Determination of the Profile of New Psychoactive Substances Among Users from the Homeless Population: A Mixed-Method Approach

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A thesis submitted in partial fulfilment of the requirements of Bournemouth University for the degree of Doctor of Philosophy

December 1, 2021

Bournemouth University

Faculty of Science and Technology

Declaration

I declare that no material contained in this thesis has been used in any other submission of an academic award.

Acknowledgements

First and foremost, I would like to thank my supervisors, Dr Amor Adbelkader, Dr Sulaf Assi, Dr Patrick Van Calster and Mr Tilak Ginige for their continued encouragement and support throughout this journey. Their expert guidance has provided me confidence, improved my knowledge and developed me as researcher for which I am very grateful. I would like to give special thanks to Sulaf Assi for the levels of support and guidance during this entire PhD, truly going above and beyond.

I would also like to thank my family for their encouragement and generosity during this PhD. Without it, this journey would have been extremely challenging and practically impossible with the amount financial and personal support you have provided.

A big thank all the charities and support services that disseminated the questionnaire for this research. You truly made this research come to life. I would like to thank Ornella Corazza for your knowledge and expertise towards the questionnaire.

Abstract

The emergence of new psychoactive substances (NPS) among the homeless population has been highlighted as a growing concern in the recent years. NPS have plagued the homeless population in recent years creating a number of associated economic and social issues. The majority of previous research have focused on using either qualitative or quantitative techniques; however, few studies have used mixed-methods approach. Therefore, this thesis has complemented the gap in previous research by using a mixed method approach to determine the profile of NPS among the homeless population.

Two quantitative studies, including a systematic review and semi-structured questionnaire that enabled to understand the prevalence of NPS in the UK and worldwide, were conducted. Additionally, one qualitative study was performed and comprised Twitter analysis that confirmed NPS encountered among the homeless and their effects from the views of the public and service providers. The aforementioned three studies determined NPS used among the homeless population and flagged the impurities in them. NPS and impurities were further confirmed by chemical analysis conducted using Fourier transform infrared and Raman spectroscopy.

Substantial information obtained in this thesis, not reported in previous literature, demonstrated the potential for mixed-method approach in giving a greater insight into experience of NPS among the homeless. The systematic review highlighted the surge in synthetic cannabinoid receptor agonists (SCRAs) among the homeless in the UK, USA and Canada that occurred after 2016; whereas alcohol, cocaine and heroin had been more prevalent prior to 2016. Continued SCRAs use contributed to long-term adverse events especially anxiety, depression and psychosis. In this respect, the findings of the questionnaire confirmed the latter findings related to SCRAs use in the homeless population. Homeless in the UK reported short and long-term adverse events linked to SCRAs use that were readily accessible to them but not always as pure substances. Hence, they had access to SCRAs in different matrices including herbal, e-liquids and paper. The variable effects experienced upon SCRAs use further flagged their unknown purity. This was further explored in the Twitter study that reported variable effects experienced to drugs in different geographical area. Subsequently, the spectroscopic chapters identified the different concentrations of SCRAs impregnated into paper matrices.

In summary, the findings from this thesis contributed to the scientific literature by informing policy makers, law enforcement, medical practitioners and homeless service providers about the profile of NPS use among the homeless population.

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List of Abbreviations

AB-FUBINACA	N-[(1S)-1-(aminocarbonyl)-2-methylpropyl]-1-[(4-fluorophenyl)methyl]-1H-indazole-3-carboxamide
ADR	Adverse drug reaction
AKB-48	N-(1-adamantyl)-1-pentyl-1H-indazole-3-carboxamide
API	Active pharmaceutical ingredient
ATR	Attenuated total reflectance
AUDIT	Alcohol use disorders identification test
BC	British Columbia
BCE	Before the Common Era
BU	Bournemouth University
BZP	Benzyl piperazines
CASP	Critical Appraisal Skills Program
cm	Centimetre
CNS	Central nervous system
COVID-19	SARS-Cov-2
DAST	Drug Abuse Screen Test
DEA	Drug Enforcement Agency
DSM	Diagnostic and Statistical Manal of Mental Disorders
dTGS	Deuterated triglycine sulphate
ED	Emergency department
EMCDDA	European Monitoring Centre for Drugs and Drug addictions
EU	European Union
EWA	Early Warning Advisory
Exp(b)	Odds ratio
FDA	Food and Drug Administration
FTIR	Fourier-transform Infrared spectroscopy
GC	Gas Chromatogram
GED	General Equivalency Diploma
g/m^2	Grams per meter squared
HPLC	High performance liquid chromatography
IBM	International Business Machines

ICD	International Classification of Disease
ICH	International Council of Harmonisation
IR	Infrared
LC	Liquid chromatography
LOD	Limit of detection
LSD	Lysergic acid diethylamide
Matlab	Matrix Laboratory
MDMA	3,4, methylenedioxylmethamfetamine
MDPV	3,4-methylenedioxypyrovalerone
mg	Milligram
MINI	Mini International Neuropsychiatric interview
mL	Millilitre
MoH	Ministry of Housing
MMU	Manchester Metropolitan University
MT-45	1-cyclohexyl-4-(1,2-depheylethyl)piperazine
NBOMe	N-methoxybenzyl
NMR	Nuclear Magnetic Resonance
NPS	New Psychoactive Substance
NSO	New Synthetic Opioid
NY	New York
PC	Principal component
PCA	Principal component analysis
PCP	Phencyclidine
PLSR	Partial least squares regression
Prop 47	The Safe Neighbourhoods and Schools Act
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta analysis
PSA	Psychoactive Substance Act
PTSD	Post traumatic stress disorder
RMSEC	Root mean square error calibration
RMSEP	Root mean square error prediction
SCRAs	Synthetic cannabinoid receptor agonists
S.E	Square error

SF	San Francisco
SOC	Standard Occupational Classification
SPSS	Statistical Packages for the Social Sciences
Δ^9THC	Delta nine tetrahydrocannabinol
TLC	Thin layer chromatography
UNODC	United Nations Office on Drugs and Crime
USA	United States of America
UK	United Kingdom
U-47700	3,4-dichloro-N-[2-(dimethylamino)cyclohexyl]-N-methylbenzamide
VIP	Variable Importance in Projection
WHO	World Health Organisation
5F-PB-22	Quinolin-8-yl 1-(5-fluoropentyl)-1H-indole-3-carboxylate

Chapter 1: Introduction

1.1. The emergence of new psychoactive substances

The use of drugs and alcohol has been an inseparable part of human society for centuries (Sarvet and Hasin 2016). Since records began archives of human history indicated the use of opium in Mesopotamia (~4000 BCE), production of alcohol in a brewery in Egypt (~3500 BCE) and cannabis consumption by the Chinese emperor Shen Nung ~2737 BCE (Dos Santos and Hallak 2021). The patterns and prevalence of psychoactive compounds has continued to change throughout history for several reason, but few are worth mentioning. First, improved cultivation and the cross breeding of psychoactive plants yielded higher drug concentrations leading to a higher potency, which are more pleasurable (Aldrich 1997; Duarte 2005). For example, the earliest records of opium use were in Mesopotamia (~4000 BCE) but it was not until 1803 that morphine was synthesised by German physician, Fredrich Sertuerner. A mere century later (1898) heroin was first synthesised and opioid potency increased as a result (Presley 2018). Improvements in the purity of street heroin in the 1980s led to the drug being consumed intravenously, which enables the drug to have 100% bioavailability (Norn et al. 2005; Hempstead and Yildirim 2014). Additionally, the delta nine tetrahydrocannabinol (Δ^9- THC) content of cannabis has increased from 1.5% in 1980 to 15% in 2004 and is the result of improved cultivation techniques (Decorte 2010; Potter et al. 2016). The 1980s marked the start of the use of recreational drugs in the developed world due to improvements in cannabis and heroin purity (Darke et al. 1999; Unick et al. 2014).

The emergence of 'new psychoactive substances' (NPS) has been recorded from early-mid 2000s in New Zealand and from 2004 in Europe (Wilkins 2014). The term NPS is used to describe the many substances that rapidly emerged since the early 2000s distinguishing NPS from established illicit drugs is substantially challenging (Manchester et al. 2018; Tettey et al. 2018). First, the definition of NPS differs significantly across organisations due various terms used to describe NPS (eg, legal highs; designed drugs, bath salts and herbal incense). Second, the definitions have been time-dependent: was this when the drug was first detected, available, synthesised or used or were they not classified in the international drug control statutes (Baumann et al. 2017).

The driving force behind the emergence of NPS is unique with increased globalisation and improvements in information technology allowing the manufacturers of NPS to modify, synthesise and bring new substances to the market quickly considering users needs (Simonato et al. 2013; Corazza and Roman-Urrestarazu 2018). The connectivity offered by the Internet helped facilitate access to methods of drug synthesis and international drug control statutes (Deluca et al. 2012). It also enabled NPS to be sold online and in retail shops in countries with poor drug regulatory measures (Wadsworth et al., 2017).

1.2.Types of NPS

Categorising NPS is dependent on the organisation that has defined the term, similar to an organisation changing the definition. However, NPS are either categorised due to their chemical class or psychoactive effect (Werse et al. 2019). The United Nations Office on Drugs and Crime (UNODC) classes NPS by effects group and includes dissociatives, hallucinogens, opioids, sedatives, synthetic cannabinoid receptor agonists and stimulants (Odoardi et al. 2016). Figure 1.1 shows the NPS stimulant transformation through modification of cathinone and amphetamine.

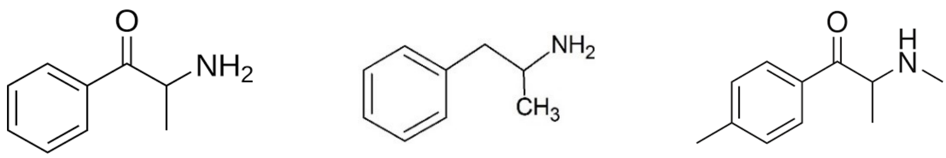


Figure 1.1 Chemical structure of cathinone (left), amfetamine (centre), and mephedrone (right)

1.2.1. Synthetic cannabinoid receptor agonists

Synthetic cannabinoid receptor agonists (SCRAs) are a group of NPS that bind to the same cannabinoid receptors as traditional cannabis with selectivity and sensitivity for CB1 and CB2 receptors (Mills et al. 2015). Unlike the partial agonist THC, many SCRAs are full agonists of the CB1, which may contribute to the drugs side effect profile. First synthesised in the 1980s at Pfizer, SCRAs were initially developed as potential analgesics, but the potency and unknown effects had little pharmacological importance (Hudson and Ramsey 2011; Mbvundula et al. 2006). It was not until the appearance of herbal highs in 2004 that the consumption of SCRAs recreationally was first reported (Vandrey et al. 2012). The SCRAs are usually added to the plant material by dissolving the solid form into a solvent (e.g., ethanol) via soaking or spraying. In some cases the solid form is added to the plant material (Caviness et al. 2015). They are usually sold under the denomination of Spice that could contain multiple synthetic cannabinoids in different concentrations, making it very difficult to determine substance specific effects (Vandrey et al. 2012).

The majority of available knowledge on the toxicity of NPS comes from scientific literature including clinical observations and/or failed clinical trial data (Fattore 2016; Tait et al. 2016). Research into the adverse events associated with SCRAs consumption reported severe toxicity following Spice ingestion leading to seizures and tachycardia (Tait et al. 2016). Moreover, mass poisonings have been reported in the US after individuals attending a party had all smoked the same SCRAs leading to severe cardiovascular and nervous system reactions (Hopkins and Gilchrist 2013).

1.2.2. Synthetic cathinones and empathogens

Synthetic cathinones are primarily related to the parent compound cathinone and closely related to the phenethylamine family (Figure 1.1) (Schifano et al. 2020). Cathinone is one of the psychoactive compounds in the khat plant that is commonly chewed by the user for the stimulant effects (Cox and Rampes 2003). Synthetic cathinones also include several substances that have been used as active pharmaceutical ingredients (API) in medicinal products, e.g. amfepramone. Synthetic cathinones were originally marketed using false labelling to avoid regulatory measures by advertising the compounds as ”bath salts” or “plant food” or “research chemicals” masking their use as psychoactive substances (Banks et al. 2014; Karila et al. 2015). The most popular of all the synthetic cathinone derivatives was mephedrone in Europe and 3,4-methylenedioxypyrovalerone (MDPV) in the United Sates, where both substances quickly became replacements for traditional stimulant drugs such as cocaine and MDMA between 2007 – 2010 (Gibbons and Zloh 2010). Due to their initial legal status users often presumed they were safe alternatives to traditional illicit drugs (Carhart-Harris et al. 2011). With some NPS products containing different concentrations and derivatives than specified on the packaging the associated adverse events were frequent. Typical adverse events associated with synthetic cathinone consumption include agitation, tachycardia, palpitations, chest pains, paranoia, hypertension, hyperthermia, seizures and death (Maskell et al. 2011). With how rapidly these drugs appeared in the population and their numerous associated adverse events resulted in Scheduling for three synthetic cathinones by the Drug Enforcement Administration (DEA) and a psychoactive blanket ban in Ireland (Windle and Murphy 2021). A diverse range of reasons for why individuals were motivated to use synthetic cathinones were reported in the literature. For example, some synthetic cathinone users consumed them at music and social events to achieve euphoria, increased sociability, increased music appreciation and overcome social anxiety. The doses of synthetic cathinones varied between users and derivative, but typically range between 1 – 200 mg. Frequent redosing of synthetic cathinones is likely due to their faster excretion and less blood-brain barrier penetration as they are more polar than natural cathinones (Carhart-Harris et al. 2011). The route of administration was most frequently nasal insufflation (snorting) but oral and injection routes were also reported (Papaseit et al. 2016).

1.2.3. Synthetic psychedelics and new synthetic opioids (NSO)

Synthetic hallucinogens are man-made substances that are designed to mimic the effects of classical hallucinogens such as lysergic acid diethylamide (LSD). The most common derivatives of these substances are known as the 2C and N-methoxybenzyl (NBOMe) families (Mohr et al. 2018). The 2C family was first synthesised by Alexander Shulgin in 1974 and produced effects similar to both LSD and MDMA (Shulgin 1986). These drugs are usually distributed in the form of blotting papers, liquids, tablets, capsules and less frequently in powder form (Isbister et al. 2015). Initially synthetic hallucinogens were created with the intent of being used for psychotherapy purposes but were found to have little therapeutic or industrial use and so are now only used in neurochemistry and pathogenesis of human disease (Suzuki et al. 2015). Although these substances are not commonly consumed by drug users the high potency and unknown adverse events impose risks to consumers (Burish et al. 2015). Moreover, the adverse events associated with consumption of hallucinogen NPS were reported in the form of agitation, delirium, hallucinations, psychosis, seizures, nausea and vomiting. Although adverse events occur frequently fatalities are rarely reported for hallucinogenic NPS (Suzuki et al. 2015).

Opioid abuse has been a global problem for many centuries. The plethora of new synthetic opioids (NSO) and their use over the last decade has created an epidemic-level issue in some countries. NSOs mainly include fentanyl analogues, U-47700 and MT-45 that are now the most common drugs involved in drug-related overdose deaths in the United States (US) (Prekupec et al. 2017; Concheiro et al. 2018; Salle et al. 2019). Like heroin, morphine, and other opioid drugs, NSO work by binding to the opioid receptors which are found in areas that control pain and emotions. If individuals use NSOs frequently, the brain will adapt to the drug diminishing the sensitivity of the receptor hence, regular high doses will achieve the same effect (Karila et al. 2019). Fentanyl was first synthesised in 1960 by Paul Janseen in Belgium for the purposes of treating pain and approved by the US FDA as an intravenous anesthetic (Stanley 1992). Within the first year of approval fentanyl sales increased 10-fold and reports of drug use and misuse by clinicians was reported. In 1994, the FDA issued a warning regarding the dangers associated with fentanyl and should only be prescribed to patients with severe pain that could not be managed otherwise (Armenian et al. 2018). The consumption of NSOs is less popular than both SCRAs and synthetic cathinone derivatives due to their poor availability, high price, potency and numerous cases of overdose cases associated with their use. One review reported that 94% of NSO related hospitalisation ended in fatality compared to 6% for synthetic cathinones and less than 1% for SCRAs. The majority of NSO derivatives are injected, smoked or snorted by users (Prekupec et al. 2017).

1.3. Growth of the NPS market

The NPS market has been on a continuous increase internationally at a rapid and unanticipated rate due to improved information technology allowing NPS manufacturers to distribute them worldwide (Machado et al. 2019). According to the United Nations Office and Drugs and Crime (UNODC), there were more than 1047 NPS derivatives in 2020 (UNODC 2020). The Internet provided manufacturers and users a platform to distribute and discuss new substances entering the market (Zaami 2019). Initially, brick and mortar outlets were crucial for the sale of NPS to the public and little could be done to prevent NPS supply and conventional detection methods were unable to detect all the new emerging NPS compounds (Miliano et al. 2018). For example, brick and mortar outlets were crucial in the sales of mephedrone to the public whereas the Internet provided the ‘new’ entrepreneurs a direct link to the supply, usually in China. Since the international control and regulation of NPS in 2016 the growth of the online market has decreased in both prevalence and emergence of newly discovered NPS compounds (Rueter and Pardo 2017). Hence, after the NPS act, NPS markets moved to the dark web and street dealers that sold mixtures of traditional and NPS drugs.

1.3.1. NPS and UK law

The Misuse of Drugs Act 1971 regulates the production, supply and possession of “controlled drugs” by providing the legislative basis for the UK’s response to illicit drugs. Controlled drugs are listed in either Schedules 1 or 2 of the Misuse of Drugs Act 1971. Controlled drugs are further categorised into three categories (class A, B and C) dependent on how harmful they are. The Misuse of Drugs Act 1971 makes it an offence to import, produce, supply or possess a controlled drug. Possession charges for Class A substances is up to seven years in custody or an unlimited fine, Class B is five years in custody and unlimited fine and Class C is two years in custody and an unlimited fine.

For the supply, importation and production of controlled substances Class A substances lead to a life sentence, Class B and C is up to 14 years in custody. The Misuse of Drugs Act 1971 controls substances based on their chemical structure and not the effect or drug class itself.

A separate legislative regulation that bans the supply, production and possession of all psychoactive compounds excluding caffeine, nicotine, alcohol and food products is known as the Psychoactive Substance Act (PSA) 2016 (Gross 2015; Stevens et al. 2015). This legislation aimed to reduce the use of NPS in the general population. After a decade of regulating specific NPS compounds, the UK government proposed a ‘blanket ban’ that would prohibit any substance that gives the user a psychoactive effect (Shapiro 2016). Policy makers and governmental officials reported that banning specific compounds on their chemical structure was ‘outdated’ and thus regulation was not possible due to more than 450 substances being reported to the EMCDDA in 2015 (Deen et al. 2021).

1.3.2. Vulnerable populations and the law around NPS

Although possession of NPS is regulated and prohibited under the PSA (2016) it was suggested that arresting homeless individuals who are in possession of NPS would not stop consumption but instead increase the costs of policing (Rueter and Pardo 2017; UNODC 2020). Therefore, in the UK it is common for law enforcement to confiscate the NPS sample and gather intelligence about who they may have purchased it from. Confiscation will only occur is the NPS sample is small (Orsolini et al. 2019).

1.3.3. NPS false marketing

NPS have come in a variety of different forms and preparations used for both consumption and concealment purposes (Miliano et al. 2018). The majority of NPS are usually in the form of the illicit compound they are intending to mimic such as SCRAs as a herbal preparation or stimulants as powdered form (Wadsworth et al. 2017). NPS products more recently, have been concealed in a variety of fabrics and textiles smuggling the contraband. Researchers have documented this in UK prisons where SCRAs are being smuggled impregnated into paper avoiding on-spot detection (Ford and Berg 2018). Additionally, the police and researchers at Manchester Metropolitan University (MMU) have reported that this concealment method has now been used by street dealers selling Spice to the homeless (Ralphs et al. 2021).

Table 1.1 Concealment of NPS in different matrices

NPS products	Concealed in	Labelling
Cathinones	White powder	Plant food
NBOMe	Blotter	LSD alternative
Benzodiazepines	Tablet	Xanax/diazepam
Benzodiazepines	Paper	Spice
SCRAs	Paper	Spice
SCRA	Herbal material	Spice

SCRAs: synthetic cannabinoid recptor agonists, LSD: lysergic acid diethylamide, NBOME: 2-(4-bromo-2,5-dimethoxyphenyl)-N-[(2-methoxyphenyl)methyl]ethanamine.

