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Article

Exploring profile, effects and toxicity of novel synthetic opioids and classical opioids via Twitter: A qualitative study

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ABSTRACT

Background and aims: Novel synthetic opioids' use has been increasing over the last decade and the opioid epidemic has attributed to 70 % of drug-related deaths worldwide. Lately, Twitter has become one of the key social media platforms where the public express their unfiltered and honest views and opinions anonymously and freely.

Methodology: This research comprised a qualitative study that explored the motivations, effects and toxicity of novel synthetic opioids from the perspectives of Tweeters. Tweets were extracted using NVivo 12 Pro by using the Chrome NCapture where thematic content analysis was applied. Extracted data from relevant tweets were coded into subthemes and themes.

Findings: Five main themes were found related to uses of opioids; public knowledge and attitude, desired effects, adverse events, and harm reduction strategies. For public knowledge and attitude, users reported about harm sources of opioids, as well as purity, addiction potential and lethal effects. The main uses of opioids included self-medication and for recreational purposes. For self-medications, users sought opioids against anxiety, depression, pain, and overcoming a previous opioid addiction. However, adverse events related to opioid use surpassed the desired effects and were: psychosis, addiction, withdrawal, respiratory depression and lethal effects. Most of the adverse events were linked to novel opioids rather than classical ones.

Conclusions: Twitter provided a valuable source of information regarding opioids' modalities of use, desired effects and adverse events. These findings benefit practitioners and healthcare professionals dealing with opioid users.

Introduction

Novel synthetic opioid (NSO) use has surged over the last decade and impacted death rates in the US and worldwide (Abbate et al., 2022; Rudd et al., 2016). According to the Centre for Disease Control and Prevention (CDC), over 450,000 people have died from opioid overdose in the last 10 years (Centers for Disease Control and Prevention (CDC), 2020). In this respect, prescription opioids and non-prescription opioids have been reported (Edlund et al., 2014; Zawilska, 2015; Coombs et al., 2023).

NSOs included mainly novel fentanyl analogues that increased with the appearance of new psychoactive substances (NPS) and included derivatives that are 100xs more potent than fentanyl (Zawilska, 2015; European Monitoring Centre for Drugs and Drug Addiction, 2020). Such derivatives include carfentanil and acetyl-alpha-methyl-fentanyl that

use has led to extreme increase in deaths globally (Suzuki and El-Haddad, 2017; Sutter et al., 2017; Volkow and Blanco, 2023). NSOs were not only found in opioid products; but also, in adulterated drugs e.g. cannabis, cocaine, heroin and benzodiazepines (Sutter et al., 2017). In this respect, the presence of NSOs in adulterated drug products contributed to the product products' lethal effects (Sutter et al., 2017).

In recent years, social media has provided a rich source of information regarding the public's beliefs and perspectives towards drugs of abuse (Coombs et al., 2023; Smailhodzic et al., 2016). Hence, social media platforms became popular for sharing information. Twitter is a social media platform where users (tweeters) can post messages known as 'tweets' and which has gained vast popularity in recent years. Research has shown people are more honest when posting feelings and opinions online (Kumar and Sebastian, 2012). Therefore, it is an ideal tool for researchers to gain in-depth insight into perspectives of users'

posting via Twitter. The COVID-19 pandemic has also amplified the use of social media, face-to-face contact ceased and therefore people spent more time online. People turned to social media as an emotional platform to voice their opinions and feelings anonymously and freely (Shah et al., 2020). This made Twitter an ideal place to monitor the use of classical and NSO discussions.

Previous research related to using Twitter for exploring opioids determined prevalence of opioids and users' experiences of opioids' effects. Geographic variation in misuse of prescription opioids were determined by Twitter and natural language processing (Chary et al., 2017). Likewise quantitative analysis of tweets was used to investigate opioid prevalence in North Carolina (Anwar et al., 2020). Prescription opioid and illicit sales and online sales were studied using Twitter and unsupervised learning opioids were studied (Cuomo et al., 2023; Mackey et al., 2017; Mackey et al., 2018). The extent of opioid use and modalities of use were also determined from Twitter using quantitative analysis (Lossio-Ventura and Bian, 2018). Recently content analysis of Twitter was conducted to study use of illicit opioids looking at users' experience and policies of using opioids (Tofighi et al., 2020), unreported opioid effects (Jiang et al., 2020), as well as opioid use disorder (OUD) (Tofighi et al., 2020).

This research complemented previous studies in exploring comprehensively and in-depth the perception and behaviour of tweeters alongside their experiences of desired effects and adverse events relating to opioids. This research utlised Twitter to understand tweeters perspectives on NSOs' use, effects and toxicity. It enabled to gain insight into the Tweeters truthful opinions and attitudes towards opioids.

