be more appropriate to place stricter regulations and legislation in place instead. Some also expressed the contradiction between having a drug checking service inside festivals despite the presence of police whose priority is to prevent drugs from entering festivals in the first place [62-64]. This finding shows that although the public appreciates the service, clearer guidelines on the legal aspects of taking drugs in the festival environments is required. This would also provide further assurance to users who may want to use drugs to use services like The Loop or ACT GTM Pill Testing Service (Australia) without the fear of prosecution or criminalisation [65].

In addition to the general public's perceptions of drug testing, politicians and the wider scientific community may have contradicting views [31]. Prof. Alison Ritter, Director of

the Drug Policy Modelling Program at the National Drug and Alcohol Research Centre (NDARC), and Andrew Leibie, a scientist with Safework Laboratories and a member of the International Association of Forensic Toxicologists have both expressed arguments for and against drug testing, respectively [31]. Arguments for drug testing, as described by Prof. Ritter debated that drug testing has been shown to influence market trends and the life of a drug in the illicit drug market. It has indirectly informed drug makers to avoid harmful adulterants, influenced people's behaviour to reduce/ stop drug use, enabled access to care and support, and represented an invaluable source of information on drug use. In contrast, arguments against drug testing, as described by Leibie, focussed on the reliability and accuracy of onsite testing techniques [31]. Following a public Hearing in New South Wales (NSW) concerning an inquest into the death of six patrons of NSW music festivals, the Magistrate Harriet Grahame, Deputy State **Coroner recommended the trialling of 'pill testing' to reduce drug-related harms and enhance public health and safety** [66].

Given the limited knowledge on the public's perceptions on drug checking interventions, Twitter was employed as a platform to enhance the understanding of tweeters' opinions via opinion mining or sentiment analysis [67].

The size of the dataset of relevant tweets that was collected was limited compared to other studies where data was also collected from the Twitter platform. This is possibly because the topic explored in the present study is relatively novel and is of concern to a limited population (mostly festivalgoers). To enhance the understanding of a tweeters' opinions, opinion mining or sentiment analysis or stance detection were used to determine whether the opinion is positive, negative or neutral [67]. Sentiment analysis is a useful tool in analysing behaviour; however, there are challenges associated with this method as it may not be suitable for tweets using informal language, misspellings, slangs and symbolic forms of words [68]. The analysis of sentiments does not necessarily indicate an individual's views on drug testing i.e. whether the user is in favour of drug testing or not in favour. For example, in the following tweet: *"Supporting #pilltesting won't just reduce risks for young people attending music events, but also save money & win votes",* the sentence represents factual opinion and expressed explicitly as written. Conversely, stance detection determines favourability towards a target [69] i.e. if a person is in favour or not in favour of drug testing. Various software and algorithms are available to classify tweets. In this research, the software was not used to explore a user's tweet. Once tweets were collected using each of the keywords, the favourability of an opinion was manually examined and assigned a category (i.e. in favour or not in favour). The process was independently reviewed.

Results from the present study are in good agreement with findings from other twitter studies. Relevant tweets highlighted the public's perceptions of drug checking. They also highlighted the role of the media in influencing the acceptance of drug checking. Tweets in favour of drug checking acknowledged that drug checking: is a part of

effective law reform, a public health intervention and an enabler of trust with the political system. Tweets perceived drugs as "a health issue and not a crime" and that "prohibition may lead to drugs being cut and mixed".

Tweets identified in favour of drug checking highlighted tweeter's opinions that drug checking could prevent harm and/ or potentially deaths, and that helping to save a life is of greater importance than not using drug checking at all. This view is broadly in line with international developments in drug legislative reforms, which are receiving increasing support for drug checking and other harm reduction interventions [1, 10, 70]. This is also in line with previous findings demonstrating evidence of harm reduction through drug checking [1, 8, 54].

Drug checking advocates promoted the evidence-base underpinning drug testing arguing that it deters rather than promotes drug use [31, 54, 65, 71-72]. In Australia, Butterfield et al. (2016) highlighted that drug checking services enabled the monitoring of emerging psychoactive substances, inform decision-making related to the management of symptoms of toxicity and promote access to treatment [27]. Drug checking services have also been described as early detection systems and effective monitoring tools [30, 73]. In addition to individuals being provided with harm reduction advice, drug checking services allow a greater understanding of recent drug trends and monitoring of drug supply, particularly in relation to Novel/ emerging Psychoactive Substances (NPS) [3, 30, 73].