1.3.4. Changes in availability due to PSA 2016

Concern was raised that introducing the PSA (2016) would drive the supply of NPS underground potentially affecting the purity and concentration of the NPS sold (Stevens et al. 2015). Although the availability of the compounds was driven to the black-market reducing consumption in the general population NPS became more available for the homeless population (Home Office 2018). Interviews conducted with the homeless population and stakeholders revealed that NPS dealers now specifically target the homeless offering delivery services and even free samples (Ralphs et al. 2021).

1.3.5. Popularity of NPS products

The popularity of NPS products has differed since the emergence in the early 2000's (Johnson et al. 2019). The initial emergence of NPS occurred in New Zealand where benzylpiperazine tablets/pills were the most popular NPS used (Wilkins 2014). It was 2007 when the stimulant mephedrone entered the market and quickly became an international favourite (Gibbons and Zloh 2010). Mephedrone use was most prevalent among young adults participating in the dance music scene where 41.3% of the participants were users. The use of mephedrone and its popularity continued until 2010 when international control and regulation prohibited the production, supply, importation and possession of NPS compounds (Carhart-Harris et al. 2011). From 2010, an increase in the number of NPS sold in brick and mortar outlets and online retailers was observed (Winstock et al. 2011). This allowed entrepreneurs to create a market for these products through attractive packaging and deceptively labelling (e.g., herbal incense) the products. Between 2010 – 2016 the number of NPS stimulant and cannabinoids derivatives rapidly increased as did their popularity, especially among young adults aged between 16 – 24 years (Vandrey et al. 2012). With national and international changes to legislation regarding psychoactive substances the consumption of NPS among the general population decreased but increased in prison and homeless populations (Ford and Berg 2018; Alexandrescu 2020). The most popular NPS now are SCRAs and have been for the past five years (Home Office 2018).

1.4. NPS prevalence of use

To collect information about the prevalence of NPS use in the general population several countries have opted to include NPS in national drug surveys. However, due to a limited number of countries opting for the inclusion of NPS in drug surveys global prevalence estimates remain country specific (Gomes de Matos et al. 2018). Based on this only a few countries (Australia, Canada, Ireland, New Zealand, the USA and UK) have estimated the prevalence of NPS among the general population ranging between 0.4 to 5.9% (EMCDDA 2016; UNODC 2019). The estimates, however, will be completely dependent on the location and time (year) of the survey with and prevalence increased from 2007 until 2016, where prevalence has decreased since (Home Office 2018). The decrease in NPS prevalence was due to the national and international control and regulation of the substances. In the UK the estimated NPS prevalence among the general population was 2.8% for individuals aged between 16 to 59 years old prior to the PSA (2016), and now is reported to be 0.3% (Home Office 2018). The majority of the consumption came from the 16 to 24 years old age group where up to 6.1% of individuals had consumed NPS. In the US, more recent national NPS use estimates that the prevalence of SCRAs and bath salts are 10 and 1%, respectively (Iwersen-Bergmann et al. 2019).

1.4.1. Biological sex and age

Biological sex and age for NPS users has been similar to biological sex and age of traditional drug users. Lifetime prevalence of NPS consumption in the US was significantly higher in males than females, being 0.27% and 0.07% respectively (Iwersen-Bergmann et al. 2019). For age, the younger generation consumed more NPS than any other age group and NPS prevalence decreased with age. Individuals aged 18 to 65 years old had a NPS use of 0.49%, those aged 26 – 34 years 0.22%, 35 – 49 years 0.07% and 0.1% for individuals aged over 50 years (Iwersen-Bergmann et al. 2019). In the UK there was no statistical data on the prevalence of NPS among males and females. However, prevalence in age groups was a little different in the UK and only individuals aged between 16 – 24 and 16 – 59 years old were reported (Home Office 2018).

1.4.2. NPS desired effects

The effects desired from NPS consumption will be dependent on the drug class. SCRAs were first identified in 2008 by the EMCDDA and were initially used as alternatives to herbal cannabis, particularly to escape positive drug test (EMCDDA 2016). They have since proliferated worldwide and approximately 280 SCRAs have been identified (Specka et al. 2020). SCRAs interact with the endocannabinoid system and desired effects include relaxation, euphoria and disinhibition; all effects sought after from traditional herbal cannabis users. For synthetic stimulants users, individuals seek to experience effects of euphoria, increased feelings of empathy and compassion, increased self-confidence, boosted energy and alertness and increased libido and sociability (Vandrey et al. 2012; Ellsworth 2019). Synthetic hallucinogen consumption affects behavioural, perceptual and regulatory systems of the body and common desired effects include euphoria, alterations in space and time, broadening thought processes, and providing psychedelic, spiritual and mystical experiences (Suzuki et al. 2015). The sought-after experiences for users of synthetic dissociatives include out of body experience which is described as a sense of disconnection between thoughts, memory, and consciousness, euphoria and depersonalisation. Synthetic depressants are broadly classified into two sub-categorised; synthetic benzodiazepines and NSO (Armenian et al. 2018). For benzodiazepines, the primary motivations overlap the desired effect, such as anxiolytic and hypnotic effects, and to manage withdrawal symptoms. Synthetic opioids were created to bind to the same receptor in the brain as opiates, and individuals desire effects such as euphoria, anxiolysis, feelings of relaxation and drowsiness (Mohr et al. 2018).

1.4.3. NPS adverse events

The use of NPS is often linked to physical and mental health problems. Each class of NPS will have their own specific adverse events but in general, common adverse events include seizures, agitation, aggression, psychosis, and dependence (EMCDDA 2016; UNODC 2019). The data surrounding NPS and associated adverse events is very limited and information on long-term adverse events are still unknown. Much of the knowledge and understanding of NPS harms come from case reports and hospital admission data mostly involving synthetic cannabinoids and stimulants (Shapira et al. 2020). For most NPS classes pharmacological similarities exist between the NPS and the substance they are intending to mimic but is not the case for SCRAs (Alexandrescu 2020). Harms associated with SCRAs use have been reported more serious than plant-based cannabinoids, including cardiovascular and central nervous system adverse events that are observed with stimulant derivatives (Ellsworth 2019). Moreover, the addiction to SCRAs is similar to opioid addiction with qualitative research reporting homeless population were substituting their heroin addiction to a Spice addiction (Armenian et al. 2018). The high number of cases that reported adverse events associated with SCRAs consumption recorded less than 1% were fatal and caused death. This is a low estimate when compared to the number of cases reported from NSOs and the number of associated fatalities (94%). A reason for this could be due to publication bias and a countries capacity to identify and report on SCRAs fatality cases (Graziano et al. 2017).

1.4.4. Trends in use over time

The rapid emergence of NPS compounds since the early 2000's challenged traditional approaches to drug monitoring, surveillance and public health (UNODC 2010). The first reports of NPS use emerged in New Zealand in 2004 where partygoers used synthetic benzodiazepine (BZP) pills. Within one-year New Zealand had restricted access to synthetic BZP but a total of 13 new NPS had been notified to the EMCDDA (Wilkins et al. 2017). It was not until 2007 that the first reports of mephedrone availability and use in Europe occurred which was considered an influential event in the emergence in NPS compounds (Beharry and Gibbons 2016). The availability and use of mephedrone was due to a reduction in MDMA purity caused by a decreased availability in the precursor safrole oil. Mephedrone is a short-acting stimulant with reported effects similar to amfetamine and MDMA which explains why it quickly became an alternative to MDMA (Gibbons and Zloh 2010). With effects similar to MDMA the use of mephedrone was highly prevalent among young adults in social events such as clubbing, parties and festivals (Schifano et al. 2011). The use of mephedrone did result in negative effects and fatality which caused the substance to be banned in 2010 in the UK and EU (Deen et al. 2021). After international control of mephedrone sales NPS had solidified their place as drugs of abuse among the general population. In the following years it became popular among individuals to share their NPS experiences with other users through online drug discussion forums (Bigdeli et al. 2013). This created a new type of drug users, namely the psychonaut users that inform others about their experience with different effects of NPS and traditional drugs (Corazza and Roman-Urrestarazu 2018).

After more than a decade of trying to regulate and control NPS the UK introduced the PSA (2016) designed to ban all psychoactive substances excluding nicotine, alcohol and food products. The ban on psychoactive substances did raise concern from policy makers about driving NPS sales underground changing the type of NPS user (Home Office 2018). Almost immediately after the introduction of the PSA articles from the media highlighted the high prevalence of SCRAs among the homeless and prison populations (Ellsworth 2019). The use of SCRAs in UK prisons has been identified since 2013 and has increased since (Ford and Berg 2018). The PSA 2016 did cause a shift in methods used to conceal NPS in prisons by impregnated SCRAs in textiles and paper avoiding detection. Moreover, the homeless population have also been affected by the PSA (2016) and are now said to be the largest consumers of NPS. The PSA (2016) did shift the use of NPS from the general population to vulnerable populations after 2016 (Devany 2019). Figure 1.2 shows the trends in NPS user since their emergence to present.

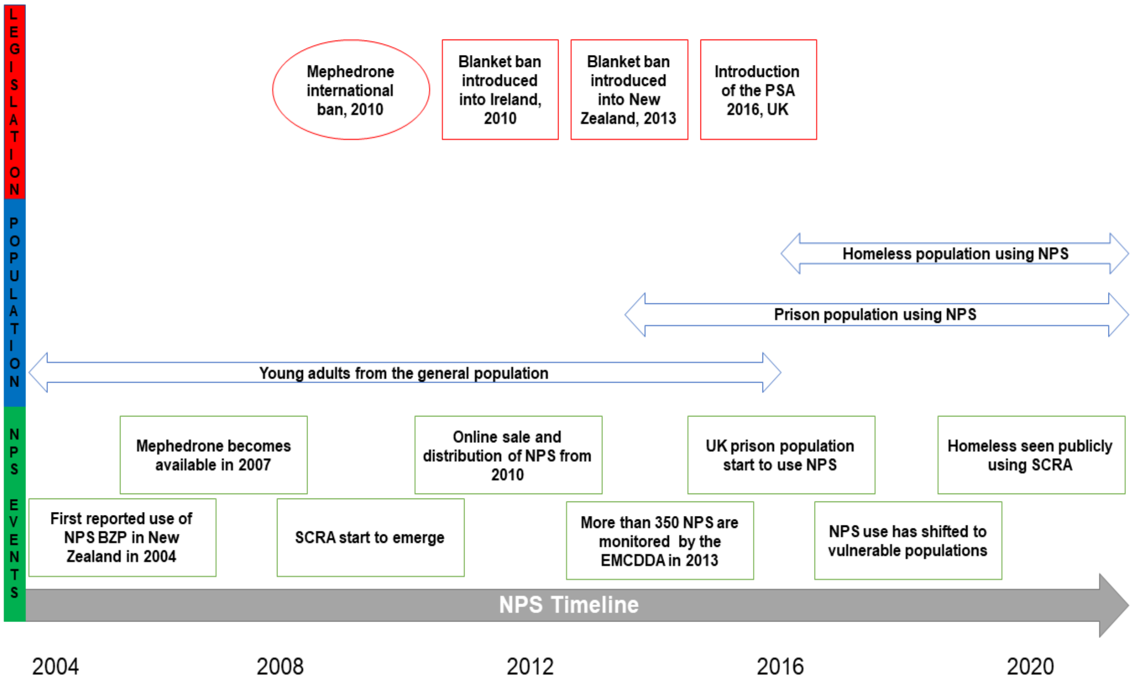


Figure 1.2 NPS trend line between 2004 - 2020

1.4.5. Changes in NPS trends due to PSA 2016

After introduction of the PSA (2016), the Home Office reported a significant decrease in the consumption of NPS in the general population which was driven by the reduction of use in the young adult population (16 – 24 years old). As mentioned above, policy makers were aware that the PSA blanket ban could drive NPS underground potentially infiltrating vulnerable populations. The use of NPS in vulnerable populations has been evaluated since 2016 and suggests that the PSA only reduced consumption in the general population, whereas, vulnerable populations increased their use (Home Office 2018).

The use of NPS in the general population is estimated to be 0.5% of adults aged 16 – 59 years old after the PSA but was as high as 2.5% in 2014. For young adults (16 – 24 years old) the prevalence of NPS prior to the PSA was reported at 5.5%. The use of NPS is now said to be highest in vulnerable populations including the homeless, prisoners, injection-drug users, men who have sex with men and people in contact with mental health services. Research conducted in Scotland that evaluated the prevalence of NPS among vulnerable populations reported people who inject drugs were most at risk from NPS use followed by mental health service users and the homeless population. Moreover, the prevalence of NPS among the homeless population has been reported to be as high as 95% in Manchester but is 30% in Scotland and suggests prevalence estimates are dependent on the geographical location (Macelod 2016).

Although the consumption of psychoactive substances among the homeless population has been documented in literature for more than 40 years the emergence of NPS among the homeless is relatively new (Wenzel et al. 2009). It was not until 2016 that individuals from the homeless population were reported to be consuming NPS and in public areas (Ralphs et al. 2016; Ellsworth, 2019; Gray et al. 2021). Serious concern was raised from the UK media about visibly intoxicated homeless individuals in a “zombie state” increasing the strain on public services. Most of the available information regarding homelessness and NPS use report the high prevalence of the SCRAs Spice, but NPS stimulants and opioids are also used (Alexandrescu 2020). Prior to 2016 information regarding homelessness and NPS use is limited but does report NPS injection use among homeless individuals in Ireland (Giese et al. 2015). Although no official data has examined the consumption of NPS before and after 2016 (pre and post the PSA) the available literature suggests that the homeless started using SCRAs during or after 2016 and used stimulants before (Shapiro 2016).

1.5. Homeless population

Throughout the world, homelessness poses a significant public health threat and challenge encountered in every country. The association between homelessness and serious life implications has been extensively documented throughout the literature regarding physical and mental health. The most recent global survey estimates that more than 1.5% of the world's population are homeless and lack adequate shelter at any given time. Considerable differences are observed between homelessness in the developed and developing world.

Recent data from the Shelter organisation estimates that 320,000 people are homeless on any given night (Shelter 2019). In the UK individuals can be categorised into 'statutory homeless' or 'rough sleepers' depending on where they sleep. Individuals who are classed as statutory homeless were defined as living in supported-sheltered accommodation including hostels, emergency accommodation and sofa-surfing. Rough sleepers were defined as sleeping outdoors including the streets, tents, cars and derelict/abandoned buildings.

1.5.1. Biological sex and age

Throughout the literature males are the more likely to be homeless than females throughout the world. In the UK, 83.4% of the homeless population are reported to be males and for the US, 70% (Shulman et al. 2018). Age, on the other hand depends on geography, ethnicity and gender. In the UK, 32% of homeless individuals were reportedly aged between 36 – 45 years old (Mcmillan et al. 2015).

1.5.2. Morbidity and mortality

Individuals experiencing homelessness are significantly more likely to suffer from mental and physical health problems. The conditions people are subject to when homeless increases the likelihood of having unhealthy lifestyles that cause long-term health problems. Associated risks of homelessness are often encountered in the form of mental and physical health problems and increased periods of homelessness exacerbate existing issues. Life expectancy for the UK homeless is 45 years old, much lower than the expected 80 years in the general population.

1.5.3. Substance use prevalence

Problem drug using among this population has been extensively documented in scientific literature. The challenges exposed to when faced with homelessness can lead to substance misuse, and substance misuse that in turn leads to homelessness (Doran et al. 2018). Homelessness and substances use often coexist, resulting in high morbidity. Estimates of substance use among people experiencing homelessness vary depending on the population studied and definitions used but are consistently above average

(Bonevski et al. 2013; Krupski et al. 2015). Better understanding the interactions between homelessness and substance use is important to respond to these overlapping serious life issues. Homelessness had been associated with worse drug and alcohol use severity and outcomes and drug overdose is the leading cause of death among people experiencing homelessness (Krupski et al. 2015). Among the homeless population, recreational use and pain relief are interlaced in substance consumption patterns. Substance use may mask the presence of pain and delay the use of health services thus reducing the access to health care that may lead to self-medication of pain with street drugs (Dassieu et al. 2019).

1.5.4. Pattern of substance use among the homeless population

Although the high prevalence of traditional drugs (heroin, cocaine, crack cocaine and cannabis) has been extensively documented (Fazel et al. 2008; Baggett et al. 2013; Linton et al. 2013), NPS have become an increasing risk to this population over the last few years (Home Office 2018). Hence, NPS has been documented and reported from the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and United Nations Office on Drugs and Crime (UNODC) since 2005, yet they only became popular among the homeless population since 2016. In 2016, the PSA banned all psychoactive compounds (excluding food, nicotine, alcohol and caffeine) and in turn moved NPS use to the black market and street dealers. The Home Office has identified that the consumption in the adult population has considerably reduced since the PSA, mainly driven by the reduction of use among those aged 16 to 24 years old. The prevalence of NPS among vulnerable populations appear to be different, with evidence that the NPS use remains the same and has been unaffected by the PSA, especially in the homeless population (Home Office 2018).

1.5.5. NPS harms

The addictive potential of NPS has been documented throughout literature but major information about specific NPS derivatives is still missing. The homeless population die in a broad range of causes such as disease, suicide, drug poisoning, cancers and pneumonia. An estimated 289 (37.1%) deaths were related to drug poisoning in 2019 in England and Wales but did not contain information regarding NPS and associated fatalities.

1.5.6. NPS prevalence among the homeless population

Not long after the introduction of the PSA (2016), the UK media started reporting NPS use among the homeless populations due to the increased consumption of the SCRAs, Spice (Daily Mail 2016). The majority of media articles highlighted how the homeless were visibly intoxication in public areas suggesting that 95% of the homeless were users of Spice. While prevalence estimates were exaggerated from the media it did promote awareness and gain attention from researchers to investigate the prevalence. Researchers from Manchester, London, Nottingham and the North-East have all investigated the prevalence of NPS among the homeless population reporting prevalence in the range of 20 – 88% (Ralphs et al. 2016; Devany 2019; Ellsworth 2019; Gray et al. 2021). The large range of prevalence is due to the different locations that homeless were investigated and no study investigated the homeless population UK-wide but rather focused on specific cities. Although the findings are not generalisable across the UK homeless population NPS prevalence in the homeless population remains consistently above the national average (Home Office 2018).

1.5.7. Motivations behind using NPS

It is thought that initially the homeless population started to consume NPS due to their cheap price, high potency, ease of access, and non-detectability in drug tests (Macleod et al., 2016). While these factors motivated the homeless to start using NPS it quickly became apparent that their continued use was associated with motivations similar to traditional drugs; escaping the realities of homelessness and self-treatment of physical and mental health conditions (Ralphs et al. 2016; Devany 2019).

1.5.8. Motivations behind traditional drug use

As mentioned in the previous section the motivations behind using NPS are similar to traditional drug use being pain relief and management, alleviating mental health issues, escapism and pleasurable effects (Mallet et al. 2005). It is worth noting that although the majority of the homeless populations substance use was due to the aforementioned reasons, differences are observed between different homeless sub-groups (Tsai et al. 2014). For example, homeless veterans (individuals who worked in the army) were more likely to consume substances to alleviate mental health issues, namely post-traumatic stress disorder (PTSD), whereas homeless youths would consume substances as a coping strategy (escapism) of their homelessness (Santa Ana et al. 2016).

1.5.9. Effects desired from homeless individuals when using NPS

Positive effects have been reported across all NPS classes and are specific to the type of NPS. Effects desired from stimulant NPS include increased energy, alertness and improvement in their mood and is mostly reported from mephedrone users (Devany 2019). For benzodiazepine NPS the desired effects included anti-anxiety, relaxation and improvement in moods (Macleod 2016). A key positive effect the homeless reported using SCRAs was sleep aid/promotion and often using to help sleep on the streets. Additional positive effects associated with SCRAs include anti-anxiety, relaxation and pain relief (Irving et al. 2017). NSOs and the associated positive effects include anti-anxiety, euphoria, relaxation and calmness. The reported use of NSO derivatives in the homeless population includes the fentanyl derivatives only (Park et al., 2018).

1.5.10. Adverse events associated with NPS among the homeless

Adverse events experienced from homeless individuals have not differ significantly from those experienced by the general population who use NPS. Mental health harms have affected both SCRAs and stimulant users and vary in severity. Anxiety and paranoia were both frequently associated with NPS cannabinoid and stimulant derivatives but mood swings were primarily associated with stimulant use (Ralphs et al. 2016; Ellsworth 2019; Gray et al. 2021).