Methods

Study design

A qualitative study of Twitter platform was conducted as it allowed to capture authentic information regarding tweeters attitudes, beliefs and emotions (Dekeseredy et al., 2021; Storey and O'Leary, 2022).

Ethical approval

Ethical approval for the research was not required as highlighted by LJMU ethics committee. Ethical considerations were taken when conducting the research that complied with the Declaration of Helsinki (1964), the Misuse of Drugs Act (1971), the Misuse of Medicine Act (1971), the Psychoactive Substances Act (2016) and the Data Protection Act (2018). Hence only publicly available posts/data were accessed, and anonymity was maintained in all stages of the research (Eysenbach and Till, 2001; Vainio, 2013).

List of definitions

An adverse drug reaction (ADR) is defined any response to a drug which is noxious and unintended, and which occurs at doses normally used in man for prophylaxis, diagnosis, or therapy of disease, or for the modification of physiological function (World Health Organization, 1972). An adverse drug event (ADE) was defined as any untoward medical occurrence that may be present during treatment with a medicine but does not necessarily have a causal relationship with this treatment, that is, an adverse outcome that occurs while the patient is taking the medicine but is not, or not necessarily, attributable to it (World Health Organization, 1972). Opioid use disorder (OUD) was defined as a persistent use of opioid its adverse consequences (Blanco and Volkow, 2019). Drug overdose is defined as the intake of a high dose of a drug that results in serious harm or lethal consequences (Eddy et al., 1965). Polydrug use is defined as the intake of more than two drugs (Hakkarainen et al., 2019).

Data collection

Search terms related to: "Fentanyl", "Opioid", and/or 'Harm' and their synonyms were used to extract tweets. Extracted tweets were then collected NCapture tab for Chrome and imported into NVivo 12 Pro for analysis. Table 1 shows the terms used and their synonyms. Tweets were collected and recorded on daily basis between October 2022 - May 2023.

Inclusion and exclusion criteria

Included tweets were those that mentioned the use of opioids. Any tweets which contained identifiable information, hyperlinks or clinical trials were excluded. Identifiable information included any information that indicated the identity of the individuals' posting a certain tweet or identity of individuals' included in a certain tweet.

Data analysis

Data analysis was conducted according to the standards for reporting qualitative research (SRQR) (Appendix I). Thematic content analysis was adopted where each tweet was read and re-read carefully prior to coding. Then similar codes were grouped into subthemes of different levels that in turn were grouped into themes (Javadi and Zarea, 2016). It is noteworthy to mention that a single tweet could be coded into single or multiple themes depending on the categories it belonged to (Fig. 1). Coding was made separately by two researchers (CT and SA) and validated by a third researcher (AA) where any discrepancies were resolved by discussions. After validation of coding, themes and sub-themes alongside were organised in Microsoft Excel (version 2016) tables. In total, 726 tweets were coded into five main themes relating to use of opioids and their characteristics ($n = 384$), public knowledge, attitude and behaviour towards opioids ($n = 14$), desired effects ($n = 21$), adverse events associated with opioids ($n = 117$), and harm reduction strategies ($n = 26$).

To identify moods and/or opinions of tweeters in text, sentimental analysis was adopted by classifying emotions as positive, negative or neutral (Bhadane et al., 2015; Montoyo et al., 2012). In this respect, two emotional models were used: being Thayer's model that classified tweets from positive ($+1$) to negative (Thayer, 1990) and Plutchik's model that classified emotions based on eight basic categories being: anger, anticipation, disgust, fear, joy, sadness, surprise and trust (Plutchik and Kellerman, 2013) (Fig. 2).

Results

Initial Twitter extraction yielded 10,013 tweets of which 667 (6.66 %) were found relevant after applying the inclusion and exclusion criteria. Thematic content analysis yielded five main themes relating to (1) Uses of opioids and their characteristics, (2) the public's knowledge, attitude and behaviour towards opioids, (3) desired effects, (4) adverse opioid events (AOEs) and (5) harm reduction strategies (Table 2 and Appendix II).

Characteristics of opioid use among tweeters

Main subthemes related to characteristics of opioid use included: Medicinal uses of opioids ($n = 94$), modalities of prescription opioids ($n = 125$), drugs adulterated with fentanyl ($n = 124$), transportation of

Table 1
Key terms and synonyms used in the study.