In the present study, some tweeters stated that drug checking helps identifying trends e.g. identification of harmful adulterants/ identification of harmful adulterants, identifying counterfeit products such as e-liquid preparations, enabling a scientific basis to capture data, identifying drugs that may have potential therapeutic effects e.g. use of psilocybin for the treatment of treatment resistant depression. Other perceived benefits from tweets also include harm reduction awareness; harm reduction from risky drugs; reduction of risky consumption; reduction of the economic and social burden on society; preventing youths from having criminal records and punitive fines; reducing the use of sniffer dogs.

Furthermore, there is potential for users' behaviours to be positively influenced by these services: findings from a supervised consumption site (SCS) in Canada found that drug users were more likely to reduce their drug dose when results were positive for fentanyl [19]. Additionally, a study, which looked at the use of self-checking fentanyl test strips found that users were five times more likely to change their drug use behaviour when fentanyl was identified [20]. At festivals, Measham (2018) reported that users are likely to dispose of their drugs if found to be harmful or potentially containing a lethal substance and that 21.3% of people consequently chose to dispose of their substances. Similarly, Australia's first 'pill testing' trial at Grooving the Moo (GTM) in 2018, reported that 42% would change their drug use as a result of the intervention and 18% would either dispose of the drugs or were uncertain as to what

they would do [53]. However, the effectiveness of harm reduction advice provided at places like festivals may be challenging as users are already likely to be under the influence of substances before using the service [10]. For example, during The Loop's pilot study, 62.9% of service users had an alcoholic drink and 43% had already consumed other drugs other than alcohol before using the service [8] potentially impacting upon the level of engagement and ability to provide informed consent. A study by Saleemi et al. (2017) found that festivalgoers whose samples tested negative for MDMA at a rave were less likely to consume their drug products. In this case, the true content was communicated to the users who made more informed decisions regarding the intake of the samples [54].

Drug checking provides people with information on the content of their products, which they usually would not otherwise know when substances are obtained illicitly [10, 74). In the absence of this information, users may be misinformed, taking substances that they did not intend on taking or consuming drugs with unclaimed contaminants, which puts them at an increased risk of harm [75]. Although drug checking services do not condone the use of drugs, and outline that not consuming drugs is the safest option, the fact that users have already obtained drugs with the intention to use should be taken into consideration [9]. For this reason, some services also provide individuals with advice and information on how harms can be reduced [5, 10, 76].

Compilation of information from various drug checking services enable timely public health alerts to be escalated, shared and communicated when samples are likely to be associated with potential significant risk of harm, for example, due to their relative high strengths or unclaimed toxic adulterants [77-78]. For example, in 2015, DIMS issued public warnings over "Superman" pills, which were sold as ecstasy and have been shown to contain 170 mg of para-methoxy-metamphetamine (PMMA), a highly toxic compound that is produced instead of MDMA if the precursor 4-methoxy-PMK (4-methoxy piperonyl methyl ketone) is erroneously/ intentionally employed instead of PMK (piperonyl methyl ketone) [77]. In the UK, the same pills caused the death of four young people where no drug checking service was available [10]. Previous research has also identified notable levels in pills with relatively high purity as well as harmful cutting agents [53]. Intelligence UK seizure data over the period 2017 ‘quarter 4’ to 2018 ‘quarter 3’ showed that the average purity of cocaine was ca. 80% and was commonly cut by benzocaine, caffeine, phenacetin, creatine, paracetamol, boric acid, lactose, lidocaine, and/or levamisole [79]. In contrast, amphetamine had a very low average purity (ca. 11%) over the same period and was found to be cut with caffeine, glucose, lactose and/or creatine. For ecstasy, over the same period, the average purity of the powders/crystals was 87% and the average amount in tablets/capsules was 153 ± 9 (median = 156 mg/ tablets/capsules) [79]. The identification of drugs is also important for new emerging health threats, in particular potent, highly harmful and difficult to detect fentanyl derivatives [80]. Only a small number of drug checking technologies are able to detect a small number of fentanyl analogues [15]. Drug

checking services have been available at supervised consumption site (SCS) to prevent fatal overdoses from drugs such as fentanyl derivatives [17-18].

Tweets highlighted the need for drug checking due to the increasing access of drugs to people of all ages and the potential for criminalisation. Call have been made to encourage drug checking innovations in order to find ways to improve the detection of challenging and potentially lethal fentanyls.