1.5.11. Methods of NPS consumption used by the homeless population

With most research and media articles reporting the use of SCRAs among the homeless population the majority consume herbal materials under the denomination of Spice via smoking. Until recently the homeless were consuming Spice as a herbal preparation but researchers in the Manchester and local Police agencies reported that NPS dealers are now soaking paper or cigarettes in a solvent (usually ethanol or acetone) containing SCRAs in an attempt to avoid suspicion from the police when searched (Lloyd et al. 2018). This method of impregnating NPS has been documented in UK prisons since 2014 and raised significant concerns among prison staff and governmental officials about reducing NPS consumption in prisons (Ford and Berg 2018). Additional NPS are normally consumed the same the traditional drug they intend to mimic such as stimulant powders are consumed via nasal insufflation, fentanyl (opioid) derivatives via injection and NBOMBe (LSD derivatives) orally via a blotter (Ellsworth 2019).

1.6. Instruments used for NPS detection and their inherent weaknesses

The recommended methods proposed by the UNODC are very sensitive in identifying and quantifying NPS, but methods are limited when analysing NPS impregnated into papers, textiles and fabrics (UNODC 2019). The use of two-tier hyphenated techniques such as gas chromatography-mass spectrometry (GC-MS) and Liquid chromatography-mass spectrometry (LC-MS) are destructive and not portable so using infrared (IR) and Raman spectroscopy offers a portable, rapid, cost effective and non-destructive methods for analysis of NPS. However, there are no IR and Raman spectroscopic libraries of NPS impregnated into paper fabrics and textiles for on-spot detection. This in turn makes NPS identification in these matrices challenging for the police, parcels services and Border control (EMCDDA 2018).

1.6.1. Recommended methods for NPS identification

The majority of NPS were identified for the first time following chemical analysis of seized substances crossing country borders (Figure 1.3). If deemed or suspected of being an NPS, the national early warning system reports this to the EMCDDA which will include the chemical and analytical information and the circumstances seized. If confirmed as a new substance then formal notification is issued on behalf of the reporting member state. This notification will include any information on the name, chemical and physical properties, analytical methodologies used for identification and toxicology. Both border control and forensic laboratories have the competence and experience to analyse drugs and illicit substances using qualitative and quantitative techniques. Normally the aforementioned laboratories use GC-MS, LC-MS, IR and NMR spectroscopy to analyse NPS compounds. Quantitative techniques analyse the purity, limit of quantification and concentrations whereas qualitative techniques identify NPS compounds and limit of detection (LOD).

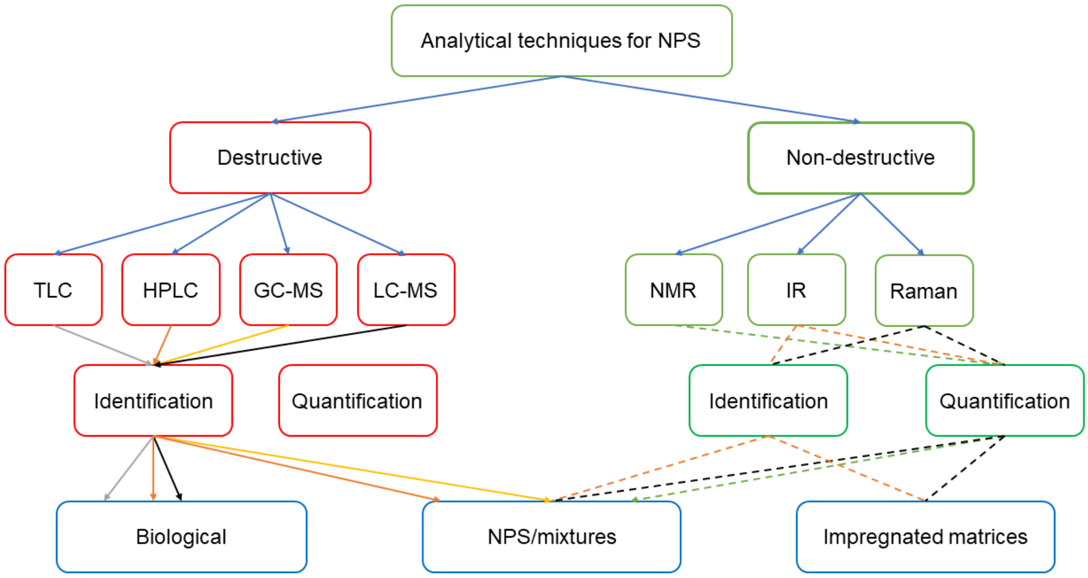


Figure 1.3 Analytical techniques commonly used to analyse NPS samples

1.6.2. Thin layer chromatography (TLC)

Thin-layer chromatography (TLC) is an affinity-based method to separate compounds in a mixture. TLC is a widely used technique for identification and separation of drug products. Using two phases, a stationary and mobile phase, the mobile phase travels up the plate by capillary forces and sample components migrate varying distances depending on their affinities for the stationary and mobile phases. The stationary phase is composed of a uniform layer of silica or alumina gel coated onto a piece of glass, metal or plastic (Sherma and Fried 2003). The use of TLC to detect and determine NPS is not usually used a method by forensic and toxicological analysts on its own but has been used to detect and determine NPS tryptamines (Kato et al. 2007). TLC is normally coupled with mass spectrometry for the detection of NPS (Cheng et al. 2011).

1.6.3. Gas chromatography - mass spectrometry

GC-MS allows for the separation of organic molecules that can be made volatile. The so-called hyphenated technique is actually two techniques that combine to form a single method of analysing mixtures of chemicals (Maštovská and Lehotay 2003). Gas chromatography separates components of a mixture and mass spectrometry characterises each of the components individually based on their molecular weights (Karasek and Clement 2012). By combining the two techniques, an analytical chemist and toxicologist can both qualitative and quantitatively evaluate a mixture of drugs

(Geyer et al. 2016). GC-MS has been extensively used for NPS identification whether it is in raw powdered form or in biological fluids (Nisbet et al. 2019).

1.6.4. High performance liquid chromatography (HPLC)

HPLC is a separation technique for compounds dissolved in a liquid sample and allows quantitative and qualitative analysis of the components. HPLC has been used to analyse NPS in a variety of different biological matrices proving to be highly selective and sensitive compared to classical immunoassays or colourmetric tests (Montesano et al. 2017; Graziano et al. 2019). HPLC is especially useful in identifying and quantifying NPS in blood, saliva and urine in case of severe intoxications or fatality (Trana et al. 2020). The majority of HPLC detection systems use an ultra violet (UV) detector as it has the best combination of sensitivity, linearity, versatility, and reliability.

1.6.5. Fourier transform infrared (FTIR) and Raman spectroscopy

Vibrational spectroscopy measures the interaction between light and matter revealing the molecular characteristics of the sample of interest. Two regions are examined in an Infrared spectrum being the fingerprint and functional group. The fingerprint region (500 – 1500 cm^{-1}) contains a very complicated series of absorptions and will include of most of the spectral information comprising of bending vibrations. The functional group region runs from 1500 – 4000 cm^{-1} and comprises of stretching vibrations. FTIR spectroscopy and more recently Raman spectroscopy are often used in control for recognition of drugs and illicit substances (Günzler and Gremlich 2002). Based on molecular vibrations, their mechanisms can be applied directly on samples either in solution or on powder (Smith and Dent 2019). The handheld instruments are fast, robust, portable and easy to operate, and the obtained spectra provides a chemical fingerprint through spectral band and functional group interpretation (Baker et al. 2014). The spectral bands present in the IR or Raman spectrums are characteristic of functional groups and therefore provide information about the chemical structure as shown in table 1.2 and 1.3, below.

Table 1.2 IR functional group bands

Class of compound	Functional group	Position	Intensity
Alkanes	C-H stretch	2990 - 2850	Medium and sharp
Alkenes	= C-H stretch	3100 - 3000	Medium and sharp

	C=C stretch =C-H bend	1680 - 1620 995 - 685	Weak and sharp Strong and sharp
Aromatic compounds	C-H stretch C=C stretch C-H bend	3100 - 3000 1625 - 1440 900 - 680	Medium and sharp Medium and sharp Strong and sharp
Alcohols	O-H C-O	3200 - 3550 1050 - 1150	Strong and broad Strong and sharp
Amines	N-H stretch C-N stretch	3300 - 3500 1030 - 1230	Medium and broad Medium and sharp
Nitriles	C=N stretch	2280 - 2200	Strong and sharp
Aldehydes	C-H stretch C=O stretch	2900 - 2800 1765 - 1680	Strong and sharp Strong and sharp
Ketones	C=O stretch	1735 - 1665	Strong and sharp
Esters	C=O stretch	1765 - 1715	Strong and sharp
Carboxylic acids	O-H stretch C=O stretch	3200 - 3500 1715 - 1680	Medium and broad Strong and sharp
Amides	N-H stretch C-N stretch	3500 - 3150 1700 - 1630	Medium and sharp Strong and sharp
Anhydrides	C=O stretch	1850 - 1800	Strong and sharp
Acid Chlorides	C=O stretch	1815 - 1770	Strong and sharp
Nitro compounds	NO2 stretch	1540 - 1560	Strong and sharp
Thiols	R-S-H stretch	2600 - 2550	Medium and sharp
Alkyl & Aryl halides	C-F stretch C-Cl stretch C-Br stretch C-I stretch	1400-1000 840-600 <700 <600	Medium and sharp Medium and sharp Medium and sharp Medium and sharp

Table 1.3 Raman functional group bands

Class of compound	Functional group	Position (cm^{-1})	Intensity
Alkanes	C-C	250-400	Strong
	C-O-C stretch	1060-1150	Weak
	$C-CH_3$	1355-1385	Weak
	CH_2	2770-2830	Strong
	$C-CH_3$	2810-2960	Strong
Alkenes	C=C stretch	1500-1900	Strong
	C=N	1630-1665	Strong
	$= CH_2$	3010-3080	Strong
	CH=CH	2980-3020	Strong
Aromatic compounds	C-C chain vibrations	1580-1600	Strong
	C-S	1080-1100	Strong
	N=N	1410-1440	Medium
	N-H	1590-1670	Medium
	C-H	2870-3100	Strong
Alcohols	O-H	3210-3300	Weak
Amines	C-N	1200-1350	Medium
	NH2	1600-1690	Strong
	$N-CH_3$	2750-2830	Weak
	N-H	3150-3480	Medium
Nitriles	C=N	2220-2260	Medium
Aldehydes	C=O stretch	1710-1725	Medium
	C-H stretch	2780-2830	Weak
Ketones	C=O	1600-1710	Medium
Esters	C=O	1730-1745	Medium
Carboxylic acids	C-H	1315-1435	Medium
	O-H	2880-3530	Weak
Amides	C-N	1550-1700	Strong
	N-S	1050-1210	Medium
Anhydrides	C=O	1740-1830	Medium
Acid Chlorides	C=O	1740-1780	Medium
Nitro compounds	$C-(NO_2))$ stretch	1530-1590	Medium
Thiols	S-H stretch	2530-2610	Strong
Alkyl & Aryl halides	C-F stretch	720-800	Strong

	C-S stretch	670-780	Strong
	C-Br stretch	500-700	Strong
	C-Cl stretch	550-800	Strong
	C-I stretch	480-660	Strong

1.6.6. Nuclear magnetic resonance (NMR) spectroscopy

Nuclear magnetic resonance (NMR) spectroscopy is based on the phenomenon whereby the nuclei of certain atoms are immersed in a static magnetic field and exposed to a second oscillating field. The nuclei which are close to one or another will exert an influence on each other's magnetic field and the effect is recorded as an NMR spectrum reflecting the chemical, physical and biological properties. The analytical technique is used in quality control and structural determination of the content in a sample. By quantitatively analysing mixtures NMR can determine the substances concentration of known substances and for unknown substances, NMR can be used to match against spectral libraries or infer the basic structure directly.

1.7. Rationale

The emergence of NPS among the homeless population was first reported in 2014. Local charities in Exeter worked with the Police to address a growing concern regarding new drugs being sold as 'legal highs' to rough sleepers (Johnson et al. 2013; St Petrocks 2017). The joint partnership ended in the 'legal high' shop being closed down in November 2014 after using a new anti-social behaviour order. This was the first use of using this specific order to deal with this problem, and other county and city councils shortly followed (Smyth et al. 2017). Following the growing concern surrounding NPS, the PSA (2016) were introduced in May 2016. Although the blanket ban did provide hope in reducing the consumption of NPS among the general population, there was concern that the PSA (2016) would drive the sales of NPS underground into the black market, potentially affecting vulnerable populations such as the homeless (Home Office 2018).

Shortly after introduction of the PSA (2016) the use the SCRAs, 'Spice', was reported by the media to being used in public by the homeless. By the media reporting the homeless were using SCRAs frequently a variety of different academics from medical (Yoganathan et al. 2021), sociological (Macleod et al. 2016; Gray et al. 2021), and toxicological fields (Smith and Staton 2019) have investigated the issue. Investigations into the 'new' phenomenon revealed that between 20 – 88% of the homeless were users of NPS, nameless SCRAs. Research conducted by Gray, Ralphs and Williams (2020) studied and explored motivations and harms that revealed similar motivations to traditional drug use. A finding that has been confirmed by others (Macleod et al. 2016; Irving 2017; Devany 2019). However, these studies have used small groups of homeless individuals from specific geographical locations. This in turn limited the reliability of data collected on prevalence, as the findings are not generalisable to the wider homeless population. It is worth to mention that the recorded prevalence of NPS consumption in the UK does not take into account vulnerable populations such as the homeless, which limits the validity of the data collected on NPS prevalence. There is also not available information about the specific NPS dose in relation to onset of effects, the duration, and dose-specific adverse events.

Additionally, the majority of studies had focused on using just one research design and not using additional methods to approach the issue. By not studying the issue using a mixed-methods approach, confirming the NPS derivative used cannot be confirmed and with new concealment methods reportedly being consumed by the homeless, detection of NPS becomes difficult. There is the assumption that the homeless would be consuming SCRAs through herbal preparations, which are confiscated when found. But new methods of concealing these substances vast quantities of NPS can be carried on a person without raising suspicion (Lloyd et al. 2018).

This thesis therefore aims to fill the gap in current literature regarding NPS consumption among the homeless population. This has been achieved from five research studies using a mixed-method approach. By contributing research from a mixed-methods approach, it is hoped that this research impacts policy makers, health care professionals, homeless service providers and law enforcement. The approach to tackle this issue is discussed in full below (Chapter 1.7.1.), which explains how each research objective were developed, the method used and implications of the results for literature.

1.7.1. Research Objectives

This thesis determined the profile of NPS among users from the homeless population. Five broad objectives were used to guide the thesis and provide research parameters:

1. To map the emergence of NPS among users from the homeless population.
2. To investigate the prevalence, motivations and effects of the UK homeless population.
3. To explore the attitudes of the public and service providers regarding homelessness and NPS consumption.

4. To chemically profile NPS compounds in different matrices that are used by the homeless.
5. To detect and predict the purity of NPS compounds impregnated into paper.

The first objective was created to capture data in the available literature of substance use among the homeless population. By keeping this objective broad, data about substance use and associated trends in the homeless population was insightful in identifying the emergence of NPS among the homeless population. Investigating this broader context helped to understand the emergence of NPS among the homeless population. Furthermore, this objective enabled an investigation into the different NPS derivatives used by the homeless population and the associated risks involved with consumption.

To provide a narrower focus for the thesis, the second objective investigated NPS consumption among the homeless population, UK-wide. Existing literature investigating NPS consumption among the homeless population has collected data from local and regional areas but not countrywide. Investigating NPS consumption among the homeless population helped in identifying the prevalence and the underlying mechanisms of their consumption. In addition, what motivates the homeless continue NPS use was explored.

To provide an in-depth understanding of how NPS affect the public and service providers, the third objective was derived from social media data on exploring the attitudes regarding homelessness and NPS consumption. Information regarding the perspectives of the public and service providers about homelessness and NPS use is limited but provided valuable data. Qualitative interviews were used to collect data but failed to understand how homelessness and NPS use affected society. While the relationships between NPS use and homelessness have been explored the concern of how homelessness and NPS use affect society has not been established. Given the significance of the effect on society homelessness and NPS use causes, including this as a primary objective enabled the exploration of these issues within the social media setting of Twitter data.

The final two objectives were derived from observations that existing literature highlighted the potential threat NPS impregnated into paper pose. Although the most common method to consume NPS is either in raw form or in preparation (impregnated into a herbal material) researchers and local police forces have reported that cigarettes and pieces of paper and impregnated with NPS, usually SCRAs and sold to the homeless population to avoid suspicion that could lead to on-spot detection. The development of spectral libraries to detect NPS impregnated into paper has received attention in relation to NPS being smuggled into prisons but not for on-spot detection in the homeless population. Moreover, no study had validated spectral libraries for detecting NPS in different matrices. Given the reported high prevalence of NPS and new methods of concealing NPS, the significance of including this primary objective enabled detection of NPS and cutting agents impregnated into paper.

In addressing these objectives, this thesis draws on multiple theories but it does not set out test any of them. Instead, the theories were influential in the methodological approach of mixed-methods research providing analytical insight. Whilst the primary objective of using a mixed-methods research design is that the data collected can provide stronger evidence by reducing the limitations encountered in each methods design.

1.8. Thesis overview

The remainder of this thesis is structured as follows: Chapters 2 documents the methodological underpinning for this thesis, beginning by explaining the reasons for using a mixed-methods research paradigm. The methodological approach of mixed-methods design is then discussed with each chosen method discussed and evaluated.

Chapters 3, 4 and 5 provide in-depth insight into the prevalence, motivations and effects of NPS among users from the homeless population.

Chapter 6 and 7 describe the use of IR and Raman spectroscopic instruments to investigate the identification and detection of NPS impregnated into paper.

Chapter 3 focuses on the emergence of NPS among the homeless population through a systematic review of quantitative studies. It details the emergence of NPS among the homeless population and highlights any NPS consumed by the homeless population and the associated adverse effects.

Chapter 4 investigates the prevalence, motivations and effects of NPS among the homeless population. By using a semi-structured questionnaire, the knowledge and experiences of NPS users from the homeless population can be investigated to explain certain NPS attributes associated with homeless users.

Chapter 5 explores how NPS and homelessness have affected public and service providers providing insights into how the attitudes of the public are affects by visible homelessness and NPS consumption. This enabled the publics knowledge and experiences to emerge of how NPS and homelessness are viewed by wider society.

Chapter 6 and 7 investigates the detectability and predictability of NPS compounds impregnated into paper using portable IR and Raman spectroscopy. Connections to the literature are made throughout chapters 3, 4 and 5 to understand the issues associated with NPS and homelessness where chapters 6 and 7 aim to prevent the use of NPS among the homeless population in public. Chapter 8 summarises the study chapters and draws out the main contributions that this thesis makes to existing knowledge. The limitations encountered in each chapter are also highlighted. This thesis ends by concluding the thesis findings and highlighting areas that significant contributions of knowledge have been made.

Chapter 2: research context and methodology

This chapter provides an overview of the methods used for the determination of the prevalence, motivations and effects of new psychoactive substances (NPS) among users from the homeless population. Information about participant selection or recruitment is provided and the measures, procedures, and analytical techniques for each study are described. This chapter comprises the research context and methodology adopted in this thesis. It also discusses the theoretical framework behind the studies and explains the technique of the specific methods.

The aim of this PhD research was to determine the prevalence, motivations and effects of new psychoactive substances among users from the homeless population. It also discusses the theoretical framework behind the study and explains the choice of the specific methods. A mixed-method approach was taken and to address the aim, four key research questions were addressed:

- Evaluate the prevalence and uses of NPS and homelessness

- Understand the attributes of the UK homeless population and the associated issues with their NPS use
- Explore public and service provider attitudes regarding NPS use and homelessness
- Detect and predict the purity of NPS products in paper matrices using IR and Raman spectroscopy.

2.1. Theoretical framework

A theoretical framework consists of concepts, together with their definitions, and existing theories that are used for this particular research. The theoretical framework must demonstrate an understanding of theories and concepts that are relevant to the topic that will be researched (Kivunja 2018). A theoretical framework strengthens a study in numerous ways. First, a theoretical framework connects the researcher to existing knowledge, which when guided by a relevant theory gives the basis for the hypothesis and choice of research method (Grant 2014). The theoretical assumptions of a research study forces the researchers to address questions of why and how, which allows the research to generalise about various aspects of a phenomenon rather than simply describing a phenomenon observed (Perez 2015).