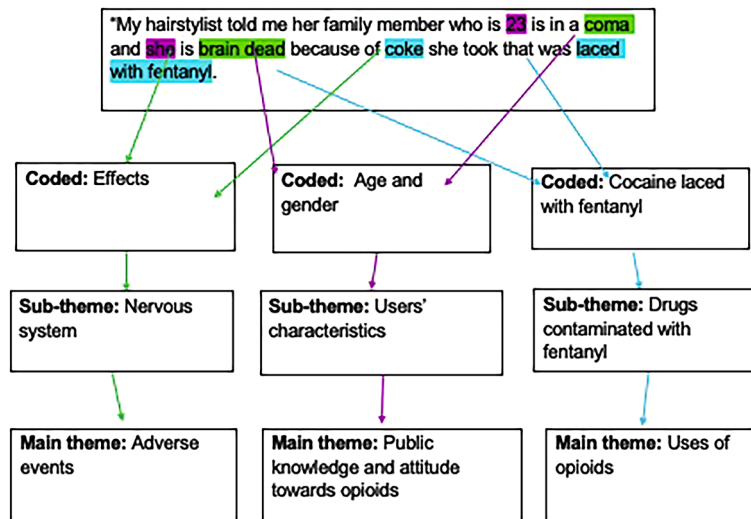| Key term	Synonym(s)
Fentanyl	Fentanyl(s), Fentanyl derivatives
Opioid	Opioid(s), Synthetic Opioid(s), Novel Synthetic Opioids
Harm	Toxicity, Toxicities, Adverse Event(s), Death

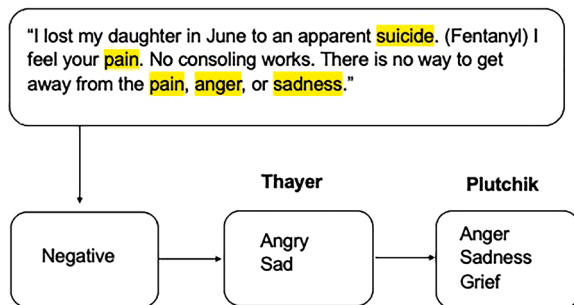**Fig. 1.** Coding process adopted in the study.

Fig. 2. Sentiment analysis applied to extracted data.

opioids ($n = 38$) and novel synthetic opioids ($n = 13$).

Medicinal uses of opioids comprised analgesic use (pain, pre-surgery or post-surgery), anaesthetic use and treating opioid dependence. Where specified, opioid derivatives reported included fentanyl and oxycodone. Fentanyl was mentioned more often and was perceived as 'relatively safe if taken under medical supervision' (TW26). Fentanyl was mainly used in patch form for post-surgical pain in different conditions including arthritis, broken bones, cancer, chronic pain, dental issues, endometritis, kidney stones and war injuries. It is also worthnoting that both single opioid use and combination were reported including: 'fentanyl and oxycodone', 'fentanyl and Propofol', 'fentanyl and morphine' and 'fentanyl and codeine'.

On the other hand, only fentanyl was mentioned within the context of anaesthesia pre-surgery injection forms. One user reported:

'Fentanyl is given to almost every surgical patient by anaesthesiologists across the globe (TW27)'.

For treating opioid dependence, tweeters reported using methadone, buprenorphine or buprenorphine/naloxone combination (Suboxone) for treating opioid dependence.

Modalities of prescription opioids subthemes were related to doctors' over-prescription of opioids, guidelines relating to opioids or individuals' use of opioids. Doctors' over-prescription of opioids was censured as a cause of building up addiction among users. At other instances, over-prescribing was blamed as the cause of tolerance, addiction, dependence, rise in carfentanyl production (due to fentanyl shortage) and lethal effects:

'Over prescribing upfront doesn't kill people, but it does get them chemically dependent. Then when they have to turn to heroin because pills are too much, you catch fentanyl or impure stuff (TW99).'

Tolerance was outlined by tweeters as the requirement of higher doses over time to achieve the same effects of opioid. It was described as high, problematic and expensive:

'Getting off of those things was one of the hardest things I've ever done, but I am so much happier now (TW116).'

Guidelines and policies were also blamed for opioid tolerance and addiction where tweeters reported that lack of prescription opioids urge users to move to street opioids that are more potent:

'Overregulation of prescription opioid medications have forced many people to choose between suffering in pain or rolling the dice in an illicit market saturated with increasingly potent fentanyl analogues (TW134).'

Regulations were blamed for patients' lack of access to their medicines, suffering pain, experiencing withdrawal symptoms, turning to street drugs, having overdoses and/or dying from overdoses.

Not only strict regulations were blamed for street opioid consumption, but also misuse of prescription opioids. Thus, misuse of prescription opioids had made users addicted to opioids and opiates before substituting them with street heroin and/or illicit fentanyl. Illicit opioids were reported as impure, of variable doses and that contributed to their harmful effects.