Many barriers were perceived to implementing drug checking. A survey, which explored the views of more than 2,300 young Australians aged 16-25 years, found that over 82% were in support of 'pill-testing' as it allowed them to make informed decisions [81]. Despite increasing support within the drug-taking community for drug checking and associated positive outcomes [1], such services have limitations and barriers to wider implementation such as appropriate funding and obtaining relevant licences/ political support. Additionally, there were concerns that drug checking may encourage illicit drug use and criminality [8-10, 55-57]. On the other hand, there is often a stigma associated with individuals who consume drugs, which can pose as a barrier for those wanting to seek [25].

There have been concerns that dealers may misuse drug testing information such as information about the purity of sample to promote their products [10]. Kerr & Tuper (2017) argued that even if this is the case, drug checking services can "shift and stabilise" the drug market since dealers would want to ensure their products are not harmful and users can make better informed decisions rather than being patronised by the dealers. However, a study by Bardwell et al. (2019) found that dealers may use drug checking technology to reduce the risk of harm by providing improved information to customers [16]. Saleemi et al. (2017) found that less than 60% of users, whose samples tested positive for MDMA reported that they may still not consume it. It was suggested that this group may not have been the users themselves, but rather friends of users or dealers.

In the present study, tweets against drug checking focussed on the concerns over the quality of drug checking particularly with false positive results, which may lead to punitive outcomes, discrimination and prejudice. Communicating the content of substances is at the heart of these services. However, this depends on the available expertise, funding and detection techniques. There can be significant associated costs of specialised analytical equipment and expertise required to facilitate such services and limitations in being able to deliver timely, highly accurate and precise results [8-10, 55-57, 82].

Tweets collected in the present study identified some gaps and made some proposals to reduce harms from drugs. These include: the need to evaluate the drug checking services, need to improve drug checking technologies to face challenges caused by new trends e.g. opioid crisis, call for an open science approach discussing the

practicalities of implementing drug checking, calls to transform drug policy, need for education on harm reduction, drug education prior to events where drug consumption is inevitable, raising awareness, calls for an ethical Charter with insights focussed on success specific to local jurisdictions, calls to regulate drugs e.g. in a limited way for example via prescription for +21, then over-the-counter at pharmacies, sharing drug checking results amongst stakeholders, learning from alcohol policies as alcohol is also a drug [83].

The present study is a brief overview and findings suggest that the public are generally in favour of drug testing, particularly the use of drug checking services in places like festivals where drug deaths can be prevented, and education can be provided to people who would not otherwise seek help or support for their recreational use. The positive response from drug checking services trialled at places like The Loop and GTM demonstrate the sense of trust and ability to enter a non-judgemental environment where users can seek advice without being criminalised or prosecuted for their actions [8, 53]. Therefore, such services may support improve engagement with drug treatment services and enable more people to access appropriate help and support.

In October 2018, a Trans-Tasman Charter was signed between Australia and New Zealand in which the two countries collaborated to develop drug checking services at events, festivals and other suitable locations [11]. This new initiative demonstrates the significance of drug checking services, where services are now expanding and being of importance in other parts of the world outside of Europe. Although harm reduction approaches such as drug checking is not aimed at eliminating the use of illicit substances, the benefits of reducing harm and minimising risks continue to be appreciated by the public. Therefore, suggest continued work to explore public perception as this develops/expands internationally.

Limitations

The analysis of tweets using isolated words or sentences may introduce bias due to the subjectivity of its nature. The tweets sample size was limited in comparison to other Twitter studies where larger samples were obtained. This is due to the limited number of search terms, the duration and season of data collection, and the exclusion of re-tweets. Other studies collected a high number of tweets due to the use of a large number of search terms [84], data collection of a long period of time (e.g. a year) [85], and the use of original tweets as well as re-tweets [86]. In our study, we have analysed only those tweets circulated in autumn, where the summer season would have been a more appropriate season for festivals. A further limitation of this study was that the software was unable to highlight the exact geographical location of these tweets and hence, our findings are not generalisable and cannot be representative of views of the UK. In this study, views of users with private accounts were not captured.

Conclusions

The literature review revealed mixed opinions towards drug checking with some promoting them as significant influence for a change in behaviour towards drug use, whilst others perceiving them as promoting drug use. From Twitter, views in favour of drug checking suggested that it would be an overwhelmingly useful strategy in reducing drug-related harms and saving lives. Overall, significantly more tweets were in favour of drug checking; however further research is required into the views of the UK public. Tweets in favour of drug checking perceived the service as a part of effective law reform, a public health intervention that serves in raising awareness and countering the role of the internet, preventing harm and/ or potentially deaths, helps in identifying novel trends related to drugs, enables a scientific basis to capture data, reduces harm from risky drugs or risky consumption, reduces the economic and social burden on society and prevents youths from having criminal records and punitive fines. Drug checking was perceived to positively influence users' behaviours, supports engagement with treatment services and supports individuals in making more informed decisions. Tweets against drug checking focussed on the concerns over the quality of drug checking particularly with false positive results, which may lead to punitive outcomes, discrimination and prejudice. The present study showed that Twitter can be a useful platform to capture people's perceptions and main factors influencing people's perceptions on drug checking/ testing.