2.2. Epistemological position

In social research the term “paradigm” is used to refer to the philosophical assumptions or to the basic set of beliefs that guide the actions and define the worldview of the researcher (Bloomberg and Volpe 2016). Paradigms are conceptual and practical tools that are used to solve specific research problems. Postpositivist researchers use quantitative methods focusing on precision, generalisability, reliability, and replicability to solve specific research problems (Braun and Clarke 2006). Constructivism typically uses qualitative methods in which the researcher relies on the participants views, opinions and experiences to develop subjective meaning of the phenomena (Mertens 1998). Participatory action research is conducted using an agenda of reform and empowerment i.e., by changing the lives of socially vulnerable populations and is often associated with qualitative methods focusing on advocacy and change (Burke-Johnson and Onwuegbuzie 2004). Pragmatism, however, claims to bridge the gap between scientific method and reasoning. The approach is based on the proposition that researchers should use the philosophical and/or methodological approach that works best for a particular research problem that is being investigated and is often associated with mixed-methods research. This research was conducted from a pragmatic perspective. A key consideration in conducting the research through this paradigm was the research purpose of using a combination of both quantitative and qualitative methods to understand the research problem (Burke-Johnson and Onwuegbuzie 2004). The use of mixed-method research allows the combination of qualitative and quantitative approach. Bloomberg and Volpe (2016) explained that in contrast paradigms such as post-positivism where knowledge claims arise from antecedent conditions, for pragmatism, knowledge claims arise from situations or actions.

2.3. Mixed-method approach

A mixed-methods approach was deemed the most appropriate method considering the suitability in answering the research questions. The goal of mixed-method research is to draw the strengths from qualitative and quantitative methods and minimise their respective weaknesses. Predominantly used to improve the generalisability of the findings, a mixed-method research procedure offers a powerful tool for investigating complex processes and systems (Mertens 2007). More specifically for this research the literature revealed gaps in relation to NPS use among the homeless population. Although previous studies highlighted the general use of NPS among the homeless very limited studies explored NPS specifically in the homeless. Therefore, in order to address the research question, a pragmatic paradigm that involved mixed-method research was adopted. In this respect, a quantitative systematic review was conducted to investigate the prevalence of substance use and was deemed an appropriate first study in order to gain knowledge regarding homelessness and NPS consumption and toxicity. The systematic review was investigative in nature and identified the emergence of NPS among the homeless population. This was then further complemented by another quantitative study that was prospective in nature and explain the knowledge and experiences of NPS among users from the homeless population in the UK using a semi-structured questionnaire. This study identified the prevalence, motivations and effects of NPS among users from the homeless population. After completion of the semi-structured questionnaire a qualitative prospective study exploring the public and service providers attitudes regarding NPS use and homelessness on the Twitter platform was conducted. This allowed the voice of the general public and service providers to emerge as their opinions are often missing from research. To compliment the qualitative and quantitative results in terms of NPS identification, prospective experimental studies regarding NPS in different matrices were developed using portable spectroscopic methods.

The order in which the methods were implemented is noteworthy and whether phases are carried out sequentially or concurrently is an important element of mixed methods research (Mertens 1998; Creswell and Poth 2018). For this research, an exploratory sequential design was undertaken. The findings from the systematic review helped inform the design and plan for the quantitative questionnaire (study two), which in-turn helped inform the design of the qualitative study (study three) and experimental studies (study four and five). Having determined the prevalence of NPS in the homeless population and uncovered the attitudes of service providers and the public, it was necessary to complete the research by conducting experimental research with NPS impregnated into liquid and paper matrices to detect and predict the purity of NPS using portable spectroscopic technique. The first three research studies informed policy makers and service providers about homeless individuals affected by the use of NPS. The prospective experimental chapters validated rapid and non-destructive methods for detection of NPS in different matrices and that is beneficial for law enforcement agencies working in the field.

While recognising the contribution of the traditional approaches and the vital role of quantitative and qualitative research methods, the use of experimental research further describes and explains the complex problem (Christensen et al. 2004). Using holistic science as an approach the research aims are studied as a whole and not just the sum of their parts (Leitch and Day 2000). Although mostly used in medical studies that focus on psychiatric and physical health (mind and body) issues of the participants, the approach of holistic science is often used to produce culturally situated and theory-enmeshed knowledge through an ongoing interplay between theory and methods, and researcher and research (Amini 2001; Saleem et al. 2014). The interplay between pragmatic theory, mixed-method design and a holistic approach will best describe and explain the complex system of homelessness and NPS consumption. Therefore, to address the research question, a pragmatic paradigm that involved mixed-method research was adopted. In this respect, a quantitative study was used as an explanatory study in nature and identified NPS prevalence, motivations and effects. A qualitative study used to complement the quantitative and explored the effects of NPS and homelessness on the general public and service providers. Using the most identified NPS consumed by the homeless populations discovered in the quantitative research, and the new ways of consumption to avoid detection such as liquid and paper substrates highlighted in throughout the research the experimental research was selected. The experimental research complimented both the quantitative and qualitative studies and allowed for the detection and prediction of NPS in liquids and paper products.

2.4. Retrospective and prospective research

The terms “prospective” and “retrospective” refer to the timing of the research in relation to the development of the outcome (Euser et al. 2009). In retrospective studies, the outcome of interest has already occurred and in prospective, the outcome had not occurred when the study starts, and participants are followed up over a period of time to determine the outcome (Ranganathan and Aggarwal 2018).

In prospective studies the researchers conceive and design the study, recruit participants, and collect exposure data before any of the participants have developed any of the outcomes of interest (Vandenbroucke 1991). Any prospective study aims to determine what are the results and questions for future research (Euser et al. 2009). Participants in this research design will agree to participate in the study and most often need individuals from specific populations, age groups or gender. For this research design the outcomes for disease and their prevalence are easier to understand and note and the study of multiple factors/risks can be conducted effectively (De Rango 2015). These advantages do however come with some disadvantages and prospective studies can be costly. In addition to the costly nature of this research a particular bias can develop for a few participants which may fail the entire study and determining and identifying multiple variables can be confusing for researchers (Vandenbroucke 1991).

Retrospective studies are designed to analyse pre-existing data and are based on the participants exposure status and outcome. In essence, the researcher looks at historical data to identify individuals ‘at risk’ or ‘free from risk’ (Euser et al. 2009). Retrospective studies are very efficient as they take less time and cost much less than prospective studies, but this advantage also creates potential problems (Sedgwick 2014). The exposure status is sometimes not clear as the data collected was not designed to be used in another study. Even is the exposure status is clear, other risk factors that affect the exposure status are unlikely to be accurate in retrospective research studies (Caruana et al. 2015; De Rango 2015). Though not prone to loss of follow up the disadvantages of retrospective studies outweigh the advantages (Levin 2006). Retrospective studies represent an inferior level of evidence when compared to prospective studies and leads to some key statistics not being measured and cannot determine causation, but only association. Participants are often recruited via convenience sampling and thus, is not representative of the population of study (Merrill 2012).

Most research conducted into homelessness and NPS use have used prospective study designs as the emergence of NPS compounds within the homeless population has only recently been documented and published. Research that used retrospective study designs used hospital admission data and fatality case reports from SCRAs users and so did not focus on NPS and homelessness as the main issue but instead was highlighted as important information. Systematic reviews using both retrospective and prospective have been used to investigate homelessness and mental health interventions with substance use as a risk factor and is not measured. The prior reviews have reported a high prevalence of both alcohol and substance use but no information on NPS consumption was reported. It is therefore imperative that a review evaluates the prevalence and trends in substance use within the homeless population considering mental and physical health issues as risk factors.

A necessary first stage of this thesis was to collect and analyse research conducted into homelessness and substance use and assess the emergence of NPS within the homeless population. By systematically collecting and analysing secondary data conducted by researchers in other studies information regarding homelessness and substance use, namely NPS can be evaluated. Information in the first chapter aims to capture the homeless populations consumption of NPS, whilst highlighting key areas that were under-researched that are to be further explored and explained in the chapters two, three, four and five in this thesis. As the “Gold Standard” of evidence-based research the systematic review are often designed to provided and exhaustive summary of current evidence relevant to a particular research question. Moreover, by formulating research questions that are broad or narrow in scope researchers can gain an understanding of the areas where an assessment of a precisely defined subject would be useful for future research.

Table 2.1 Advantages and disadvantages of prospective and retrospective research studies

Prospective		Retrospective	
Advantages	Disadvantages	Advantages	Disadvantages
To measure multiple variables completely and accurately	Expensive and inefficient	Relatively low cost	Data that was not collected in a predesigned proforma with

			specific requirements, some data will be missing
Minimal bias in selection, recall and exposure	Cannot be used for studying rare diseases	Shorter duration, due to events having occurred already	Requires proper control groups, which are often hard to obtain
Can be used to examine the relationship between exposure and disease	Longer duration than retrospective design	Possible to study multiple exposure factors simultaneously	Based on previously recorded information, thus susceptible to memory or registry bias when retrieving data
	Losses to follow up participants overtime		
	Prone to selection bias due to lack of randomisation		

2.5. Quantitative analysis

Quantitative research is defined as a systematic investigation of phenomena by gathering quantifiable data and performing mathematical or computational techniques (Watson 2015). The process of collecting and analysing numerical data can be used to find patterns, make predictions, test relationships between variables and generalise results to the wider populations. It is formed from a deductive approach where-by testing theory promotes objective empirical data to test an understand relationships. Two main types of quantitative research methods are used and are primary and secondary quantitative research methods (Sukamolson 2007). Primary quantitative research is the most widely used method for conducting various types of research in the social sciences (Creswell and Poth 2018). The distinct feature of primary research is that the researcher focuses on collecting the data rather than depending on data collected from previously done research. There are four methods of primary-quantitative research and includes survey research, correlational research, casual-comparative and, experimental research (Goertzen 2017).

Survey research is the most fundamental tool for all quantitative outcome research methodologies and studies. A survey will use various types of collection techniques such as online polls, paper questionnaires, web surveys, etc. By conducting survey research an organisation can collect data from a pool of individuals and analyse the data to produce numerical results. For this reason, this type of research can be conducted with specific target audiences/populations and with the prerequisite for this research is that respondents must have to randomly sampled, the researcher will maintain accuracy and reliability of the results. Survey research is divided into two types, cross-sectional and longitudinal. Cross-sectional research uses observational surveys where the researcher collects information of specific target population at any given time and by using this data collection tool multiple variables can be evaluated and compared. Longitudinal surveys collect data a little differently as information is collected across various time frames to observe a change in respondent behaviour and thought-processes. Longitudinal surveys are extensively used in medicine and applied sciences for the use of observing changes over a period of time. This overcomes the only disadvantage of cross-sectional survey design where the cause-effect relationship cannot be established as it usually evaluates variables at one particular-time.

For this specific PhD it was more suitable to use a cross-sectional survey design due to the three-year timeframe and the complexities associated with reaching the homeless population. After analysing prospective and retrospective data using a systematic review, which aimed to evaluate substance use trends among the homeless population. After initially assessing and evaluating the use of NPS among the homeless population it was then necessary to determine the prevalence, motivations and effects of NPS among users from the homeless population. Using a cross-sectional survey research design, homeless individuals are asked a series of questions about their demography, NPS use, motivations and effects associated with their consumption of NPS.

Previous quantitative research have used a range of techniques including questionnaire surveys, case reports and hospital admission data to examine NPS consumption among the homeless population. The research conducted using case reports and hospital admission data identified the most prevalent adverse events and the underlying sociodemographic characteristics but failed to produce any information about prevalence. The questionnaire surveys did investigate the prevalence and reported that roughly 50% of the homeless were users of NPS. Quantitative method have not however, focused on just NPS consumption among the homeless but instead measured the problem in addition to other vulnerable populations.

2.6. Qualitative analysis

The use of qualitative analysis provides a way to get an in-depth understand of the underlying reasons, attitudes, and motivations behind various human behaviours (Strong 1992). The in-depth perception and understanding of others is why qualitative analysis is used in multiple disciplines (Tong et al. 2014; Rosenthal 2016). The purpose of conducting a desk-based qualitative study was to maximise the data available whilst minimising ethical issues through a non-intrusive approach. The information obtained from the study was through experiments of others and the observation of the researchers through drug discussion content and therefore, is empirical data (Lusk 2016). Given that qualitative research is characterised by flexibility, openness and responsivity to the research context, the steps of data collection and analysis are not separate and consecutive like they are in quantitative research. Instead, the sampling, data collection, analysis and interpretation are related to each other in a cyclical manner and not in a stepwise approach. Qualitative research can be performed by five different approaches. All the approaches have different purposes behind their design and implementation whether that be to describe a cultures characteristic or to describe experiences as they are lived. The different qualitative approaches included phenomenology, grounded theory, ethnography, historical and case study.

Phenomenology is an approach to qualitative research that focuses on the commonality of a lived experience within a particular group and arrive at a description of the nature of the phenomenon. Interviews are typically conducted with a group of individuals who have had first-hand experience or knowledge of an event to gain an insight into the phenomenon and attempt to answer the broad questions. With roots in philosophy, psychology and education, phenomenology attempts to extract pure and untainted data through the process of the researcher constructing universal meaning of an event, situation or experience.

Ethnography is the study of social interactions, behaviours and perceptions that occur within a certain population, group, or organisation. The primary aim of ethnography is to provide rich in-depth information about peoples views and actions, as well as the nature of the location they inhabit through collecting information through observations and interviews. As Hammersley stated “Ethnographers task is to document the culture, perspectives and practices of the people within their setting aiming to ‘get inside’ the way each group perceives the world”.

Grounded theory is a research method concerned with the generation of theory, which is grounded in data that has been systematically collected and analysed. Developed by researchers Glaser and Strauss during their study-‘Awareness of Dying’ it aimed to uncover social relationships and behaviours of groups, known as social processes. Initially starting with open questions, the researchers presume they know little about the meanings that drive the actions of their participants.

Case study research is an investigation and analysis of a single or collective case, intended to capture the complexity of the object of the study. By drawing together holistic, ethnographic, phenomenological, and biographic research methods the researcher selects their method informed by case intuition. Case studies were one of the first types of research to be used in the field of qualitative methodology and today, account for a large portion of research presented in books and articles in psychology, education, history and medicine. Despite the long history and widespread use, case study research has received little attention among researchers in the social sciences. Mills et al (2010) elaborated on how only a few texts deal directly with case studies as a central subject with no reference provided on the design and methods to be implemented in case study research. Instead, case studies are done on an individual basis and the design and methods will be done on a case-by-case basis.

Historical research studies past events to interpret the information and explain the cause of the events, and their effect in present day. This is usually done by examining existing documents or by interviewing individuals who lived through those events in order to understand the past. All researchers who use qualitative methodologies may be classified as a historical researcher. The observations, inquiring about, and interacting with the participants is built on the previous work conducted by others which will validate their findings.

A large portion of the research conducted into homelessness and NPS consumption have used qualitative methods to gain an in-depth understanding of the underlying prevalence, motivations and effects. Conducted by using interviews and focus groups these research studies gained an in-depth understanding of the motivations and harms associated with the homeless populations NPS use. Gray, Ralphs and Williams reported the homeless were motivated to use synthetic cannabinoid receptor agonists due to their escapism effects in combination with the high potency, low price, ease of access and non-detectability in drug screening tests. It was also found that continued SCRAs consumption resulted in physical and mental health problems for the homeless affecting homeless shelters and emergency services. The use of qualitative research enabled the researchers to understand the motivations and harms from personal interaction and probe further if more information was required. Although it was established that NPS motivations were similar to traditional drugs the effects of homelessness and NPS consumption on the public and service providers are still not fully understood. Qualitative information collected from interviews with service providers suggested that the homeless populations ease of access to SCRAs resulted in high SCRAs prevalence. Information regarding the publics attitudes and how they have been affected by homelessness and NPS consumption is difficult to collect through interviews, focus groups, and observational studies due to the poor generalisability of the findings. Collecting real-time qualitative information through extracting data from social media platforms such as Facebook and Twitter researchers can overcome this limitation and provide in-depth rich information.

2.6.1. Social media analysis

Social media networks have transformed the sources of information. Recent years have seen a significant increase in academic interest in the possibility of using social media as a tool to examine and evaluate information (Buckingham and Willett 2013; Gebremeskel et al. 2014). In particular, the microblogging service Twitter has been used as a learning tool in the fields of medicines as well as for disease surveillance and management and public health concerns (Triple 2011; Sinnenberg et al. 2017; Osagie et al. 2020). This ability was demonstrated in predicting influenza cases and surveillance for an Ebola outbreak in 2014. However, both studies collected large amounts of data and analysed the data quantitively. Research from Talbot (2020) and Sandhu (2019) has shown how focusing on specific populations can provide an understanding of the attitudes and behaviors towards the specific populations. More generally, research into how social media is used to discuss homelessness and new psychoactive substances and other health risk behaviors is still in its infancy, but research has been carried out into drug use among the general population for both cannabis and alcohol use (Grant and O'Mahoney 2016; Unger 2020).

After determination of the prevalence, motivations and effects of NPS among users from the homeless population (chapter two) it was then crucial to explore the attitudes and behaviours of the service providers regarding the issue. Using qualitative analysis of social media data on the Twitter platform the information and opinions from the individuals who provide a service to the homeless population is explored. By thematically analysing Twitter data the reoccurring patterns and themes are further identified and explored with the aim to voice the opinions of the service providers. Collecting qualitative information from Twitter will help understand how society is affected from the homeless population using NPS.

2.7. Prospective experimental studies

Prospective experimental studies are research that is conducted in which the conditions are under the influence and direct control of the researcher. The researcher creates changes in the explanatory variables and notes the changes in the response variable. Any research that is conducted under scientifically accepted conditions uses experimental methods (Christensen et al. 2004). The success of experimental studies hinges on the researchers confirming the change of variable based on the manipulation of a constant variable. This should establish a notable cause and effect relationship (Gall et al. 1996). There are three types of experimental design including pre-experimental, true experimental research design and quasi-experimental research. The way that research studies are classified are based on conditions or groups, determines the type of design (Ross and Morrison 2004).

In pre-experimental research, a group or various groups (including NPS) are kept under observation after implementing factors of cause and effect. This research is conducted to understand if further investigation is required for these particular groups.

True experimental research relies on statistical analysis to prove or disprove a hypothesis, making it the most accurate form of research. Of the experimental designs, only true design can establish a cause-effect relationship within a group and three factors need to be established: there is control group that wont subject to changes, a variable can be manipulated and, the data is randomly distributed (Gall et al. 1996).

In quasi-experimental designed research, an independent variable is manipulated, but the participants of a group are not randomly assigned. Quasi-research is used in field settings where random assignment is either irrelevant or not required (Ross and Morrison 2004).

Experimental work with NPS have been done by using a variety destructive and non-destructive techniques. The majority of forensic laboratories use double-hyphenated techniques such as GC-MS, LC-MS and HPLC which are the ‘gold standards’ of forensic analysis but destroy the sample. The United Nations Office on Drugs and Crime (UNODC) reported that more than 880 NPS have been identified by forensic laboratories worldwide and would have used the ‘gold standard’. Non-destructive techniques such as FTIR and Raman spectroscopy have also been accepted by the UNODC to analyse NPS.

2.8. Structure adopted in this thesis

The structure adopted in this thesis is composed of four stages using a mixed-method approach (Figure 2.1). Stage one, the systematic review consisted of an investigative study to uncover the emergence of NPS among the homeless population. Stage two, a semi-structured questionnaire identified the prevalence of NPS, the motivations and effects among users from the homeless population. Stage three explored and uncovered the attitudes and opinions regarding homelessness and NPS consumption from the social media platform, Twitter. The final stage consisted of two experimental research studies that were designed to detect and predict NPS impregnated into paper and liquid matrices using portable Infrared and Raman spectroscopy.