Impure drugs were an issue that was often stated where fentanyl and its derivatives were also reported as adulterants in other drugs. The latter drugs included: ketamine ($n = 1$), heroin ($n = 19$), oxycodone ($n = 9$), ecstasy ($n = 2$), cocaine ($n = 22$), cannabis ($n = 27$), benzodiazepines ($n = 17$), unspecified pills ($n = 11$) and unspecified powder ($n = 6$). Users reassured that fentanyl could be found as adulterant in any drug whether prescription or not. In some instances, users indicated ways to identify drugs laced with fentanyl. For instance, cannabis laced with fentanyl had a rubbery smell that was similar to burning plastic. However, this was not the case for cocaine laced with fentanyl where tweeters instructed users not to buy from dealers they do not trust:

'You guys please don't do coke right now unless it's from someone you trust ... cause right now there's a big batch of fentanyl going around!! I heard of four people who had seizures cause of it (TW252)'

Tweeters knowledge and attitude regarding opioids

Subthemes under Tweeters knowledge and attitude regards opioids included: reasons behind using opioids ($n = 38$), characteristics of users' using opioids ($n = 14$), context of using opioids ($n = 5$) and using other drugs alternatives to opioids ($n = 23$).

Tweeters reported using opioids for mental health problems ($n = 31$), trauma ($n = 2$) and limited opioid prescriptions ($n = 5$). Mental health problems were experienced due to broken relationships, social

Table 2
Themes and subthemes extracted in the study.

Theme	Sub-theme	Example quotation (s)
Characteristics of uses ($n = 394$)		
Medicinal uses of opioids ($n = 94$)	Treatment of pain using analgesic opioids after medical surgery ($n = 14$)	I was given a shed load of fentanyl after endometriosis surgery. Didn't need any more pain relief for 12 h. I was away with the fairies.
	Treating opioid dependence with other opioids ($n = 8$)	Many hospitals start po (tablets) methadone inpatient to help with withdrawal symptoms & have protocols to help guide clinicians. It is absolutely doable and 30 - 40 mg of methadone is very unlikely to cause respiratory depression or qtc changes in someone using heroin or fentanyl.
	Use of fentanyl as anaesthetic ($n = 13$)	fentanyl is the most commonly used surgical anaesthetic, recognised relatively non-toxic and used safely in our hospitals daily.
	Use of fentanyl for the treatment of pain ($n = 44$)	Fentanyl was invented to provide relief to dying cancer patients where the pain surpasses all other pain medications.
	Use of opioids other than fentanyl as analgesics in context outside surgeries ($n = 5$)	Opioids are the most effective class of FDA-approved analgesics.
	Combination of two or more opioid painkillers for medicinal use ($n = 10$)	I have a fentanyl patch and 10 mg instant release oxycodone four times a day, I've been on them for five years now
Modalities of prescribing opioids ($n = 125$)	Doctors are over prescribing opioids leading to addiction ($n = 13$)	The problem in the US was a massive opioid addiction problem from over-prescription.
	Over use of opioids will lead to a tolerance ($n = 9$)	People who are opioid dependent develop tolerance. They require high doses opioids to gain the same effect.
	Guidelines are preventing pain patients from receiving opioid medication due to the opioid crisis ($n = 55$)	By restricting opioids, lawmakers are condemning more people to die: some with addiction and some with pain.
	Opioid addiction from prescribed drugs leads to the consumption of illegal opioids ($n = 45$)	The gateway to heroin and fentanyl is legal prescription of painkillers… ironically, cracking down of those prescriptions has driven up demand for the illegal substitutes at this stage.
Drugs adulterated with fentanyl ($n = 124$)	Ketamine laced with fentanyl $n = 1$	if there is fentanyl laced ket in Perth you know your stash in Seattle is not gonna be safe
	Heroin laced with fentanyl $n = 19$	Substances like fentanyl are sometimes added to heroin. Drugs sold as heroin combined with additives creates a high risk of fatal overdose
	Oxycodone laced with fentanyl $n = 9$	I hope y'all ain't taking percs right now 9/10 it's laced w fentanyl

Table 2 (*continued*)