List of abbreviations

API: Application Programming Interface
DIMS: Drug Information and Monitoring System
GTM: Grooving the Moo
MANDRAKE: Manchester Drug Analysis and Knowledge Exchange
MAST: Multi-Agency Safety Testing
MDMA: 3,4-methylenedioxymethamphetamine
NPS: New Psychoactive Substances
PMMA: paramethoxymetamphetamine
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SCS: Supervised Consumption Site
WEDINOS: Welsh Emerging Drugs & Identification of Novel Substances Project

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AG conceived the paper, the main conceptual ideas and the proof outline. IM led on writing the initial draft and the data collection from Twitter under the supervision of AG. RG Contributed to the categorisation of the tweets. RG and FS reviewed the paper and supported the work overall. All authors reviewed and contributed to the writing of the paper.

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References

1 Groves A. “Worth the test?” Pragmatism, pill testing and drug policy in Australia. *Harm Reduct J.*, **2018**,15(1):1–13.

2 Oute, J., Nygaard-Christensen, M., Lindholst, C., Thomsen, K.R., Boelskifte, L., Elmholdt, E., Hesse, M., Kolind, T. Literature Review of Drug Checking in nightlife – Methods, Services, and Effects, **2018**. https://www.sst.dk/-/media/Udgivelser/2019/Engelsk-version-Litteraturgennemgang-om-stoftest-i-nattelivet.ashx?la=da&hash=38C42CFA74BB5A333B024F3B127440D55538BF29 (Accessed December 29, 2019).

3 United Nations Office on Drugs and Crime (UNODC). World drug report 2018. Analysis of drug markets. Vienna. **2018**. https://www.unodc.org/wdr2018/prelaunch/WDR18_Booklet_3_DRUG_MARKETS.pdf (Accessed December 29, 2019).

4 Sherman SG, Morales KB, Park JN, McKenzie M, Marshall BDL, Green TC. Acceptability of implementing community-based drug checking services for people who use drugs in three United States cities: Baltimore, Boston and Providence. *Int J Drug Policy*, **2019**, 68:46–53.

5 Winstock AR, Ramsey J. Drug checking and pill testing – what it can and cannot do and why it matters. Global Drug Survey, **2017**. https://www.globaldrugsurvey.com/past-findings/gds2017-launch/drug-checking-and-pill-testing-what-it-can-and-cannot-do-and-why-it-matters/ (Accessed June 23, 2019).

6 Barratt M, Kowalski M, Maier L, Alison R. Global Review of Drug Checking Services 2017. Drug Policy Model Progr Bull No 24, **2018**. https://ndarc.med.unsw.edu.au/sites/default/files/ndarc/resources/Global%20review%20of%20drug%20checking%20services%20operating%20in%202017.pdf (Accessed March 23rd, 2020).

7 DanceSafe. About Us, **2019**. https://dancesafe.org/about-us/ (Accessed May 27, 2019).

8 Measham FC. Drug safety testing, disposals and dealing in an English field: Exploring the operational and behavioural outcomes of the UK’s first onsite ‘drug checking’ service. Int J Drug Policy, **2018**, 67, 102-107.

9 Alcohol and Drug Foundation (ADF). Drug checking: a harm reduction strategy, **2018** https://adf.org.au/insights/drug-checking-a-harm-reduction-strategy/ (Accessed December 1st, 2018).

10 Brunt T. Drug checking as a harm reduction tool for recreational drug users: opportunities and challenges, **2017**. http://www.emcdda.europa.eu/system/files/attachments/6339/EuropeanResponsesGuide2017_BackgroundPaper-Drug-checking-harm-reduction_0.pdf (Accessed March 23rd, 2020).

11 Pill Testing Australia. TRANS TASMAN Charter for pill testing, **2019**. https://pilltestingaustralia.com.au/trans-tasman-charter/ (Accessed September 15th, 2019).

12 Harm Reduction Wales. Annual report 2017-2018, **2018**. http://www.wales.nhs.uk/sitesplus/documents/888/Philtre_Annual_Report_2018_FINAL.pdf (Accessed December 1st, 2019).