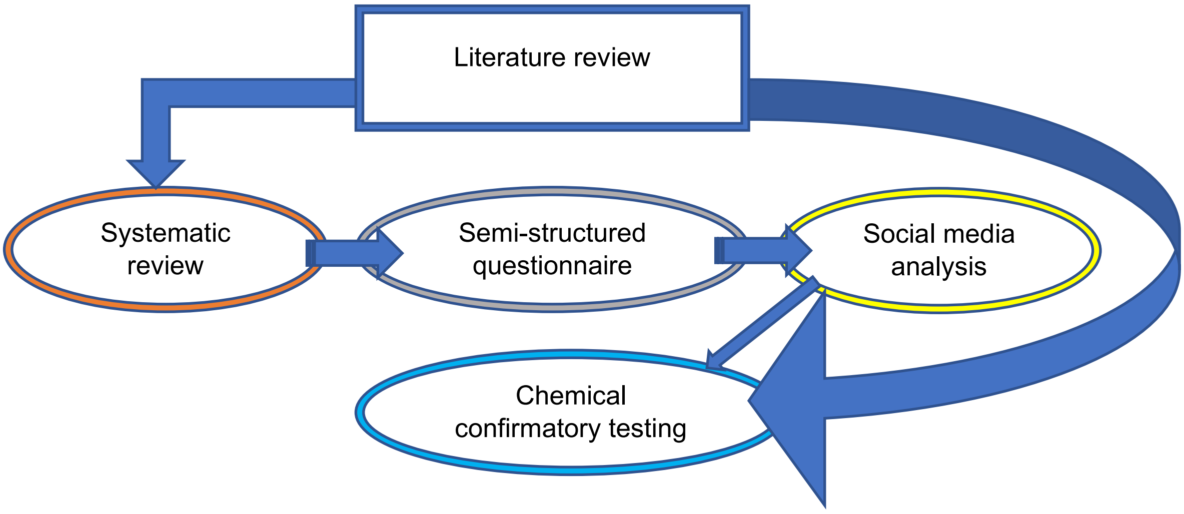


Figure 2.1 Schematic diagram of thesis structure

2.9. Framework adopted in this thesis

Although the underlying mechanisms that cause homelessness and substance use are not fully understood, two principal pathways have been postulated: social causation and social selection (referred as "social drift"). The theory of social causation originates in sociological and psychological literature and specifically posits that neighborhood-level economic disadvantage and lower social status are fundamental stimuli that induce psychological distress such as substance use (Johnson et al. 1997; Fountain et al. 2003). Abandoned and substandard housing in combination with disinvestment in resources, may provide venues for illicit drug use (Fountain et al. 2003). The social selection hypothesis argues that those with mental health disorders are more likely to drift into or remain in poverty due to increased health expenses, loss of employment, and associated earnings (Coumans and Spreen 2003; Glasser and Sywiak 2003; Kemp et al. 2006). Most of the current evidence about the relationship between substance use and homelessness supports a social selection model, indicating that substance use may be a direct pathway to homelessness (Saraceno et al. 2005; Chiu et al. 2017; Wickham et al. 2017). However, this model was not adopted in this research due to the low prevalence of NPS among users in the public and the relatively new emergence among the homeless population, two factors that disagree with NPS causing homelessness.

According to social causation theory, social network processes may also lie in the casual pathway linking neighborhood characteristics to illicit drug use (Johnson et al. 2003). There is also considerable evidence that suggests substance use increases as a very clear consequence of homelessness and serves as a method of coping with the stress of street life (Flisher et al. 2007; Lund et al. 2010). The social causation model suggests that substance use increases as a very clear consequence of homelessness and serves as a method of coping with life on the streets (Fountain et al. 2003).

There is nothing new about the homeless population using drugs and alcohol to self-medicate from life's stresses associated with life on the streets. Nevertheless, the non-homeless population use more alcohol and drugs when they are experiencing difficulties in their own life. It is not surprising to learn that drug and alcohol consumption Is key to acceptance in the homeless subculture, supporting the causation theory. What is of interest is if social causation theory can be applied to the consumption of NPS among users from the homeless population. The consumption of NPS among the homeless population is reported to be highly prevalent, whereas for the public the consumption of NPS is only 0.4%. For this research social causation theory has been chosen as the theoretical framework that will be adopted in this thesis.

Chapter 3. Systematic review

3.1. Introduction

Around 380,000 individuals in the United Kingdom (UK), 740,000 individuals in the United States (US) and 150 million globally are reported to be homeless at any given time (Busch-Geertsema et al. 2016; Shelter 2019; Kidd et al. 2021). Although most live-in sheltered accommodation such as hostels, emergency accommodation and sofa-surfing, research has suggested that 45% are unsheltered (GOV UK 2019). Although many factors can be responsible for homelessness, the shortage in low-cost housing, the global recession, and a lack of community-based supports over the past three decades are thought to have contributed to increasing levels of homelessness and substance use (Fazel et al. 2008; Tyler 2013; Crisis 2020). Apart from contributing to increased rates of mortality and serious mental health disorders, the presence of drug use disorders among the homeless population is likely to increase rates of morbidity, criminality and longer periods of homelessness (Macleod et al. 2016).

Substance use is a major public and global health threat associated with multiple adverse health effects and undesirable social outcomes (Aldridge 2020). A comprehensive body of research has reported a high prevalence of substance use among the homeless population. In this respect, substance use in the homeless population is three to four times higher than non-homeless individuals (Rew and Fitzgerald 2001; Rosario et al. 2012; Bramley et al. 2016; Santa Maria et al. 2018; Khezri et al. 2020). A reason offered for this high prevalence of substance use among homeless individuals is as a coping strategy for homelessness. Substance use may also be the cause of homelessness itself with many studies reporting a bi-directional relationship between substance use and homelessness (Prangnell et al. 2017). Substance use often results in acute and chronic adverse drug events (ADEs) among the homeless population that interfere with the quality of life (Tyler 2013).

A meta-analysis of international studies found that alcohol prevalence ranged from 8.7% to 84.8% and substance use prevalence ranged from 4.5% to 63.3% among homeless population (Santa Maria et al., 2018). With drug overdose being the leading cause of death among the homeless, knowing the prevalence rate of substance use would better enable the understanding of the interactions between the overlapping issues (Chambers et al., 2013; Lebrun-Harris et al., 2013; Latimer et al., 2017; Laporte et al., 2018). Prior reviews on homelessness and substance use have not focused on the overlapping problem, but rather on mental health issues and effectiveness of interventions. The consistent association has been found between substance use and homelessness, which has underpinned a broad range of social policies and public health initiatives (Rosario et al. 2012). However, such analyses have not adequately assessed the current drug trends among individuals who face considerable social exclusion. Although, new drugs have been reported to have entered the black market, such as SCRAs and fentanyl derivatives, no review to date has documented the emergence of such compounds in the homeless population.

More reliable estimates of the prevalence of substance misuse in the homeless population should help inform public policy and the development of drug support services that are tailored to current drug trends. The most recent review did not consider the drug trends among the homeless population and made no attempt to explore the differences in drug consumption. Therefore, this systematic review examined unbiased sources of data regarding the prevalence of substance use, effects and toxicity among individuals from the homeless population.

The systematic review was chosen as the first research study in this thesis in order to assess NPS prevalence among the homeless populations. The systematic review was a crucial first chapter to gain academic evidence that the homeless population are now using NPS. This knowledge would then uncover any insufficient data collected regarding homelessness and NPS use which in turn will inform the structure, research aims and objectives for the second chapter - a semi-structured questionnaire.

3.1.1. Research aims and objectives:

With a targeted population of homeless adults aged between 18 to 64 years old, the specific aims of this study were to evaluate the prevalence and uses of NPS among the homeless population. In line with the overarching study aim of evaluating the prevalence of NPS, the findings were also considered in the light of the participants underlying motives, substance use cause and risk factors and adverse events. Consequently, the objectives of the study were to:

1. Understand socio-demographic characteristics of the homeless population from different geographical locations
2. Examine the trends and patterns of substance use among the homeless population over the past 15 years
3. Assess the risk factors associated with substance use
4. Determine the adverse events associated with substance use
    a. Most affected systems within the body
    b. Identify adverse events associated with specific drug substances

3.2. Method

3.2.1. Aim of study

The aim of study one was to evaluate the prevalence and uses of NPS and homelessness through systematically searching relevant publications and evaluating the results. The systematic review was a necessary first study in this PhD in order to assess the prevalence of NPS in the homeless population and identify motivations behind their consumption and the associated effects of their use. The systematic review subsequently informed the semi-structured questionnaire and the selection of NPS and matrices for the chemical confirmatory studies (studies four and five). This systematic review was designed and reported according to the PRISMA statement, an intentionally recognised 27-item checklist ensuring the highest standards in systematic reviewing.

3.2.2. Search strategy

We searched the following 13 databases between 2007 – 2020: British Nursing index, Cochrane library, Embase, Google, Google Scholar, Medline, National Electronic Library of Medicine, PsychExtra, PsychInfo, PubMed, ScienceDirect, Scopus, and Web of Science. The search terms were derived from previous reviews. A citation search was carried out and additional articles were identified from citations yielded by the electronic search. In addition, we searched different international homeless organisations across the world in order to identify official definitions and different classifications of homelessness; these were the Salvation Army, Shelter, Institute of Global Homelessness (IGH), Depaul International and St Mungo's.

The following search terms were used: 'substance use', 'homelessness', 'homeless', 'rough sleepers', 'substance abuse', 'drug use' and 'drug abuse'. The search strategy involved the use of the seven terms in each database as follows: 'substance use and homelessness' or 'substance use and rough sleepers' or 'homeless and substance use' or 'substance use among the homeless population' or 'rough sleepers and new psychoactive substances' or 'homeless and new psychoactive substance use' or 'homelessness and drug use' or 'substance use prevalence in the homeless population' or 'homeless and Spice use' or homelessness and injection drug use' or 'homeless drug abuse'.

3.2.3. Inclusion and exclusion criteria

Studies were included in the systematic review if they investigated substance use among the homeless population and had explicit data on adult homeless population (ages ranged between (18 – 64 years old). The studies eligible were those published during or after 2007 and the abstract written in English. The search terms were derived from previous reviews. A citation search was carried out and additional articles were identified from citations yielded by the electronic search. Exclusion criteria were postulated prior to the search. Research articles and reports were excluded if titles and/or abstracts indicated that studies focused on:

1. Studies that had other marginalised population in them in addition to the homeless.

2. Intervention and rehabilitation studies

For the purposes of this review, homelessness were defined as being without suitable or permanent accommodation. This ‘umbrella term’ includes street dwelling homeless, also known as rough sleepers, those in sheltered in accommodation and staying with friends or family. Mental health and homelessness have been extensively researched. For that reason, these behaviours were not included in the search criteria. However, where research in this review reports on mental health alongside substance use or abuse it has been included in the analysis.

3.2.4. Data extraction

Titles and abstracts of the articles gathered during the search were screened by two-independent researchers against the exclusion criteria. Full articles were read in detail by the first author and excluded if they focused on any excluded topic.

The final articles were read in full and numeric data detailing prevalence of substance use was extracted. Information on the country where the research was conducted, size of the sample, sampling strategy, study design, age range, ethnicity and substance use and abuse information. In addition each article was assessed for information pertaining adverse drug events and societal problems associated with substance use and abuse. When articles contained information on the relationship between their substance use and their homelessness this was also recorded.

3.2.5. Data analysis

We carried out data analysis using SPSS version 26 (IBM, Armonk, NY, USA). The summary of statistics included the reported prevalence rate, dependency, mental and physical health problems, resulting from substance use among the homeless population. The reported prevalence rate was calculated as the number of participants who consumed at least one substance *numerator) divided by the total number of participants in each study (denominator). We also identified the main adverse effects associated with substance use and to simplify the comparison, the adverse effects were classed into six main categories based on the systems within the body. The six categories are as followed: cardiovascular, neurological, respiratory, hepatic, renal and gastro-intestinal systems. No meta-analysis was done due the nature of the included studies being both retrospective and prospective, differences in sample size and methods for data collection.

3.2.6. Data Validation

The remaining publications were subject to bias evaluation also known as data validation. The CASP and Cochran quality assessment tool was used to evaluate publication bias for the included studies. To ensure the reliability of the data used, Higgins test of homogeneity was chosen (Higgins et al. 2003). In total, 25 publications were reviewed and used for the systematic review. The findings were then extracted to create tables comprising of different characteristic traits presented from homeless individuals using substances. The evaluated publications were also subject to validation from myself, the research and all four supervisors (AA, SA, PVC and TG) using Cohens Kappa coefficient. The result after data validation achieved a study interrater reliability statistic of 0.95, an almost perfect level of agreement between researchers (Cohen 1960).

Table 3.1 Interpretation of Cohens Kappa (Cohen 1960)

Value of Kappa	**Level of agreement**	**% of Data that are reliable**
0-0.20	None	0-4%
0.21-0.39	Minimal	4-15%
0.40-0.59	Weak	15-35%
0.60-0.79	Moderate	35-63%
0.80-0.90	Strong	64-81%
Above 90	Almost perfect	82-100%

3.3. Results

In total, 38,383 studies were retrieved (Figure 3.1) before applying the limitation of time (beyond 2007) and age (> 18 years old) limits. When applying the inclusion/exclusion criteria and removing duplicates, 262 studies were extracted. Out of the 262, there were 220 that were excluded because they did not focus on substance use in the homeless population. The abstracts of the remaining 42 studies were evaluated, and 17 were found not relevant. The search resulted in 25 studies that investigated substance use in homeless populations.

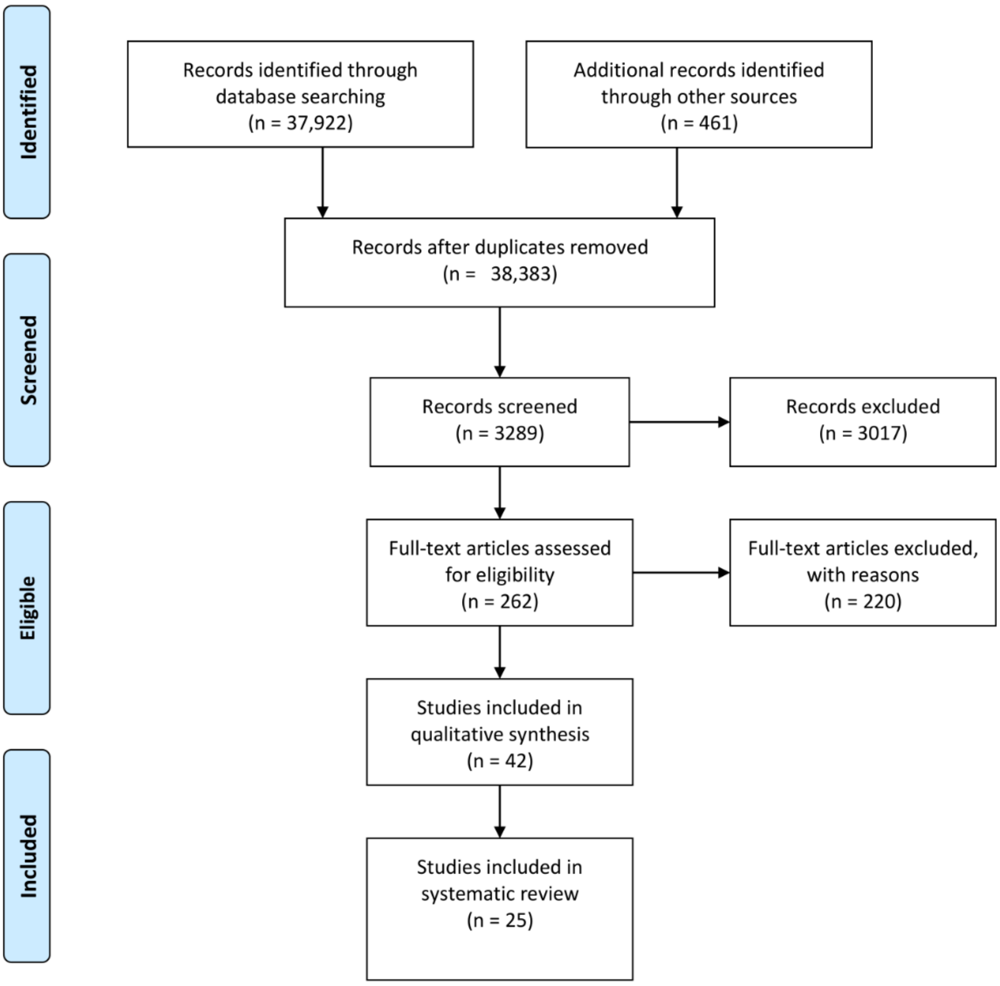


Figure 3.1 Flow chart of studies included in systematic review quantitative studies

3.3.1. Study characteristics

Twenty-five articles were included in this review. The majority of publications examined homelessness in the United Sates (n= 17) followed by Canada (n=4), United Kingdom (n=2), Italy (n=1) and Spain (n=1). Most of the studies used cross-sectional research design, a few were longitudinal, cohort, case report and retrospective. Prospective studies included case report (Etienne et al. 2016; Manseau et al. 2017; Shabaz et al. 2018; Torres and Espiridion 2020), cross-sectional (Johnson and Fendrich 2007; North et al. 2007; Tyler and Johnson 2007; Wenzel et al. 2009; Gomez et al. 2010; Rhoades et al. 2011; Torchalla et al. 2011; Palepu et al. 2012; Palepu et al. 2013; Torchalla et al. 2014 ; Tsia, Wesley and Rosenheck 2014; O'Brien et al. 2015; Barnett and Owusu 2016; Neisler et al. 2019; Guillen et al. 2020; Reitzel et al. 2020) and cohort (Riley et al. 2015; Doran et al. 2018). Retrospective studies included cross-sectional (Maremmani et al. 2015; Joseph et al. 2019; Yamamoto et al. 2019;) and cohort studies (Miller-Archie et al.

2019). Full psychiatric interviews using The Diagnostic and Statistical Manual of Mental Disorders (DSM), International Classification of Diseases (ICD) and Mini International Neuropsychiatric Interview (MINI) were used in interview studies. The AUDIT and Clinical Alcohol and Drug Use Scale were used to measure alcohol use and abuse in interview studies and the Alcohol Frequency Questionnaire for questionnaire studies (Glovannucci et al. 1991; Saunders et al. 1993; Amorim 2000; Edition 2013; WHO 2009).

Homelessness was defined in Chapter 3.2.3: Inclusion and Exclusion criteria. Many studies involved interviews with homeless individuals who resided at homeless shelters. The majority of studies focused on interviewing homeless individuals at the homeless shelters (temporary accommodation) and only one focused on interviewing street homeless. Participants included in this review were between the ages of 18 – 64 years old. The sample size varied considerably ranging from just one participant in a case report to 96,099 participants collected in a retrospective study of Emergency Department (ED) data. The duration of the studies ranged between one week to four years.