Theme	Sub-theme	Example quotation (s)
	Ecstasy laced with fentanyl $n = 2$	They cutting Molly with fentanyl now too, so I'll probably never try that either.
	Cocaine laced with fentanyl $n = 22$	Stop doing coke. there has been fentanyl laced cocaine going around the city. Over 15 reported overdoses and multiple deaths in about a week!
	Cannabis laced with fentanyl $n = 27$	I recently heard a guy say "somebody died from weed laced with fentanyl. this is why you should never smoke weed."
	Benzodiazepines laced with fentanyl $n = 17$	My friend was just found dead a little over a week ago from xanax laced w/ fentanyl
	Unspecified pills laced with fentanyl $n = 11$	The illicit market is creating pills pressed with fentanyl, designed to look like Vicodin, oxycodone, Xanax, ecstasy and more.
	Unspecified or multiple powdered drugs laced with fentanyl $n = 6$	there's another wave of recreational drugs being laced with fentanyl in the Bay Area.
Transportation of opioids and opioid source ($n = 93$)	Illict fentanyl is being manufactured in China $n = 31$	China has been a primary source of fentanyl trafficked into the United States. It is a powerful prescription drug for severe pain that's made and sold illegally. It led to more than 37,000 overdose deaths in the U.S. in 2019
	Illicit fentanyl is being trafficked through Mexico $n = 7$	hundreds of people a day are dying from fentanyl smuggled in from Mexico
	China is the main source of fentanyl $n = 4$	The Chinese Communist Party continues to look the other way while their fentanyl manufacturers flood the American illicit drug market with fentanyl.
	Decriminalisation and legalisation of illicit opioids will reduce to numbers of abuse and death $n = 22$	I think legalising all drugs and would fix the problem of the fentanyl crisis happening here. Instead of charging someone with possession, maybe try implementing rehab/ therapy.
	Prescription opioids are misreported by governments as responsible for overdoses and deaths rather than illicit opioids $n = 17$	I realise the narrative that the gov't has fuelled. But Senator, this opioid hysteria is KILLING and harming chronic pain patients. The epidemic is one of illicit fentanyl- not one of prescription drugs. Many now live in chronic pain as doses have cut so far. We need your help.
	Fentanyl derivatives are linked to deaths $n = 2$	Fentanyl alone if it comes in contact with skin can cause and overdose and death in a few minutes.
	Opioids are adulterated with other drugs $n = 10$	when you don't have a regulated supply the demand side of it has to buy what they can get which means cartels or dealers continuously

Table 2 (*continued*)

Theme	Sub-theme	Example quotation (s)
	Novel synthetic opioids/ derivatives (*n* = 13)	experiment and alter drugs to make them more addictive by "lacing" them. An entire new class of synthetic opioids — a family of compounds called benzimidazoles — is now showing up in U.S. drug busts and leading to overdose deaths.
Tweeters knowledge and attitude (*n* = 129)		
Reasons for using opioids (*n* = 38)	Mental health problems *n* = 28	People are seeking escape from pain, especially in econ-declining regions, & when you mix in deadly; accessible drugs like opioids/fentanyl, cheap alcohol, broad access to guns, high levels of uninsured/underinsured citizens, lack of mental healthcare, it is a deadly combination.
	Trauma *n* = 2	You're right! What often makes people want to use opioids/fentanyl is a history of trauma
	Addiction *n* = 5	I was addicted to fentanyl, for almost a year. That *** ain't no joke. I hate that everyone's glorifying it now like it's something "fun". It's horrible.
Characteristics of opioid users *n* = 13	Age group *n* = 8	Several of us also have suffered the loss of loved ones due to fentanyl in our circle of family/friends that are generally young people.
	Ethnicity *n* = 3	Millions of whites are dying from heroin and fentanyl overdoses, get your priorities straight, y'all worried about the wrong thing.
	gender *n* = 3	We have some pregnant women coming in with opiate withdrawal. Concerned could be botched up self inductions while on fentanyl.
Context of opioid use (*n* = 5)	Homelessness and drug use in public places *n* = 5	Homeless are shooting up fentanyl on the streets and San Francisco gives them complimentary needles and won't even arrest the dealers selling the junk.
Using other drugs as alternatives to opioids (*n* = 23)	Cannabinoids *n* = 16	I was on the maximum dosage of fentanyl for years before cannabis saved me.
	LSD *n* = 1	Remarkably, changes in pain tolerance & subjective pain perception induced by low dose LSD under these circumstances were comparable in magnitude to those observed after administration of opioids (e.g. oxycodone; morphine) to healthy volunteers.
	Kratom *n* = 3	Another study now proves kratom can reduce the effects of opioid

Table 2 (*continued*)