13 Welsh Emerging Drugs & Identification of Novel Substances Project (WEDINOS). WEDINOS - About Us, **2018**. http://www.wedinos.org/about_us.html (Accessed December 23rd, 2018).

14 Sutcliffe Research Group. MANDRAKE- Manchester drug analysis and knowledge exchange, **2018** https://www.sutcliffe-research.org/mandrake/ (Accessed January 11th, 2019).

15 Bardwell G, Kerr T. Drug checking: a potential solution to the opioid overdose epidemic? Subst Abuse Treat Prev Policy, **2018**,13:20.

16 Bardwell G, Boyd J, Arredondo J, McNeil R, Kerr T. Trusting the source: The potential role of drug dealers in reducing drug-related harms via drug checking. *Drug Alcohol Depend*, **2019**,198:1–6.

17 Barry CL. Fentanyl and the Evolving Opioid Epidemic: What Strategies Should Policy Makers Consider? *Psychiatr Serv*, **2017**, 69(1):100–3.

18 Laing MK, Tupper KW, Fairbairn N. Drug checking as a potential strategic overdose response in the fentanyl era. *Int J Drug Policy*, **2018**, 62:59–66.

19 Karamouzian M, Dohoo C, Forsting S, McNeil R, Kerr T, Lysyshyn M. Evaluation of a fentanyl drug checking service for clients of a supervised injection facility, Vancouver, Canada. *Harm Reduct J*, **2018**, 15(1):46.

20 Peiper NC, Clarke SD, Vincent LB, Ciccarone D, Kral AH, Zibbell JE. Fentanyl test strips as an opioid overdose prevention strategy: findings from a syringe services program in the Southeastern United States. *Int J Drug Policy*, **2019**, 63:122–8.

21 Barratt MJ, Kowalski M, Maier LJ, Ritter A. Profiles of drug checking services in 2017. Drug Policy Model Progr Bull No 24, **2018**. https://ndarc.med.unsw.edu.au/sites/default/files/ndarc/resources/Profiles%20of%20drug%20checking%20services%20in%202017.pdf (Accessed March 23rd, 2020).

22 European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and Europol (2007), Early-warning system on new psychoactive substances — operating guidelines, EMCDDA Risk assessments, Publications Office of the European Union, Luxembourg. 2007. http://www.emcdda.europa.eu/system/files/publications/449/EWSguidelines2_98082.pdf (Accessed March 23rd, 2020).

23 Hungerbuehler I, Buecheli A, Schaub M. Drug Checking: A prevention measure for a heterogeneous group with high consumption frequency and polydrug use - evaluation of zurich's drug checking services. *Harm Reduct J*, **2011**, 8(1):16.

24 Tupper KW, McCrae K, Garber I, Lysyshyn M, Wood E. Initial results of a drug checking pilot program to detect fentanyl adulteration in a Canadian setting. *Drug Alcohol Depend*, **2018**, 190:242–5.

25 The Pharmaceutical Journal (PJ). First Home Office-licensed street drug-testing clinic opens, **2019**, Vol 302, No 7923, DOI: 10.1211/PJ.2019.20206219

26 EMCDDA. An inventory of on-site pill-testing interventions in the EU in cooperation with. Lisbon, **2001**. file:///C:/Users/Amira.Guirguis/Downloads/pill_testing_report%20(3).pdf (Accessed March 23rd, 2020).

27 Butterfield RJ, Barratt MJ, Ezard N, Day RO. Drug checking to improve monitoring of new psychoactive substances in Australia. *Med J Aust*, **2016**, 204(4):144–5.

28 Lefkovits, Z.G. A Pill too Hard to Swallow? A Public Health and Legislative Consideration of Methods to Reduce Drug-Related Harm in the Victorian Party Scene: On-site Pill Testing, Market Monitoring and Publication of Publication of Police Drug Seizure Data. Parliament of Victoria, Melbourne, Australia, **2016**. https://www.ncbi.nlm.nih.gov/pubmed/27469086 (Accessed March 23rd, 2020).

29 Camilleri AM, Caldicott D. Underground pill testing, down under. *Forensic Sci Int*, **2005**, 151(1):53–8.

30 Schroers A. Drug checking: monitoring the contents of new synthetic drugs. *J Drug Issues*, **2002**, 32(2):635–46.

31 Thomas, M. The pros and cons of pill testing. Parliament of Australia: Australia, **2018**. Available at: https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/FlagPost/2018/May/The_pros_and_cons_of_pill_testing (Accessed September 13th, 2019)

32 Barratt MJ, Bruno R, Ezard N, Ritter A. Pill testing or drug checking in Australia: acceptability of service design features. *Drug Alcohol Rev*, **2018**, 37(2):226–36.