Table 3.2 Study characteristics of the homeless population analysed

Study number	Study type	Study design	Setting	Population	Study duration (weeks)	Sample Size (number)	Country	Criteria for homelessness	Reference
1	Prospective	Structured questionnaire	Six homeless-serving shelters in Oklahoma City	Homeless individuals from homeless shelters	6	581	USA	No fixed abode and requiring services from the shelters	Neisler et al. 2019
2		Semi-structured questionnaire	Six homeless-serving shelters in Oklahoma City	Homeless individuals from homeless shelters	2	528	USA	Individuals requiring services from the homeless shelters and without a fixed abode	Reitzel et al. 2020
3			Four safetynet health clinics in Dublin	Data from health clinics	2	105	Northern Ireland (UK)	individuals who are rough sleepers, residents of emergency accommodation, and those living in insecure and inadequate housing	O'Brien et al. 2015
4		In-depth interviews	Community centre drop-in, Central Texas.	Young homeless (aged 18 to 23 years old)	9	185	USA	Individuals without stable housing and who identify with the culture and economy of living on the streets	Gomez, Thompson and Barczyk 2010

5			Temporary shelter settings in central region Los Angeles County	Women's alcohol and drug problems	10	445	USA	they currently did not have a regular place to stay (e.g., own house, apartment, or room, or the home of a family member or friend)	Wenzel et al. 2009
6			13 shelters in Skid \row Los Angeles County	Men's substance use	6	305	USA	stayed at least one night in a place like a shelter, abandoned building, voucher hotel, vehicle, or outdoors because they didn't have a home to stay in	Rhoades at al. 2011
7			Homeless shelters, streets or abandoned buildings in Madrid, Spain	Substance use and mental health among homeless women	24	138	Spain	shelter or other facility for homeless people, on the street or in other places not initially designed for sleeping (abandoned buildings, underground railway stations, etc.).	Guillen et al. 2020
8			Homeless community based venues San Francisco	Risk factors among homeless women	22	260	USA	No fixed abode and requiring services from the shelters	Riley et al. 2015

9			Urban hospital setting, New York	Substance use and homelessness among ED patients	10	316	USA	We defined current homelessness as self-report of spending the past night in a homeless shelter or outdoors, on the street, in an abandoned or public building, an automobile, or another place not meant for human habitation.	Doran et al. 2018
10			Manchester Metropolitan University	Synthetic cannabinoid homeless users	6	53	UK	both street homeless, and those non-street homeless who were leading a street-based lifestyle at the time (i.e. spending large portions of their day in Manchester city centre, primarily to obtain money to purchase substances that they then used in public places around the city centre)	Gray, Ralphs and Williams 2020
11		Structured interviews	University of Illinois at Chicago Survey Research Laboratory	Drug use assessment	6	627	USA	No fixed abode and requiring services from the shelters	Johnson and Fendrich 2007

12			University of Nebraska, Lincoln	Homeless individuals aged between 19 - 21		40	USA	An adult currently resided in a shelter or on the street or was temporarily doubling up with friends because they had run away, had been pushed out, or had drifted out of their family of origin.	Tyler and Johnson 2007
13			BC Health of the Homeless Survey, Vancouver British Columbia	PTSD and substance use among homeless	5	489	Canada	Homelessness was defined as living in a shelter or on the streets (e.g., the outdoors, abandoned and public buildings, subways, vehicles).	Torchalla et al 2014
14			Centre for Health Evaluation and Outcome Services, Vancouver, British Columbia	Homeless women	5	193	Canada	Homelessness was defined as living in a shelter or on the streets (e.g., the outdoors, abandoned and public buildings, subways, vehicles).	Torchalla et al. 2011
15			University School of Medicine in St. Louis	Homeless individuals from homeless shelters	24	254	USA	Having no fixed abode and having spent the previous 14 days in an unsheltered location	North et al. 2007

16		Semi-structured interviews	Massachusetts General Hospital	Synthetic cannabinoids among the homeless	1	8	USA	No fixed abode and requiring services from the shelters	Barnett and Owusu 2017
17		Interviewer administered questionnaire	Centre for Health Evaluation and Outcome Services, Vancouver, British Columbia	Access to treatment among the homeless	12	1191	Canada	A homeless participant was defined as living in a shelter, public space, motor vehicle, abandoned building, or not having their own place for which they paid rent.	Palepu et al. 2013
18			Homeless shelters in Vancouver British Columbia	Vancouver at home study	9	497	Canada	A homeless participant was defined as living in a shelter, public space, motor vehicle, abandoned building, or not having their own place for which they paid rent.	Palepu et al. 2012
19		Case report	Queens Hospital New York	Synthetic cannabinoid hospitalisation	0.25	1	USA	No fixed abode and requiring services from the shelters	Shahbaz et al. 2018
20			Reading hospital, USA	Use of Spice for appetite stimulation	0.25	1	USA	Self-described homelessness	Torres and Espiridion 2020

21		Homeless veterans compared on a housing initiative	New England Mental Illness Research, Education and Clinical Centre	Homeless war veterans	6	29,143	USA	Residing in a place not meant for human habitation, in an emergency shelter, in transient housing or exiting an institution.	Tsia, Wesley and Rosenheck 2014
22	Retrospective	Cross-sectional analysis of ED hospital data	New York supportive housing program	Individuals eligible for housing first scheme	60	1558	USA	No fixed abode and requiring services from the shelters	Miller-Archie et al. 2019
23			Emergency Depeartment admissions in Florida, Maryland, Massachusetts and New York.	Homeless with at least one ED visit	12	96,099	USA	Self-described homelessness	Yamamoto et al 2019
23			Health Center's Comprehensive Psychiatric Emergency Program	Medical records	1	321	USA	No fixed abode and requiring services from the shelters	Joseph et al. 2019

23		structured clinical Interviews	Homeless individuals from the Vancouver At Home/ChezSoi study	Mood patterns and substance use	48	319	Italy	Having no fixed abode and having spent the previous 30 days in an unsheltered location	Maremmani et al. 2015

NR: Not reported, Self-described homelessness was when the individual self-identified as homeless. PTSD: post-traumatic stress disorder.

3.3.2. Participant characteristics

Twenty-three studies examined the mean age of participants (92%). The results obtained from the review represent an ageing homeless population where only five studies reported a mean age below 35 years old. Eighteen studies in this review reported the ethnicity of their participants; where Caucasian and African American ethnic groups dominated the homeless population. Caucasian and African American ethnic groups ranged between 14.9 – 67.6% and 1.6 – 76.9%, respectively. The ethnic majorities and minorities reported in the review were often in their home countries but were mainly in the US and Canada. For the US, 11 studies (Johnson and Fendrich 2007; Tyler and Johnson 2007; Gomez et al. 2010; North et al. 2007; Rhoades et al. 2011; Tsia et al. 2014; Riley et al. 2015; Doran et al. 2018; Miller-Archie et al. 2019; Neisler et al. 2019 Yamamoto et al. 2019) reported the ethnic background of the participants to which African American and Caucasian were reported in all. Both of the aforementioned ethnicities were highly prevalent where African American individuals ranged between 1.6 – 76.9% and Caucasian between 11.52 – 67.6%. Other US ethnic backgrounds that were highly reported but were less prevalent were Hispanic and Latino and ranged between 2.5 – 36.2% and 4.3 – 25.35%, respectively. All four Canadian studies in this review reported the ethnic background of their participants (Torchalla et al. 2011; Palepu et al. 2012; Palepu et al. 2013; Torchalla et al. 2014). Most Canadian homeless individuals were either Caucasian (56 – 60.62%) or Aboriginal (16 – 54.4%). African Canadian homelessness was significantly less prevalent (2 – 8.9%) than Caucasian and Aboriginal. The studies from the UK did not consider the ethnic background of their participants (O'Brien et al. 2015; Gray et al. 2020).

Of the 25 studies that were evaluated in this review, 17 studies reported both male and female participants and eight reported either male or female participants but not both. From the 17 studies that included both male and female homeless individuals, all but one had a male majority ranging between 51.99 – 95.34%. For each geographical location males were more prevalent. For the US the prevalence of male homeless was between 40 – 95.34%, Canada in the range of 60.53 – 65.5% and the UK 75.23 – 88.67%. Most studies (n=16, 64%) reported education with both the mean duration (years) or the level of education achieved (e.g high school, university). The studies that reported the mean duration of education (n=3, 12%) of the participants ranged between 11.90 – 11.98 years. However, in the remaining studies (n=13, 52%) a significantly large portion of the homeless participants reported they had not completed high school education (ranging between 17.6 – 64.8%). Employment status was different among the homeless depending on the country. Specifically in the US, homeless people could have jobs where their jobs are not enough to support accommodation (Timmer et al. 2019). However, this was not the scenario in the UK and Spain where homeless people are jobless. Hence, in the UK and Spain homeless people do get government financial support through benefits claim. This affected the findings regarding jobs/employment in this review where unemployment results were between 60-95%. Hence 60% was obtained from the US whereas the 95% were from Canada, Spain and the UK

Table 3.3 Characteristics of the participants included in the systematic review

Study number	Age range (years) min - max)	Meane age (years)	Male to Female ratio	Ethnicity (%)	Education	Previous employment	Ref
1	NR	43.64	370(63.68%): 211(36.32%)	Caucasian (56.4) African American (19.97) American-Indian/Alaska native (11.6) multi-racial (9.2) Hawaiian (0.7) Asian (0.4) other (1.6)	Participants were in education for an average of 11.9 years	NR	Neisler et al. 2019
2	NR	43.59	331(62.65%): 197(37.35%)	NR	Participants were in education for an average of 11.98 years	NR	Reitzel et al. 2020
3	NR	32.4	79(75.23%): 26(24.77%)	NR	NR	NR	O'Brien et al. 2015
4	18 - 23	20.8	125(67.56%): 60(32.44%)	Caucasian (67.6) African American (1.6) Latino (4.3) American Indian (2.16) Other/mixed (23.8)	54.1% graduated school 45.9% dropped out	71.89% primary income panhandling	Gomez, Thompson and Barczyk 2010

5	NR	36.56	0(0%): 445 (100%)	African American (40.17) Hispanic (22.77) Caucasian (25.86) Native-American (2.17) Asian (1.38) Other or multi racial (7.65)	At least high school - GED (66.85)	NR	Wenzel et al. 2009
6	NR	45.56	305 (100%): 0 (0%)	African American (71.69) Caucasian (11.52) Hispanic (10.43) Other/multi racial (6.35)	Completed high school (73.31) Not graduated high school (26.69)	NR	Rhoades at al. 2011
7	NR	45.52	0 (0%): 138 (100%)	Spanish (65.2) Foreign (30.4) Both (4.3)	No education (9.4) Incomplete primary education (13) Primary education - up to 14 (32.6) Secondary education - up to 18 (18.8) Non-university higher education (8.7) University higher education (17.4)	NR	Guillen et al. 2020
8	18 - 69	47	0 (0%): 260 (100%)	Caucasian (30.4) African American (43.5) Latina (4.6)	NR	Employed (18.5)	Riley et al. 2015

				Asian (2.7) Other (18.8)			
9		49.3	257(81.32%): 59(18.68%)	Caucasian (14.9) African American (41.0) Hispanic (36.2) other (7.9)	Less than high school diploma (38.6) Graduated high school (33.2) Some college or higher (28.2)	Employed (17.7) Unemployed (39.2) Unable to work (36.1) Retired (7.0)	Doran et al. 2018
10	16 - 52	NR	47(88.67%): 6(11.33%)	NR	NR	NR	Gray, Ralphs and Williams 2020
11	18 - 40	27.3	326(51.99%): 301(48.01%)	African American (35.6) Caucasian (33.1) Latino (22.1) other races (9.2)	Completed college (32.2) Dropped out of college (27.8) Completed high-school (22.6) Did not completed high School (17.6)	NR	Johnson and Fendrich 2007
12	19-21	20.17	16(40%): 24(60%)	Caucasian (67.5) African American (20.0) Hispanic (2.5) multi-racial (10.0)	Completed high school (37.5) Currently in high school (7.5) Working on GED (12.5) Dropped out (30.0) Not reported (12.5)	Currently working (40.0) Unemployed (60.0)	Tyler and Johnson 2007
13	19 - 66	38	296(60.53%): 193(39.47%)	Caucasian (56.0) Aboriginal (40.0) African Canadian (2.0) Hispanic (0.8)	Not graduated high school (63.0) Graduated high school (27.9) University degree (7.0) Professional studies (0.2) Other education (1.9)	NR	Torchalla et al 2014

				Asian (0.6) Other (0.6)			
14	19 - 57	35.3	0(0%): 193(100%)	Aboriginal (54.4) Others (46.6)	Not graduated high school (64.8) Graduated high school (35.2)	Unemployed (94.9) Government financial support (82.6)	Torchalla et al. 2011
15	NR	41.5	186(73.33%): 68(26.67%)	African American (76.9%) Caucasian (20.0%) other races (3.1%)	Participants were in education for an average of 11.9 years	69.9% unemployed	North et al. 2007
16	22 - 61	38	5(65.5%): 3(34.5%)	NR	NR	NR	Barnett and Owusu 2017
17	NR	42.2	776(65.15%): 415(34.85%)	Caucasian (60.62) African Canadian (8.90) Aboriginal (17.13) Mixed (5.37) Other (4.95)	Graduated high school (23.17) Did not graduate high school (44.41) post-secondary school (31.65)	Employed in the previous 12 months (39.71)	Palepu et al. 2013
18	NR	40.8	363(72.74%): 136(27.26%)	Aboriginals (16) Caucasians (56) Mixed/other (28)	Did not graduated high school (57) Graduated high school (43)	92% unemployed 4% employed 4% student/housewife	Palepu et al. 2012
19	NA	22	1(100%): 0(0%)	NR	NR	NR	Shahbaz et al. 2018

20	NA	40	0(0%): 1(100%)	NR	NR	NR	Torres and Espiridion 2020
21	NR	50.05	27,784(95.34%): 1,359(4.66%)	Caucasian (40.03) Black (47.21) Hispanic (7.96) Other (3.55)	NR	100% Veterans	Tsia, Wesley and Rosenheck 2014
22	NR	48.1	1344(86.26%): 214(13.74%)	Caucasian (16.08) African American (56.48) Latino (25.35) Asian/other (2.11)	Graduated high school (51.92) Did not graduate high school (44.61) other (3.46)	NR	Miller-Archie et al. 2019
23	NR	47.7	53,394(55.56%): 42,705(44.44%)	Caucasian (31.3) Black (30.2) Hispanic (24.2) Other (14.4)	NR	NR	Yamamoto et al 2019
24	NR	NR	NR	NR	NR	NR	Joseph et al. 2019
25	19 - 66	39	223(69.91%): 96(30.09%)	Aboriginal (16.3)	56.4% in education for less than 9 years	95% unemployed	Maremmani et al. 2015

NR: Not reported.

3.3.3. Substance use

A total of twenty-one substances of five different pharmacological classes were reported and most studies reported more than one substance being consumed by the homeless population. Alcohol consumption was the most frequent substance reported (n=20, 80%) followed by heroin (n=11, 44%), cocaine (n=10, 40%), cannabis (n=9, 36%), crack cocaine (n=6, 24%), SCRAs (n=6, 24%), amphetamines (n=5, 20%), methamphetamine (n=5,), prescription opioids (n=4, 16%), sedatives (n=4, 16%), LSD (n=3, 12%), inhalants (n=2, 8%) and methadone (n=2, 8%). Less frequently reported substances included benzodiazepines (n=1, 4%), tranquilisers (n=1, 4%) CNS stimulants (n=1, 4%), synthetic hallucinogens (n=1, 4%) and PCP (n=1, 4%).

Eighteen studies had used diagnostic criteria or manual to determine substance misuse among the homeless populations in this review. The Diagnostic and Statistical Manual of Mental Disorders (DSM) was the most frequently used method to classify substance misuse (American Psychiatric Association 2013). The third (III) and fourth (IV) editions were chosen to assess substance misuse and the underlying psychiatric conditions among homeless individuals from the United States (US), Canada and Italy. The International Classification of Diseases (ICD-10/11) is a diagnostic tool that was used to classify and monitor causes of injury or death in homeless substances users (WHO 2004). Both DSM and ICD-10 tools were used to assess the associated issues with substance use including psychiatric or physical illness. However, although the studies may have focused on substance use prevalence, the use of DSM and ICD tools is to focus on the health issues substance use has affected the results of the studies. Subsequently, other researchers have used Alcohol Use Disorders Identification Test (AUDIT), Drug Abuse Screening Test (DAST), Alcohol Quantity and Frequency Questionnaire and Clinical Alcohol and Drug Use Scale’s to determine the prevalence of abuse and dependance of alcohol and drug users in this review (Skinner 1982; WHO 2001).

For the studies that reported alcohol use, seven used a full alcohol diagnosis interview or questionnaire and reported the total prevalence of alcohol use disorder among the homeless populations was between 7.5 – 100% of the homeless population. The percentage of AUDIT and Clinical Alcohol and Drug Use Scale disorders identified in interviews by the research reviewed ranged from 18% to 58%. All interviews but one used AUDIT to measure alcohol prevalence. The percentage of alcohol prevalence in homeless individuals when measured using an Alcohol Frequency Questionnaire ranged between 28.41 to 44.4%. The remaining studies reporting alcohol use and abuse were measured through participants self-reporting their use. The rates of alcohol prevalence were considerable higher in studies where participants self-reported their alcohol use. For drug use disorders the Drug Abuse Screening Test or DAST was chosen by two researchers in this review. The percentage of drug abuse prevalence when measured using DAST ranged between each abused substance. Of the two studies that used DAST to measure substance abuse prevalence, both studies had identified cannabis and heroin prevalence. Cannabis was significantly more prevalent than heroin and ranged between 39.9 to 49%, whereas heroin ranged between 15 to 26.1%.

Table 3.4 Substance use among the homeless population

Study number	**Number of drugs reported**	**Substance (%)**	**Substance class**	**Drug use (occasional/frequent)**	**Modality of intake**	**Reference**
1	1	Alcohol	Sedative	Frequent	Oral	Neisler et al. 2019
2	1	Alcohol (28.41)	Sedative	Frequent	Oral	Reitzel et al. 2020
3	3	Alcohol (58.0) Heroin (19.04) Cocaine (20.95)	Sedative opioid Stimulant	Frequent	Oral Intravenous Snorting	O'Brien et al. 2015
4	5	Alcohol (100) Heroin (13.5) Cannabis (92.97) Methamfetamine (3.24) LSD (3.8)	Sedative Opioid Cannabinoid Stimulant Hallucinogen	Frequent	Oral Intravenous Smoking Snorting	Gomez, Thompson and Barczyk 2010
5	7	Alcohol (27.6) Cannabis (29.7) Crack cocaine (20.5) Cocaine (16.8) Amfetamine (23.2)	Sedative Cannabinoid Stimulant	Frequent	Oral Smoking Snorting	Wenzel et al. 2009

6	5	Alcohol (38.09) Heroin (7.48) Prescription pills (16.79) Cannabis (55.52) Crack cocaine (39.56) Cocaine (11.89) Methamfetamine (10.74) Other (4.77)	Sedative Opioid Cannabinoid Stimulant	Frequent	Oral Smoking Snorting	Rhoades at al. 2011
7	6	Alcohol (36.2) Sedatives (48.6) Heroin (26.1) Methadone (13.7) Cannabis (39.9) Cocaine (41.3)	Sedative Opioid Cannabinoid Stimulant	Frequent	Oral Intravenous Smoking Snorting	Guillen et al. 2020
8	7	Alcohol (44.2) Heroin (15.4) Prescription opioid (25.8) Crack cocaine (46.9) Cocaine (11.5) Methamfetamine (20.8)	Sedative Opioid Stimulant	Frequent	Oral Intravenous Snorting	Riley et al. 2015

9	6	Alcohol (44.4) Sedatives (11.2) Prescription opioids (12.5) Heroin (16.7) Cannabis (34.6) Un-specified SCRAs (5.4) Cocaine (24.7) Prescription stimulants (3.8) Methamfetamine (4.8) Inhalants (1.6) Un-specified Hallucinogens (4.5)	Sedative Opioid Cannabinoid Stimulant Hallucinogen	Frequent	Oral Intravenous Smoking Snorting Inhaling	Doran et al. 2018
10	3	SCRAs	Cannabinoid	Frequent	Smoking	Gray, Ralphs and Williams 2020
11		NR	NR	Occasional	NR	Johnson and Fendrich 2007
12	2	Alcohol (92.5) Cannabis (85.0)	Sedative Cannabinoid	Occasional	Oral Smoking	Tyler and Johnson 2007
13	1	Alcohol (41.7)	Sedative	Frequent	Oral	Torchalla et al 2014

14	10	Alcohol (52.9) Benzo's (6.2) Heroin (29.5) Methadone (6.2) Prescription Opioids (16.6) Cannabis (41.5) Amphetamine (4.7) Crack cocaine (57.5) Cocaine (20.2) Methamfetamine (9.8)	Sedative Opioid Cannabinoid Stimulant	Frequent	Oral Intravenous Smoking Snorting	Torchalla et al. 2011
15	9	Alcohol (59.5) Unknown sedatives (3.6) Heroin (9.1) Cannabis (34.1) Amfetamines (8.2) Cocaine (44.7) LSD (4.8) PCP (6.4)	Sedative Opioid Cannabinoid Stimulant Hallucinogen	Frequent	Oral Intravenous Smoking Snorting	North et al. 2007
16	11	Un-specified SCRAs (100)	Cannabinoid	Frequent	Smoking	Barnett and Owusu 2017
17						Palepu et al. 2013

18	7	Alcohol (18) Heroin (15) Cannabis (49) Crack cocaine (27) Amfetamines (8)	Sedative Opioid Cannabinoid Stimulant	Frequent	Oral Intravenous Smoking Snorting	Palepu et al. 2012
19	1	Alcohol (100) SCRAs- Spice/K2 (100)	Sedative Cannabinoid	Frequent	Oral Smoking	Shahbaz et al. 2018
20	2	Alcohol SCRAs - Spice/K2 Cocaine	Sedative Cannabinoid Stimulant	Frequent	Oral Smoking Snorting	Torres and Espiridion 2020
21	1	Alcohol (16.63)	Sedative	Frequent	Oral	Tsia, Wesley and Rosenheck 2014
22	5	Alcohol (60.91) Sedatives (1.73) Heroin (9.69) Cannabis (27.40) Crack cocaine (11.48) Cocaine (17.91) Amfetamines (4.5)	Sedative Opioid Cannabinoid Stimulant	Frequent	Oral Intravenous Smoking Snorting	Miller-Archie et al. 2019
23	2	Alcohol (7.5)	Sedative Opioid	Frequent	Oral	Yamamoto et al 2019
24	1	Un-specified SCRAs (28.97)	Cannabinoid	Frequent	Smoking	Joseph et al. 2019

25	5	Alcohol Tranquillisers Heroin Cannabis CNS stimulants Inhalants LSD	Sedative Opioid Cannabinoid Stimulant Hallucinogen	Frequent	Oral Intravenous Smoking Snorting Inhaling	Maremmani et al. 2015

NR: Not reported, CNS:central nervous system, LSD: lysergic acid diethylamide, SCRAs: synthetic cannabinoid receptor agonist, PCP phencyclidine

3.3.3.1. Substance use trends among the homeless population

The trends in substance use among the homeless population differed between individuals and demographics characteristics in following patterns. Between 2007 to 2011 both alcohol and cannabis were the main substances consumed and both reported in 85.71% of the evaluated studies. Alcohol prevalence however, was higher than cannabis in all but two studies and ranged between 27.6 to 100% whereas cannabis ranged between 29.7 to 85%. Cocaine and heroin both were reported from more than half of the evaluated studies (57.1%) and cocaine (11.9 - 44.7%) more prevalent than heroin (7.48 - 29.5%). Amfetamine, crack cocaine and methamfetamine were all reported in three studies each, but the prevalence of crack cocaine significantly dominated over both amfetamine and methamfetamine.