Theme	Sub-theme	Example quotation (s)
		withdrawals, and kratom produced "significantly less physical dependence" than the reference drug morphine.
Desired effects of opioids (*n* = 24)		
Sleepiness and drowsiness (*n* = 7)		Three days of Fentanyl was the only thing that could help my ease and let me sleep.
Relaxation and euphoria (*n* = 6)		Opioids are used primarily to numb pain, especially the extreme ones. The dangers of addiction come from the side effects of painkilling – feelings of euphoria and mental pleasure, which could lead patients to crave if medication is not managed.
Pain relief (*n* = 8)		Oh I adore fentanyl. It's the only thing that genuinely stops my pain, do need a big dose though.
ADEs related to opioids (*n* = 115)		
Respiratory (*n* = 19)		We see people use fentanyl can become cyanotic, decreased respirations in minutes.
Nervous system (*n* = 19)		Those fentanyl patches work though. Our friend had them for a week, made him super drowsy and disorientated.
Difficulty in withdrawal (*n* = 13)		Suboxone, fentanyl, and Xanax withdrawals are no joke guys. Don't do drugs kids.. Just take my word for it
Psychological (*n* = 11)		He has a silver glaze in his eyes, I've seen that same look in a client in a fentanyl induced psychosis.
Addiction (*n* = 9)		Man I did a lot of drugs but none got me hooked as fast as fentanyl.
Immunological (*n* = 5)		Thinking about the time when I was in the hospital and them bitches gave me fentanyl without warning me. Did find out until about an hour later when I was itching everywhere for no reason at all.
Infection (*n* = 2)		The opioid crisis is increasing the rates of Hepatitis A and B viruses.
Lethal effects and overdose (*n* = 37)		Fentanyl depresses the human respiration rate, often fatally
Treatment of opioid overdose (*n* = 15)		
Use of naloxone as antagonist (*n* = 15)		Hi friends this is your reminder to buy Narcan (naloxone) even if you don't know any opioid users! fentanyl is being increasingly found in other drugs and you can save a life. keep a dose with you!
Harm reduction strategies (*n* = 11)		
Guidelines and use of drug testing kits		One way to combat the issue of contaminated street drugs is drug testing strips and free drug testing at harm reduction centres

problems, isolation and depression. Users then referred to opioids (to self-medicate) instead of seeking help from healthcare professionals. Moreover, tweeters reported overusing fentanyl to cope with trauma (such as post-traumatic stress disorder). In addition, use of fentanyl was linked to limited opioid prescription in conditions such as post-surgery and cancer.

Where characteristics were reported ($n = 13$), users were mainly from the youth population, where accidental overdoses had led to death. Nonetheless, adults were not excluded from fentanyl overdoses, with both genders reporting use. It was reported males are less likely to seek medical help for any physical or mental problems, and instead self-medicate with drugs. Ethnicity was underreported throughout the study, with only two reports of white people and one report of a black person being affected by fentanyl.

Regarding context of using opioids ($n = 5$), they were often used in street settings and/or homeless communities. The aforementioned settings were reported also as a consequence of opioid use that often resulted in debt problems. Subsequently, tweeters often recommended using other drugs as alternative to opioids that were: cannabis ($n = 18$), kratom ($n = 3$) and unspecified psychedelics/LSD ($n = 2$). Both medicinal and recreational cannabis has been sought. Medicinal cannabis was preferred over recreational in order to "control unregulated drug supply". Cannabis was seen to control adverse drug events resulting from fentanyl derivatives including; craving and risk of overdose, pain management and fentanyl-induced respiratory depression. Users taking medical marijuana were able to control craving for the combination of fentanyl and oxycodone. In addition, users were 20–30 % less likely to use fentanyl if they had been on cannabis. Tweeters reported the CB2 activation controlled the respiratory depression. For pain management, cannabis/kratom combination was more efficient than fentanyl/Vicodin (oxycodone/paracetamol combination). Kratom was also reported as alternative to opioids in case of pain and opioid craving yet was reported among less tweeters. Kratom was seen as a non-addictive drug that produced less dependence than opioids. Moreover, only two users mentioned unspecified psychedelics as alternative to pain management than opioids.

Desired effects

Desired effects of opioids reported by tweeters included treatment of pain (chronic pain and/or postoperative) ($n = 7$), sleepiness and drowsiness ($n = 6$), and/or relaxation and euphoria ($n = 8$). For pain relief, tweeters reported that fentanyl patches had less adverse events than other routes of administration. In addition, the effects of fentanyl's lasted up to 24 h. Yet, fentanyl was described as intense but highly addictive with special warning that it could lead to craving.

Adverse opioid events

Adverse opioid events (AOEs) outweighed their desired effects and were related to the following categories: respiratory ($n = 19$), immunological ($n = 5$), infection ($n = 2$), nervous system and psychological ($n = 30$), addictive and difficult in withdrawal ($n = 22$), and lethal effects and overdose ($n = 37$).