33 Uitemark, J. and Cohen, P. A clash of policy approaches: The rise (and fall?) of Dutch harm reduction policies towards ecstasy consumption. *Int J Drug Policy*, **2005**, 16: 65-72, 66.

34 Kozinets R V. The Field Behind the Screen: Using Netnography for Marketing Research in Online Communities. *J Mark Res*, **2002**, 39(1):61–72.

35 Paul, M.J., Sarker, A., Brownstein, J.S., Nikfarjam, A., Scotch, M., Smith, K.L. and Gonzalez, G. Social media mining for public health monitoring and surveillance. In: *Biocomputing 2016: Proceedings of the Pacific symposium;* World Scientific Publishing Co. Pte Ltd: Big Island, United States, **2016**; (pp. 468-479).

36 Cameron, D., Smith, G.A., Daniulaityte, R., Sheth, A.P., Dave, D., Chen, L., Anand, G., Carlson, R., Watkins, K.Z. and Falck, R. PREDOSE: a semantic web platform for drug abuse epidemiology using social media. *J biomed inform*, **2013**, 46(6), pp.985-997.

37 Chary, M., Genes, N., McKenzie, A. and Manini, A.F. Leveraging social networks for toxicovigilance. *J Med Toxicol*, **2013**, *9*(2), pp.184-191.

38 Cavazos-Rehg, P.A., Krauss, M., Fisher, S.L., Salyer, P., Grucza, R.A. and Bierut, L.J. Twitter chatter about marijuana. *J Adolesc Health*, **2015**, 56(2), pp.139-145.

39 Hanson, C.L., Cannon, B., Burton, S. and Giraud-Carrier, C. An exploration of social circles and prescription drug abuse through Twitter. *J med Internet Res*, **2013**, 15(9), p.e189.

40 Kalyanam, J., Katsuki, T., Lanckriet, G.R. and Mackey, T.K. Exploring trends of nonmedical use of prescription drugs and polydrug abuse in the Twittersphere using unsupervised machine learning. *Addict behav*, **2017**, 65, pp.289-295.

41 Katsuki, T., Mackey, T.K. and Cuomo, R. Establishing a link between prescription drug abuse and illicit online pharmacies: analysis of Twitter data. *J medl Internet Res*, **2015**, 17(12), p.e280.

42 Sarker, A., O'Connor, K., Ginn, R., Scotch, M., Smith, K., Malone, D. and Gonzalez, G. Social media mining for toxicovigilance: automatic monitoring of prescription medication abuse from Twitter. *Drug Saf*, **2016**, 39(3), pp.231-240.

43 Scott, K.R., Nelson, L., Meisel, Z. and Perrone, J. Opportunities for Exploring and Reducing Prescription Drug Abuse Through Social Media. *J Addict Dis*, **2015**, 34(2-3), p.178.

44 Shutler, L., Nelson, L.S., Portelli, I., Blachford, C. and Perrone, J. Drug use in the Twittersphere: a qualitative contextual analysis of tweets about prescription drugs. *J Addict Dis*, **2015**, 34(4), pp.303-310.

45 Shutler, L., Perrone, J., Portelli, I., Nelson, L.S. and Blachford, C.R. Prescription opioids in the Twittersphere: a contextual analysis of tweets about prescription drugs. *Ann Emerg Med*, **2013**, *62*(4), p.S122.

46 Thompson, L., Rivara, F.P. and Whitehill, J.M. Prevalence of marijuana-related traffic on Twitter, 2012–2013: a content analysis. *Cyberpsychol Behav Soc Netw*, **2015**, 18(6), pp.311-319.

47 Ahmed, W., Bath, P. and Demartini, G. Chapter 4 Using Twitter as a Data Source: An Overview of Ethical, Legal, and Methodological Challenges. In: *The Ethics of Online Research. Advances in Research Ethics and Integrity (2);* Woodfield, K., Ed.; Emerald:UK, **2017**; pp. 79-107. ISBN 978-1-78714-486-6.

48 Twitter. Q3 2018 Earnings Report, **2018**, 1–14. https://investor.twitterinc.com/static-files/5ce969d2-a97f-49ef-ae10-577b81f6efee (Accessed March 23rd, 2020).