Again, alcohol consumption was the most prominent substance abused in the homeless population. Heroin consumption however increased between 2012 -2016 and surpassed cannabis and cocaine. Heroin prevalence remained relatively low (15 – 19.04%) similar to 2007 – 2011. Although cannabis, cocaine and crack cocaine were reported less frequently between 2012 – 2016 the prevalence of all three remained similar to the prevalence that was reported between 2007 – 2011.

Again, alcohol consumption was prominent in the homeless population. The data shows that there is generally, in each time frame, a clear, and over the past ten years consistent, substance that dominates the homeless population. Notably, the prevalence of each substance does not differ significantly between timeframes and only differs between how many studies reported the substance being consumed. However, what is captivating is the recent emergence of SCRAs being consumed among individuals in the homeless population. A total of six studies (54.5%) reported the use of SCRAs among the homeless population between 2017 – 2020 but had not been previously reported prior to 2017 (Barnett and Owusu 2017; Doran et al. 2018; Shabaz et al. 2018; Joseph et al. 2019; Gray et al. 2020; Torres and Espiridion 2020). The recent emergence of SCRAs has seen cocaine consumption increase and crack cocaine decrease between this time frame. However, although cocaine increased and crack cocaine decreased the recorded prevalence of both substances did not differ significantly from the two other timeframes.

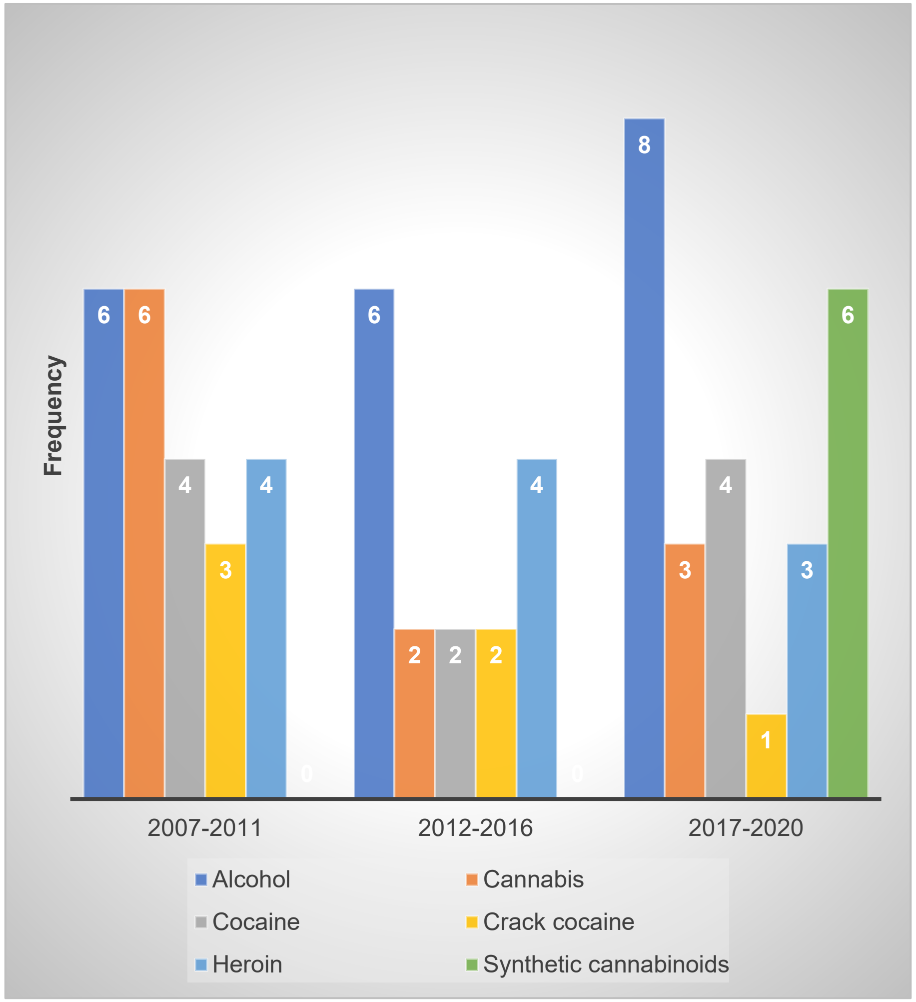


Figure 3.2 Substance use trends among the homeless population

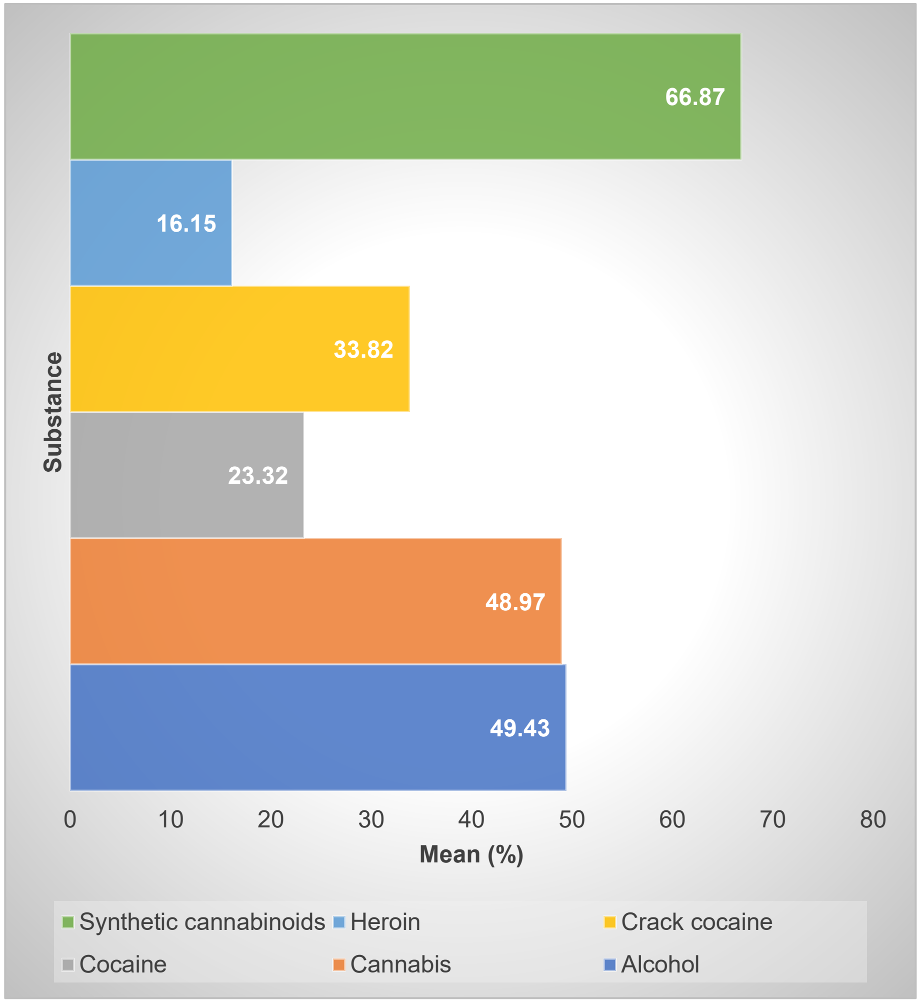


Figure 3.3 Mean prevalence of substances used in the homeless population

Figure 3.2 shows substance use trends and reported frequency of each substance in the evaluated publications. As previously discussed, Figure 3.2 shows a substantial increase in publications regarding SCRAs use in the homeless population. Figure 3.3 shows the mean prevalence of substance use among the homeless population. As shown in Figure 3.3 SCRAs are the most prevalent substance with an average of two-thirds of the population using these substances in publications that report their use. The prevalence of alcohol and cannabis were similar, and both reportedly consumed by 50% of population. The prevalence of crack cocaine was reported from one-third of the population but was less frequently reported in evaluated publications in this review than heroin and cocaine. The mean prevalence of both cocaine (23.32%) and heroin (16.15%) were both significantly lower than the previous aforementioned substances.

3.3.4. Causes and risk factors

Fourteen studies explored the relationship between homelessness and drug dependency. Unsurprisingly, alcohol was the most frequently reported substance the homeless population depended on. Across all studies males had higher prevalence of drug dependency that examined both genders. Niesler (2019) elaborated this further and reported that women were significantly less likely to have at-risk drinking problems than males. Drug dependency for males ranged between 24.7 – 82.8% and females between 8.57 – 82.4% and was classified according to the diagnostic tool that the researcher had chosen (e.g., ICD or DSM). Furthermore, drug dependency was not the only risk factor to substance misuse and other researchers in this review reported a variety of associated risk factors. Among the homeless population residing at shelters, Tyler and Johnson (2007) found that 90% had experienced physical violence/abuse prior to homeless and one-third experienced sexual abuse during homelessness, namely but not exclusively, females. Riley (2015) reported that women who consume stimulants were more likely to have suffered sexual abuse prior or during homelessness, elaborating the dangers homeless individuals can experience. Wenzel et al (2009) reported that older homeless women were more likely to binge drink and consume cocaine than younger homeless women. Similarly, drug users were more likely to present mental health symptoms. Experience of rough sleeping was linked with persistent disorder. North et al (2007) found in a sample of homeless individuals residing in a shelter who consumed cocaine could not obtain housing. The dangers associated with homelessness and substance use were profound and more than 70% of women who were addicted to drugs had attempted suicide. Doran (2018) reported than almost half of opioid users had experienced an overdose and the use of heroin and cocaine increased periods of homelessness. However, all these risk factors were associated with traditional drugs such as cocaine, cannabis and heroin and not new psychoactive substances, which have seen a recent emergence among the homeless population.

A number of risk factors were associated with synthetic cannabinoid consumption namely due to the high prevalence and unknown chemical composition. Gray, Ralphs and Williams (2020) found that 95% of street dwelling homeless in Manchester were users of the synthetic cannabinoid, Spice. The high prevalence of Spice among the homeless population is suggested to only occur in vulnerable populations and most users stated they had not known of their existence prior to homelessness (Barnett and Owusu 2017). Nonetheless, the consumption of Spice resulted in serious health consequences and increased the likelihood and duration of hospitalisation. Again, highlighting the high prevalence of synthetic cannabinoid consumption among the homeless population was elaborated in research conducted by Joseph et al (2019) where 84.54% synthetic cannabinoid emergency department (ED) visits were from homeless individuals. Shabaz et al (2018) reported that synthetic cannabinoid consumption led to acute kidney damage lasting a total of eight days. Moreover, another hospital case report reported that increased Spice use resulted in persistent asthma.

Table 3.5 Risk factors associated with substance use in the homeless population

Study number	Drug dependency (Y/N)	Drug dependency (%)		Risk factors	Reference
		Male	Female		
1	Y - 27.34	32.07	19.05	Women were significantly less likely to have at risk drinking (27.6% vs 44.7%) report having a history of problems with alcohol (26.6% vs 46.1%) and past 6-month alcohol abuse/dependence (19.1% vs 32.1%) relative to men.	Neisler et al. 2019
2	Y - 28.41	33.23	20.3	Alcohol dependant individuals were more likely to suffer from food insecurity	Reitzel et al. 2020
3	Y - 13.33	24.76	8.57	Homeless drugs users had a 94% chance of having depression than non-drug using homeless	O'Brien et al. 2015
4	Y - 61.1	62.4	58.33	Homeless individuals who sold their blood/plasma for money were 13 times more likely to abuse alcohol	Gomez, Thompson and Barczyk 2010
5	4.3	N/A	4.3	Older women had increased odds of binge drinking, using crack cocaine and cocaine but decreased odds of consuming amphetamine.	Wenzel et al. 2009
6	NR	NR	NR	Hispanic males were nearly 8 times more likely to use crack cocaine than Caucasian males	Rhoades at al. 2011
7	19.6	NR	19.6	More than 70% of women who were addicted to drugs attempted suicide	Guillen et al. 2020
8	N	NR	NR	Women who had experienced sexual violence were more likely to consume stimulants	Riley et al. 2015
9	51.4	NR	NR	Almost half (44.6%) of current opioid users had experienced an overdose.	Doran et al. 2018
10	NR	NR	NR	Street homeless in Manchester are reported to have a high prevalence of synthetic cannabinoid consumption, Spice (95%)	Gray, Ralphs and Williams 2020
11	Y - 15.1	NR	NR	Homelessness experiences before 19 years old were 66% more likely to consume drugs	Johnson and Fendrich 2007

12	Y - 75.0	NR	NR	The majority of homeless drugs users had experienced physical abuse (90.0%) and 32.5% experienced sexual abuse.	Tyler and Johnson 2007
13	Y - 82.6	82.8	82.4	Females had a significantly higher prevalence of PTSD (28.0% vs 15.5%) than males. Females also had a high prevalence of SUD-PTSD comorbidity (24.9% vs 14.9%)	Torchalla et al 2014
14	82.4	NR	82.4	Women under the age of 35 years old were more likely to abuse drugs than women older than 35 years old	Torchalla et al. 2011
15	Y - 76.6	NR	NR	Lack of housing was associated with cocaine use	North et al. 2007
16	Y - 50.0	NR	NR	Most users starting using synthetic cannabinoids when they moved into the shelter and did not know of their existence prior	Barnett and Owusu 2017
17	N	NR	NR		Palepu et al. 2013
18	29%	NR	NR	Daily substance users had a higher chance of mental health problems (3.67)	Palepu et al. 2012
19	Y - 100	100	NR	Acute liver injury induced from synthetic cannabinoids Spice/K2. Eight day recovery for alanine transferase, aspartate aminotransferases and bilirubin.	Shahbaz et al. 2018
20	Y - 100	NR	100	The self reported use of cannabis and Spice/K2 to stimulate appetite induced persistent asthma.	Torres and Espiridion 2020
21	NR	NR	NR	Caucasian veterans were more likely to to consume only alcohol than use substances	Tsia, Wesley and Rosenheck 2014
22	NR	NR	NR	Homeless individuals placed into supportive housing were less likely to visit the ED for SUD than individuals who were not selected for the program (26% vs 32%)	Miller-Archie et al. 2019
23	Y - 16.6	NR	NR	Caucasian homeless females experienced the highest rate of opioid overdose	Yamamoto et al 2019

24	NR	NR	NR	84.5% of synthetic cannabinoid ED case's were from homeless individuals, highlighting the high consumption among homeless individuals	Joseph et al. 2019
25	NR	NR	NR	two-thirds of male substance users had bipolar depression (66.7%)	Maremmani et al. 2015

NR: Not reported, ED: emergency department, SUD: substance use disorder

3.3.5. Adverse events

Among the homeless population a variety of physical and psychological issues were reported from the studies evaluated. In total sixteen studies explored the relationship between homelessness and substances use and the underlying physical and psychological issues. Physical adverse effects were reported less frequently than psychological issues but were more longer-lasting and life-threatening. Two studies examined the physical effects associated with injection drug-use and reported that 28.9% of participants were infected with Hepatitis C (O'Brien et al 2015) and 49.5% HIV positive (Riley et al 2015). Among synthetic cannabinoid users' nausea and vomiting were common side effects and had been experienced by the majority of users (50- 100%). Torres and Espiridion (2020) stated that one-third of synthetic cannabinoid users that visited the ED had symptoms of hypokalemia and when untreated usually results in vomiting and diarrhea. Therefore, a strong relationship between synthetic cannabinoids and gastrointestinal side effects was identified. However, adverse events affecting the cardiovascular, nervous, renal and respiratory systems were also recognised. Research conducted by Torres and Espiridion (2020) discovered that a third of synthetic cannabinoid users used them to stimulate appetite but found a relationship between increased Spice use and moderate persistent asthma. Alcohol related adverse events that were reported included depression, eating disorder, mood disorder, psychotic disorder and PTSD. It was difficult to determine specific adverse events for some substances as effects were generalised.

Seven of the studies used a full psychiatric interview to diagnose individuals according to DSM, ICD-10/11 or MINI criteria. The remaining studies relied on participants to self-report their psychological conditions. Participants from fourteen studies (56%) reported mental health issues compared to only seven reporting physical health issues. Depression (n=8, 57%), PTSD (n=4, 28%) and psychotic disorder (n=4, 28%) were the most common mental health symptoms reported among the homeless population in this review. Other psychological disorders reported included eating disorders (n=2, 14%), mood disorder (n=2, 14%), schizophrenia (n=2, 14%), childhood trauma (n=2, 14%), manic disorder (n=2, 14%), anxiety (n=1, 7%), attempted suicide (n=1, 7%) and panic disorder (n=1, 7%).

Some researchers have also begun to investigate whether certain types of psychological disorder, such as PTSD appear to worsen or are triggered by homelessness and substance abuse. These studies suggested that homeless individuals were vulnerable to trauma prior to homelessness and homelessness triggered and worsened the underlying issues. For example, Tsia, Wesley and Rosenheck (2014) found that in a sample of homeless war veterans, substance use and victimization during homelessness triggered PTSD in 28.97% participants.

Among homeless individuals residing on the streets, Gray, Ralphs and Williams (2020) found that 95% had consumed Spice. Fully aware of the risks they presented and deaths connected to SCRAs, individuals reported losing consciousness up to four times in one week after using SCRAs requiring emergency treatment. Homeless individuals also believed that sleeping rough aggravated their mental health problems and were addiment their mental health issues were not present prior to their SCRAs use. However, similar to traditional drugs, psychological problems such as depression, psychosis, paranoia and anxiety were linked with SCRAs consumption.

Collectively, these findings indicated a reciprocal relationship, whereby substance use often accompanies homelessness and increases the risk of physical and psychological conditions. Homelessness, in turn, appears to both compound substance use as well as increase the risk of adverse effects occurring.