Respiratory AOEs ($n = 19$) associated with fentanyl comprised cyanosis, pulmonary oedema, lower breathing rate and respiratory depression. Respiratory depression was reported within minutes of fentanyl intake and was lethal at high doses. Immunological events ($n = 4$) were reported in the form of allergic reactions to fentanyl and were described as "itchy" and "awful". Infection was only reported on two instances that included hepatitis A, hepatitis B and sepsis.

Nervous system and psychological AOEs ($n = 19$) were weakness, long lasting sedation, apnoea, anoxia, hypoxic brain injury, cyanosis, seizures, dependence and addiction, overdose and death. Brain injury, apnoea and anoxia were encountered with fentanyl on its own but more pronounced when fentanyl was used in combination with alcohol,

cocaine and heroin. The cocaine and fentanyl combination also resulted in seizures, unexpected loss of consciousness and was life-threatening.

Opioids were also described as highly addictive and difficult in withdrawals by both medicines' users and illicit fentanyl users ($n = 22$). Withdrawal from opioids were reported as difficult where withdrawal symptoms were extreme anxiety, shaking, cold sweats and insomnia.

This in turn could have contributed to overdose and death among fentanyl users that were the most frequently reported AOEs ($n = 37$). Upon opioid overdose users experienced heart attack, cardiac arrest, anoxic injury, interference with sleep apnoea resulting in death, brain injury, pulmonary oedema, respiratory depression and slowed breathing. 32 % of opioid overdoses were because of prescription drugs and in toxicology screening, fentanyl was present in 94 % of overdose related deaths.

Harm reduction strategies ($n = 11$)

Considering the AOEs, harm reduction strategies related to opioid use were treating opioid overdose ($n = 14$), treating opioid addiction ($n = 1$) and helping users with identifying laced opioids ($n = 11$).

When treating an opioid overdose, naloxone (Narcan) was reported as the optimal drug for treatment of fentanyl and heroin overdoses ($n = 14$). Naloxone was reported to reverse the CNS depression, pinpoint pupils, breathing difficulties, and unconsciousness, by blocking the central effects of opioids (Wermeling, 2013; Rando et al., 2015). One user reported that it took five shots of naloxone to reverse their fentanyl overdose, likely due to an increase in strength and toxicity of the drug (Moss and Carlo, 2019). For opioid addiction treatment ($n = 1$), methadone and buprenorphine were described as the most frequently used drugs.

In addition, helping users identify laced opioids ($n = 11$) included offering testing swabs that were provided by test centres across several states in the US:

'If your city/state has a harm reduction centre you can ask them for fentanyl testing kits, you just test a small bit of your drugs but I think safe high vs death is worth whatever you can't use after testing (TW661)'.

Sentiment analysis

When reported, sentiment analysis of Twitter users' emotions where predominantly negative ($n = 341$, 81.2 %). Of the negative emotions, four main ones emerged. In this respect, tweeters reported feeling nervous when being prescribed opioid medication ($n = 26$) and anger towards the opioid crisis ($n = 131$). When describing the loss encountered due to opioids, tweeters felt grief ($n = 26$) and sadness ($n = 73$). Vigilance was experienced by tweeters ($n = 98$) when discussing the use and dangers of illicit opioids. On the contrary only 79 (18.9 %) tweeters had positive emotions towards opioid medication. The main two reported emotions of the positive emotions were related to the effectiveness of prescription opioids ($n = 17$) and optimism towards being pain free in future ($n = 25$).

Discussion

General discussion

Research reported in the literature regarding opioid use by social media was limited to five studies. These five studies explored the sales of opioids online and/or the purity of opioids (Mackey et al., 2018; Tofighi et al., 2020; Dekeseredy et al., 2021; Al-Rawi, 2019). However, none of the aforementioned studies explored the users perceptive and experience associated with classical opioids or NSOs. With opioids contributing to 70 % of drug deaths worldwide, and the surge in opioid use over recent years, social media data offered a rich source of information regarding drug use (Kim et al., 31). Therefore, this study utilised Twitter as a social media platform in order to understand classical and novel

opioid use and effects from the perspective of users. The qualitative approach enabled understanding of in-depth experiences, attitudes (beliefs) and emotions of tweeters that could not be achieved with other research approaches. Hence content analysis allowed extraction of themes and context from large dataset ($n = 726$) (Downe-Wamboldt, 1992) and sentiment analysis enabled understanding of specific emotions encountered by tweeters (Prabowo and Thelwall, 2009). In this sense five themes were obtained relating to opioid use, public knowledge, attitude and perception, desired effects, AOEs and harm reduction.