49 Omnicore. Twitter by the numbers: stats, demographics, & fun facts, **2018** https://www.omnicoreagency.com/twitter-statistics/ (Accessed November 27th, 2019).

50 Schultz D, Jolly S. Automatic Tweet Hashtag Categorization, **2010** https://courses.media.mit.edu/2010fall/mas622j/Projects2010/SunnyJolly_DanSchultz.pdf (Accessed November 9th, 2019).

51 Moher, D., Liberati, A., Tetzlaff, J. & Altman, D. G. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med, **2009**, 6, e1000097.

52 Kerr, T. & Tupper, K. Drug checking as a harm reduction intervention: Evidence Review Report. Vancouver, Canada: British Columbia Centre on Substance Use, 2017. https://www.bccsu.ca/wp-content/uploads/2017/12/Drug-Checking-Evidence-Review-Report.pdf (Accessed March 14th, 2020).

53 Makkai T, Macleod M, Vumbaca G, Hill P, Caldicott D, Noffs M, et al. Report on Canberra GTM Harm Reduction Service. New South Wales: Harm Reduction Australia, 2018. https://www.drugsandalcohol.ie/29513/ (Accessed March 14th, 2020).

54 Saleemi S, Pennybaker SJ, Wooldridge M, Johnson MW. Who is "molly"? MDMA adulterants by product name and the impact of harm-reduction services at raves. J Psychopharmacol, **2017**, 31(8):1056-1060

55 Day N, Criss J, Griffiths B, Gujral SK, John-Leader F, Johnston J, et al. Music festival attendees' illicit drug use, knowledge and practices regarding drug content and purity: a cross-sectional survey. *Harm Reduct J*, **2018**,15(1):1.

56 Faunce T, Byrne S, Gock A, Cowling A, Faunce T. Australia's first official illicit pill testing at canberra groovin' the moo music festival: legal hurdles and future prospects. *J Law Med*, **2018**, 26(54).

57 The Loop. Equipment, **2018**. https://wearetheloop.org/equipment/ (Accessed January 11th, 2019).

58 Liu B. Sentiment Analysis and Opinion Mining Morgan & Claypool Publishers. Lang Arts Discip, **2012**,167. internal-pdf://0744994148/Sentiment Analysis and Opinion Mining.pdf (Accessed March 14th, 2020).

59 The Guardian. Festival overdose victim took multiple pills before event 'to avoid police detection', **2019a**. https://www.theguardian.com/australia-news/2019/jul/08/festival-overdose-victim-took-multiple-pills-before-event-to-avoid-police-detection (Accessed March 14th, 2020).

60 Sande M, Šabić S. The importance of drug checking outside the context of nightlife in Slovenia. *Harm Reduct J*, **2018**, 15(1):2–9.

61 Chinet L, Stéphan P, Zobel F, Halfon O. Party drug use in techno nights: A field survey among French-speaking Swiss attendees. *Pharmacol Biochem Behav*, 2007, 86(2):284–9.

62 Evans M. Anti-drug campaigners slam plans to introduce drug testing tents at music festivals, **2017**. https://www.telegraph.co.uk/news/2017/05/21/anti-drug-campaigners-slam-plans-introduce-drug-testing-tents/ (Accessed July 4th, 2019).

63 Edwards M. Inside the UK's First City Centre Drug Testing Facility, **2018**. https://www.vice.com/en_uk/article/59qdwb/inside-the-uks-first-city-centre-drug-testing-facility (Accessed July 4th, 2019).

64 Waldron J, Mokrysz C, Grabski M, Freeman T, Measham F. Just say "know" to drugs: can testing facilities make festivals safer?, **2017**. https://www.theguardian.com/science/sifting-the-evidence/2017/aug/10/just-say-know-to-drugs-can-testing-facilities-make-festivals-safer (Accessed March 14th, 2020).

65 The Conversation. Testing festival goers' pills isn't the only way to reduce overdoses. Here's what else works, **2019**. https://theconversation.com/testing-festival-goers-pills-isnt-the-only-way-to-reduce-overdoses-heres-what-else-works-118827 (Accessed March 14th, 2020).

66 Grahame, H. Inquest into the death of six patrons of NSW music festivals. Findings of Magistrate Harriet Grahame, Deputy State Coroner. New South Wales State Coroner's Court, Lidcombe: Australia, **2019**. http://www.coroners.justice.nsw.gov.au/Documents/Redacted%20findings%20in%20the%20joint%20inquest%20into%20deaths%20arising%20at%20music%20festivals%20including%20annexures%20-%208%20November%202019.pdf (Accessed March 14th, 2020).

67 Martín-Wanton T, Pons-Porrata A, Montoyo-Guijarro A, Balahur A. Opinion Polarity Detection Using Word Sense Disambiguation to Determine the Polarity of Opinions, **2010**. https://www.researchgate.net/publication/221539778_Opinion_Polarity_Detection_-_Using_Word_Sense_Disambiguation_to_Determine_the_Polarity_of_Opinions (Accessed March 14th, 2020).

68 Bindal N, Chatterjee N. A Two-Step Method for Sentiment Analysis of Tweets. *Int Conf Inf Technol*, **2016**, 218–24.

69 Mohammad SM. Sentiment Analysis: Detecting valence, emotions, and other affectual states from text. *Natl Res Counc Canada*, **2015**, 1.

70 House of Commons. Health and Social Care Committee. 2019. Drugs policy. First report of session 2019. UK: Parliamentary Copyright House of Commons, **2019**.

71 Hendrie, D. Toxicologists throw support behind pill testing ahead of major festival weekend. newsGP, **2019**.https://www1.racgp.org.au/newsgp/professional/toxicologists-throw-support-behind-pill-testing-ah (Accessed March 14th, 2020).

72 The Guardian. NSW's resistance to pill testing will drive dealers to sell 'more dangerous drugs', ACT warns, **2019b**. https://www.theguardian.com/australia-news/2019/jan/23/nsws-resistance-to-pill-testing-will-drive-dealers-to-sell-more-dangerous-drugs-act-warns (Accessed March 14th, 2020).

73 Giné CV, Vilamala MV, Measham F, Brunt TM, Bücheli A, Paulos C, et al. The utility of drug checking services as monitoring tools and more: A response to Pirona et al. *Int J Drug Policy*, **2017**, 45:46–7.

74 Ventura M, Noijen J, Bücheli A, Isvy A, van Huyck C, Martins D, et al. Drug Checking Service Good Practice Standards. Health Programme of the European Union, **2013**. http://newip.safernightlife.org/pdfs/standards/NEWIP_D_standards-final_20.12-A4.pdf (Accessed March 14th, 2020).

75 Guirguis A, Corkery JM, Stair JL, Kirton SB, Zloh M, Schifano F. Intended and unintended use of cathinone mixtures. *Hum Psychopharmacol Clin Exp*, **2017**, 32(3):1–17.

76 Komesaroff PA, Lloyd-Jones DM. Pill testing warrants assessment in careful pilot programmes. *Intern Med J*, **2019**, 49(4):419–21.

77 EMCDDA. Recent changes in Europe's MDMA/ecstasy market. Vienna, **2016**. http://www.emcdda.europa.eu/system/files/publications/2473/TD0116348ENN.pdf (Accessed March 14th, 2020).

78 Harm Reduction International (HRI). Drug-checking services, **2018**. https://www.hri.global/files/2019/03/25/drug-checking-2018.pdf (Accessed May 23rd, 2019).

79 Daily S. Class A – National drugs intelligence bulletin. Q3 2018. Teddington, UK: LGC Group, **2019**.

80 EMCDDA. European drug report 2019: trends and developments. 2019. http://www.emcdda.europa.eu/system/files/publications/11364/20191724_TDAT19001ENN_PDF.pdf (Accessed March 14th, 2020).

81 Lancaster K, Ritter A, Matthew-Simmons F. *Young people's opinion on alcohol and other drugs issues.* Australian National Council on Drugs, Australia, **2013**.
82 Sage C, Michelow W. *Drug checking at music festivals: A how-to guide*. Nelson, BC, Canada: ANKORS, **2016**.
83 Pharmaceutical Society of Australia. Minimising harm from illicit drug use through pill testing and drug checking position statement, **2019**. https://www.psa.org.au/pharmacists-support-pill-testing/ (Accessed March 14th, 2020).
84 Chan B, Lopez A, Sarkar U. The canary in the coal mine tweets: Social media reveals public perceptions of non-medical use of opioids. *PLoS One*, **2015**,10(8):1–10.
85 Rose SW, Jo CL, Binns S, Buenger M, Emery S, Ribisl KM. Perceptions of menthol cigarettes among twitter users: Content and sentiment analysis. *J Med Internet Res*, **2017**, 19(2):1–16.
86 Glowacki EM, Glowacki JB, Wilcox GB. A text-mining analysis of the public's reaction to the opioid crisis. *J Subst Abuse*, **2017**, 39(2): 129-133.