Opioid use varied between classical and NSOs where the former were used for medicinal purposes and the latter for recreational purposes. Medicinal use of opioids compromised of chronic pain treatment including post-surgery pain (including labour) (Modarai et al., 2013). This finding supported the NICE guidance that recommends the use of fentanyl's for labour (NICE, 2014). Yet in the study, users were self-medicating with both classical and NSOs, leading to addiction and overdose depending on the purity of the drug taken (Singh et al., 2020). Though opioid use had started with good intentions, tolerance and addiction had developed and was mainly attributed to NSOs that were mainly adulterated. According to the UNODC 77 % of drug related overdoses involved NSOs (United Nations Office on Drugs and Crime, 2020). Under-prescription of opioids further contributed to the use of NSOs for medicinal purposes and this made tweeters blame governmental, regulatory and healthcare organisations for the spread of the opioid epidemic. This latter finding agreed with the literature where the CDC reported a decrease in opioid prescriptions by 1 million from 2016 to 2017 (Overdose, 2018).

Thus, NSOs triggered recreational opioid use were some of the novel synthetic derivatives had high affinity to opioid receptors which escalated effects and AOEs (Costello et al., 1988). Whereas some acute effects were exaggerated, and often lethal chronic effects did not have less impact on consumers. Hence mental health problems (e.g. psychosis) resulted from opioids use, despite opioid users seeking opioid use (Sullivan et al., 2006). Over 50 % of people being prescribed opioid medication in the USA are also receiving treatment for a mental health problem (Davis et al., 2017). Drug induced psychosis were reported in literature (Ham et al., 2017; Murray et al., 2013; Maremmani et al., 2014). Yet the relationship between opioid intake and mental health in terms of causality is not clear despite the aforementioned reports on drug induced psychosis (Davis et al., 2017; Ham et al., 2017; Murray et al., 2013; Maremmani et al., 2014). This because often opioid users take multiple drugs and/or have multiple comorbidities that interact with their mental health status.

The increased use of NSOs was particularly seen among young adults that were more likely to experiment with drugs (Krieger et al., 2018). This latter finding was justified in the literature where the age demographic of Twitter users was mainly under 35 years old (90 %) (Sloan et al., 2015).

Nonetheless AOEs were often reported among users and included respiratory depression and death (Ramirez et al., 2021; Bateman et al., 2023). Dose-dependent respiratory depression was attributed to μ receptors of which some NSOs were highly selective for (Baumann et al., 2018). Some opioids such as morphine did not have effects on κ and δ receptors (Al-Hasani and Bruchas, 2011). Rapid acting derivatives such as carfentanil had non-reversible effects that were claimed and to be 100 times more potent than fentanyl (European Monitoring Centre for Drugs and Drug Addiction, 2020). Slower acting opioid derivatives' overdoses were reversed with Naloxone (Wermeling, 2013).

Strengths and limitations of the study

Using social media data platforms, such as Twitter, offered strengths as it allowed to gain true and honest thoughts and feelings of individuals in a 'blame free environment'. Yet, few limitations were encountered during research. The first was due to the qualitative research being retrospective in nature where it was not possible to attain missing

information such as drug type, dosage, and effects. Due to the anonymity of social media, validation of tweets regarding the uses of drugs was not possible and validation of effects was carried out against previously published literature as highlighted in the discussion section.Yet, the opinion shared online reflects online may not be generalisable as it reflects the online communities that are engaging within the specific platform(s). Moreover, it was not possible to ask follow up questions without breaching ethical regulations due to the anonymous nature of the Tweets.

Conclusions

The findings of this study contributed to the scientific literature regarding opioid use, effects and adverse events. Analysis of Twitter provided authentic information about the experience of tweeters regarding classical and NSOs. Tweeters were able to report effects anonymously, which contributed to having more in-depth understanding of the opioid effects and AOEs. This understanding is beneficial for healthcare professionals and could be integrated into clinical guidelines. Nonetheless, it was limited to tweeters regarding NSOs, which affected the generalisability of the findings. Subsequently, future work should involve evaluating other social media platforms, dark web and mainstream media. Moreover, if possible, clinical and toxicology testing of biological samples will increase understanding of specific modes of action and effects of NSOs.

Ethical approval

This article only used open access data and did not contain any studies with human participants.

CRediT authorship contribution statement

Abdullah Al-Hamid: Investigation, Visualization, Writing – review & editing. **Carys Tudor:** Investigation, Writing – original draft. **Sulaf Assi:** Conceptualization, Supervision, Investigation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.etdah.2023.100139.

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