Table 3.6 Adverse events associated with substance use

Study number	Physical	Psychological	Social harm	Reference
1	NR	NR	Only five percent of the homeless population were ready to change their levels of alcohol use.	Neisler et al. 2019
2	NR	Eating disorder (78.41)	Alcohol dependant individuals were less likely to engage in interventions than heavy alcohol users	Reitzel et al. 2020
3	Gastro-intestinal tract disorders (26.66) Skin problems (52.38) Hepatitis C (28.86) Deep vein thrombosis (21.9)	Depression (76.19) Schizophrenia (13.33)	Current drug users were four times more likely to have a reported poorer perceived quality of life compared to non-drug users.	O'Brien et al. 2015
4	NR	NR	There is a 26% chance that an individual will use drugs and a 36% chance an individual will abuse drugs if their street friends use drugs regularly.	Gomez, Thompson and Barczyk 2010
5	NR	Depression (55.33)	Two-thirds of drug using homeless individuals were in prison prior to homelessness	Wenzel et al. 2009
6	NR	PTSD (42.85) Depression (18.64)	Twenty percent of homeless participants had served in the military	Rhoades at al. 2011

7	NR	Psychological abuse (83.3) Physical abuse (35.9) Sexual abuse (33.4) Attempted suicide (50.3)	Childhood trauma was linked with increased likelihood drug dependency	Guillen et al. 2020
8	HIV positive (49.6)	Manic episodes (23.0) Major depression (66.0) Schizophrenia (18.3) Experienced sexual violence (9.7) Experienced physical violence (27.2)	The use of stimulants in women is significantly higher in women who have experienced sexual violence	Riley et al. 2015
9	Physical health fair or poor (53.7)	Mental illness diagnosis (58.6)	Cocaine and heroin consumption increased periods of homelessness	Doran et al. 2018
10	NR	Depression (23.4)	Spice was associated with decreased opioid use	Gray, Ralphs and Williams 2020
11	NR	NR	Drug use at 18 years old or younger was associated with earlier episodes of homelessness	Johnson and Fendrich 2007
12	NR	NR	22.5% of homeless drugs users pathway into substance use was due to a family member	Tyler and Johnson 2007
13	NR	PTSD (73.0) Depression (13.77)	Females with PTSD were nearly 7 times more likely to be a high risk of suicide than males without PTSD	Torchalla et al 2014

14	NR	Childhood trauma (83.3) Attempted suicide (50.3)	Women under the age of 35 years old were more likely to abuse drugs than women older than 35 years old	Torchalla et al. 2011
15	NR	NR	Not able to maintain housing due to cocaine use.	North et al. 2007
16	Nausea/Vomiting (50) Aggression (50) Dry mouth (38) Hallucinations (38) Increased appetite (38) Light-headedness (38) Fatigue (25) Chest pains (25)	Anxiety (25.0) Mood disorder (67.0) Psychotic disorder (38.0)	Most users starting using synthetic cannabinoids when they moved into the shelter and did not know of their existence prior	Barnett and Owusu 2017
17	NR	PTSD (22)	Males were more likely to relapse after rehabilitation	Palepu et al. 2013
18	NR	Manic episodes (20) PTSD (26) Panic disorder (21) Mood disorder (17) Psychotic disorder (53) Multiple mental disorders (48)	Being single and not in a relationship was associated with lower mental health symptoms	Palepu et al. 2012
19	Vomiting (100) Epigastric abdominal pain (100)	NR	Synthetic cannabinoid consumption was associated with increased medical treatment following hospitalisation	Shahbaz et al. 2018

20	Influenza Hypokalaemia Moderate persistent asthma	Eating disorder	Synthetic cannabinoids Spice/K2 are used to stimulate appetite	Torres and Espiridion 2020
21	NR	Psychotic disorder (9.29) Mood disorder (57.62) PTSD (28.97) Other disorder (25.13)	Heroin use in males was associated with disengagement from service providers	Tsia, Wesley and Rosenheck 2014
22	NR	NR	Individuals placed into housing had a lower chance of hospitalisation	Miller-Archie et al. 2019
23	Congestive heart failure (2.6) Chronic pulmonary disease (8.9) Diabetes (14.5) Renal failure (4.0) Cancer (1.6)	Psychosis (5.0) Depression (4.4) Neurological disorder (5.1)	Homeless individuals had a greater number of ED and inpatient visits per person than low-income individuals.	Yamamoto et al 2019
24	NR	NR	Synthetic cannabinoid users are more likely to be homeless, young males.	Joseph et al. 2019
25	NR	Bipolar depression (47.96) Unipolar depression (52.04)	two-thirds of males had bipolar depression (66.7%)	Maremmani et al. 2015

NR: Not reported, ED: Emergency department, PTSD: Post-traumatic stress disorder. Numbers in brackets are percentages (%).

3.4. Discussion

To our knowledge, this is the first systematic review to investigate the prevalence, motivations and effects of substance use among individuals from the homeless population. Two other reviews were reported in literature in relation to substance use prevalence among the homeless population. The first review was conducted by Aldridge et al (2018) and explored substance use disorders and associated mortality among the homeless population but did not look into prevalence of NPS use and motivations. The second review conducted by Heerde and Hemphill (2014) investigated substance use and sexual victimisation among vulnerable populations. This systematic review contributed to the findings of the previous two reviews by going beyond substance use and its associated harm among the homeless in two ways: (1) this review is more specific to the homeless population experience rather than looking in general at marginalised populations and thus it gives more in-depth information about their experience with substance use. (2) Further determined the prevalence and pharmacological classes of substances' used and their corresponding trends. More specifically the overall findings of this systematic review encaptured the substance use trends and emphasised the emergence of NPS, namely SCRAs being consumed in the homeless populations.

Overall, the results from this review showed that the homeless population is majority male and of Caucasian ethnic background. Moreover, substance use prevalence among the homeless population remains high where alcohol is the most popular substance used. What this review captured that is of academic importance is the emergence of SCRAs since 2017 and shows the change in substance use among the homeless population. Although SCRAs have been documented in local and national studies this is the first review to capture a change in substance use at an international level for individuals from the homeless population (Macleod et al. 2016; Irving 2017: Ralphs et al. 2021).

Consistent with most of the research conducted into the homeless population males were more prevalent than females, more likely to be unemployed and achieved lower levels of education. Ethnic backgrounds reported were consistent when compared to the respective nationality. For the US, African American and Caucasian were the two most prevalent ethnic backgrounds reported and dominated the homeless population in the US (Census 2020). When comparing research conducted by other US researchers African American and Caucasian ethnic backgrounds were the two most frequently reported but would differ between the state the researcher conducted the study (Taylor et al. 2018). African Americans were more prevalent in Los Angeles, New York and Washington DC whereas Caucasians more prevalent in Texas, Oklahoma and

Nebraska. Researchers conducting research into the aforementioned locations have reported consistent population demographics for the different ethnic backgrounds in these locations for the homeless population (Census 2020; Taylor et al. 2018). For the UK and Spain ethnic backgrounds were predominantly Caucasian and is consistent with researchers (Platt and Nandi 2018; Demeter and Goyanes 2020).

The findings of this systematic review suggested that substance use among the homeless population had a high prevalence that had a rate of more than 50% in most studies. Alcohol was the most popular substance used by individuals experiencing homelessness followed by heroin. This result confirmed the outcomes of other studies that showed alcohol was the most reported substance used by the homeless population and is likely due to its legal status worldwide (Grazioli et al. 2015; Dyb 2016; Khezri et al. 2020). Moreover, the trends in substance use showed that new drug compounds, namely SCRAs have entered the drug market and are currently being abused by the homeless population. Although synthetic cannabinoids have been used and abused by the general population since 2007 (Sumnall 2009), the consumption of the compounds in the homeless population has only been reported in literature since 2017 (Irving 2017).

The documented emergence of SCRAs being used among the homeless population could be due to decrease in drug purity since 2014. It is noteworthy to mention that the period prior to 2014 witnessed an increase in drug purity (DEA, 2019). For example, 2009 -2014 period saw increase in heroin purity from 23 – 39%. However, after 2014 heroin purity decreased by 5% and price per gram nearly doubled (Stam et al. 2018; DEA 2019). These changes are contrary to trends observed for other illicit drugs at retail, where increased supply by traffickers and demand by users normally leads to parallel decreases in price and increase in purity (Rosenblum et al. 2014). The change in heroin purity and price over the past five years led to homeless individuals seeking alternatives, and with synthetic cannabinoids being described as stronger than heroin, more addictive and substantially cheaper their use among the homeless population is now desirable (Macleod et al. 2016).

Few studies in this review reported toxicity associated with substance use. This could be attributed to the fact that most of the included studies were cohort and cross-sectional studies of the prevalence of substance use, and not toxicity. Among the studies that reported toxicity, SCRAs were most frequently associated with neurological and cardiovascular toxicity. This is most likely due to the included studies reporting SCRAs use were case reports of toxicity. Among the studies that reported toxicity, neurological and cardiovascular adverse effects were associated with SCRAs consumption. Despite the few studies that reported toxicity associated with substance use, adverse drug events were accompanied with substance use and included both physical and neuropsychiatric symptoms. Common cases involved PTSD and psychotic breakdown. In severe cases, ADRs led to suicidal ideation and eventually, attempted suicide. Lethal effects were also seen with accidental overdose when using opioids. This could be critical in the current changing scenario of drug abuse where multiple factors play a role in the safety of drugs.

3.4.1. Strengths and limitations

This research involved identify the prevalence, risk factors and effects of substance use among individuals from the homeless population. The results showed that alcohol is the most used and abused substance among the homeless population and documented the emergence of NPS since 2017. Moreover, the associated risk factors and adverse events for the different substances was investigated.

Due to the limited number of studies available, it was not possible to get the prevalence of substance use among the homeless population per country. Major information was missing regarding demography of participants, first time using substances, and the scene where the drugs were consumed, which influenced the understanding of the prevalence of substance use among the homeless population. The substance used from participants also could not be confirmed as the studies used in this review did not use any chemical testing to identify the substance. Furthermore, it was not possible to establish causality between substance and effect and was due to when subjects were reported to emergency department, only one study reported confirmatory testing on blood and urine. Instead, physicians treated symptoms and then discharged patients when the symptoms had worn off. No studies reported severity and preventability.

3.5. Conclusion

Overall, this systematic review showed substance use trends among the homeless population between 2007 to 2020. Not only did this review document substance use trends but also highlighted the emergence of NPS among the homeless population. The systematic review revealed that the use of NPS was predominantly occurring in the homeless population and almost all SCRA hospital admissions were individuals experiencing homelessness. In summary, the majority of the homeless population were males of Caucasian or African American decent. Traditional drug compounds such as alcohol, cannabis, cocaine and heroin still remain popular among the homeless population. However, NPS have become popular among the homeless since 2017 and were associated with physical and psychological harm. Substance use was more reported in males than females and in both cases it attributed to mental and physical health problems. Mental health problems associated with substance use were depression anxiety and PTSD. Physical health problems were attributed to multiple organ damage including the nervous, cardiovascular, renal and respiratory systems. The emergence of NPS among users from the homeless population has seen a decrease in alcohol, heroin, and crack cocaine prevalence. This urges the need to develop research in the area of homelessness and new psychoactive substances in order to increase awareness among health care providers, social workers, governmental agencies and academics.

Chapter 4. Knowledge and experiences of NPS among the homeless population

4.1. Introduction

Responding to concerns about rising harms associated with NPS use, on May 26 2016, the UK Government brought into force the Psychoactive Substances Act for the purpose of protecting the public, and in particular young and vulnerable populations, from the health threat posed by NPS. The PSA (2016) placed a blanket ban on all psychoactive substances unless exempt including caffeine, nicotine, tobacco and food products. The Act also does not make it unlawful to use or possess an NPS, but prohibits the sale, importation and exportation with the aim of removing availability and visibility of NPS. The Home Office has identified that the consumption in the adult population has considerably reduced since the PSA (2016), mainly driven by the reduction of use among those aged 16 to 24 years old. The prevalence of NPS among vulnerable populations appear to be different, with evidence that the NPS use remains the same and has been unaffected by the PSA (2016), especially in the homeless population (Home Office 2018).

As a population, a majority of homeless individuals report neglect, physical, and/or sexual violence before becoming homeless and pre-homelessness challenges in the form of school-related adversity, family breakdown, poor mental health, and juvenile criminal justice and child protection involvement (Roy 2004; Van den Bree et al. 2009). The challenges this population are faced with increases the risk of incarceration, substances misuse, needle sharing and becoming HIV positive. Problem drug using among this population has been extensively documented in scientific literature. The challenges exposed to when faced with homelessness can lead to substance misuse, and substance misuse can lead to homelessness (Doran et al. 2018). Homelessness and substances use often coexist, resulting in high morbidity. Estimates of substance use among people experiencing homelessness vary depending on the population studied and definitions used but are consistently above average (Bonevski et al. 2013; Krupski et al. 2015).

Although the high prevalence of traditional drugs (heroin, cocaine, crack cocaine and cannabis) has been extensively documented (Fazel et al. 2008; Baggett et al. 2013; Linton et al. 2013), new psychoactive substances (NPS) have become an increasing risk to this population (Home Office 2018). NPS are a group of chemically diverse compounds designed to mimic the effects of drugs of abuse but avoid international control. The emergence of these compounds has been documented and reported from the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and United Nations Office on Drugs and Crime (UNODC) since 2005 and was continuous until December 2018 where 888 substances had been reported to the UNODC Early Warning Advisory (EWA) (UNODC 2019). The rate of emerging NPS increased annually from 2005 until 2014 where 101 substances were reported to the EMCDDA between January to December 2014 (EMCCDA 2015). Despite the reported high prevalence of illicit drug consumption among the homeless population compared with the general population, little information is available about the consumption of NPS among the homeless population. While research has been published estimating that over 70% of the homeless population have consumed NPS (Macleod et al. 2016), research is lacking in uncovering the experiences among users from this vulnerable population. The purpose of this study was to explore the knowledge and experiences of the homeless population who use NPS to uncover demographic characteristics, NPS consumption, motivations and desired and adverse effects.

4.1.1. Research aims and objectives:

Semi-structured questionnaire completed by homeless NPS users formed the second stage of the research with the aim to understand the attributes of the UK homeless population and the associated issues with their NPS use. This allowed the knowledge and experiences of the homeless population to emerge as this information has been missing from research into NPS and homelessness.

4.2. Method

Semi-structured questionnaire completed by homeless NPS users formed the second stage of the research with the aim to understand the attributes of the UK homeless population and the associated issues with their NPS use. This allowed the knowledge and experiences of the homeless population to emerge as this information has been missing from research into NPS and homelessness.

4.2.1. Questionnaire design and settings

Questionnaires are one of the many methods for data collection in social research (Rockwood et al. 1997). The different types of questionnaires considered were self-administered, group-administered and/or postal questionnaire. Each has their own advantages and disadvantages and the final choice of questionnaire was appropriate to the purpose of the research topic (Oppenheim 2009; Saris and Gallhofer 2014). After careful consideration of the advantages and disadvantages of each type, the development of a semi-structured postal questionnaire that would be self-administered was decided to be most appropriate for this research in the homeless population (Table 4.1).

Table 4.1 Advantages and disadvantages of different questionnaire types

Questionnaire type	Advantages	Disadvantages
Group-administered	• Control over completing questionnaires • Researcher available to clarify instructions and misinterpretations of questions • A large number of questionnaires can be completed in a short amount of time	• Risk of contamination of answers • The presence of the researcher could affect responses due to intimidation
Postal-questionnaire	• Low cost • Avoidance of interviewer bias • Ability to reach participants who live at widely dispersed addresses	• Low response rate • No control over the order of questions answered • No opportunity to correct misunderstandings • Unsuitable for participants with poor literacy • No opportunity to collect ratings based on observations
Telephone	• Answers to questions are recorded	• Coverage error

	• Most individuals/families have a telephone in developed countries	• Not enough complete responses to make the results generalisable
Web-based	• Easy for researchers to develop and participants to use • Low cost • Results can be reported quickly	• Large number of households globally not connected to the internet • Population dependant

Limitations from the systematic review aided the design of the questionnaire. The previous study showed that NPS user characteristics and motivations behind using NPS were not identified. Hence, questions included in the questionnaire were designed to further investigate findings emerging from the previous study; evaluating the prevalence and use of NPS among the homeless population. Questions were asked to uncover sociodemographic characteristics to obtain information about the participants in the sample. Additionally, questions were also designed to further investigate the regarding NPS uses, motivations behind using NPS and the effects associated with NPS consumption.

Table 4.2 Themes and criteria explored in the questionnaire

Theme	**Criteria**
Sociodemographic characteristics	• Age • Sex • Sexual orientation • Duration of homelessness • Sleeping location • Occupation before homelessness • Contact with family
NPS consumption	• Consumption of NPS • Name of NPS consumed • Dose consumed • Route of administration

	• Onset of action • Duration of effects • Purchase location • Dose purchased
Motivations behind consuming NPS	• Reason for using NPS • Additional drugs consumed • Impact of PSA 2016
Desired effects	• Positive effects • Enjoyment from NPS • NPS used for pain relief
Adverse events	• Negative effects • Negative effect experienced • Duration of negative effects • Requirement of medical treatment • Duration of medical treatment • NPS used to treat mental health • Impact of NPS consumption • Drug support

The questionnaire consisted of five areas being sociodemographic characteristics, NPS consumption, motivations behind using NPS, desired effects and adverse events. The funnel approach to question layout and semi-structure design allowed participants give the freedom of opinion and understand ‘why’ the questions were being asked.

4.2.2. Sampling

Charities and support organisations throughout the UK (n = 65) that work with the homeless population were identified and contacted via email with information about the study aims and details. Out of the 65 organisations, 16 agreed to participate in the research. Then each charity and/or support organisation manager was contacted via phone to advise (Table 4.3) on what the details of the research procedure, inclusion/exclusion criteria and any information that is required for the participants. The questionnaires were sent through the post and self-administered to participants at each charity and/or support organisation. Homeless people residing in four countries

(England, Wales, Scotland and Northern Ireland) were sampled. The questionnaire was distributed to the homeless population (completed questionnaires – 105) and a response rate of 16.15% (105/650*100). The participants read the instructions themselves and centre managers also explained the research and offered support for those with poor literacy.

Table 4.3 Charities and support organisations that agreed to participate in the study

Charity number	Location	Participants invited	Completed questionnaires	Response rate (%)
C1	Liverpool	60	18	30.0
C2	Chelmsford	60	16	26.7
C3	Belfast	40	13	32.5
C4	Edinburgh	75	11	14.7
C5	Bournemouth	70	10	14.3
C6	Cardiff	50	10	20.0
C7	Glasgow	85	9	10.6
C8	Belfast	25	7	28.0
C9	Swansea	55	5	9.1
C10	Bournemouth	80	4	5.0
C11	Bournemouth	80	4	5.0

4.2.3. Participants' recruitment and selection

It was not possible to generate a random sample of the homeless people due to the lifestyle of these populations (Kidd et al. 2019). Instead, common with other major studies involving homeless population, a convenience sample was gathered, with anyone consenting to take part between the ages of 18 – 64 years old included in the sample (Smith 2010). A total of 65 charities were invited to participate in the research across the UK (England, Wales, Scotland and Northern Ireland), 49 declined to participate either by not having the staff to facilitate questionnaire dissemination or their service users were not allowed to use their facilities if they were drugs users. Sixteen accepted the invitation, however, five charity organisations were unable to facilitate questionnaire dissemination due to homeless individuals not giving consent.

Figure 4.1 Map of the UK and locations of the charities that completed questionnaires (stars)

4.2.4. Ethical approval

In compliance with Bournemouth University Codes of Research Practice (2019), BU Research Ethics Code of Practice (2019), and the Code of Good Research Practice (2019) ethical approval was granted (ID 27076). As this study involves examining health-related information, the ICH/WHO (1997) Good Clinical Practice Standards and the World Medical Association Declaration of Helsinki (1964) was considered in terms of respecting the public health privacy. The Data Protection Act (2018) was also regarded for the protection of participant information, ensuring complete anonymity of their data.

4.2.5. Data collection

Physical copies of the questionnaire were sent to charities and support organisations where participants were invited by the shelter managers to complete the questionnaire manually. Ensuring the reliability of typed data, 10% of the questionnaires were anonymised and sent to two of the research supervisors (SA and TG) to blindly check what is typed. The researchers and both supervisors compared the answers among themselves. The degree of agreement was assessed by calculating the inter-rater reliability achieving a kappa coefficient of 0.967 (Cohen 1960).

Initially, a pilot study was conducted, and questionnaires were distributed to three homeless shelters in Bournemouth and participants were invited to complete them manually. The pilot study yielded 21 complete questionnaires. Within questionnaires, homeless people were provided with space to write their views and comments regarding the questionnaire. Then, the questionnaire was modified and changed to suit the population. Conducting the pilot study enabled us to identify any issues or confusion for participants when completing the questionnaire. The addition of three new questions to the questionnaire were included and removal of one question to avoid confusion for participants. Before disseminating the questionnaire for the main study, the data was discussed with beneficiaries (charities, support organisations and the general public), that in turn confirmed the importance of the study.

4.2.6. Data analysis

The data were returned in the form of completed questionnaires and were transcribed verbatim into Online Survey and imported into SPSS v26 for descriptive statistical analysis. After the data had been imported into the data was coded into categories and were subjected to descriptive statistical analysis in the form of numbers (n) and frequency distributions (%). Additionally, the data were subject to bivariate analysis and logistic regression to compare sociodemographic characteristics of NPS and non-NPS users and predict the likelihood of NPS consumption among different sociodemographic characteristics.

4.2.7. Validity and reliability

Validity is not a fixed or universal concept but should be viewed as a construct grounded in the processes and intentions of the research methodology (Winter 2000). Rather than adhering to principles of validity in terms of accuracy of measurement it should therefore be acknowledged that, in the present research, validity relates to the transparency of the manner in which the interpretive accounts were created and constructed with quality and appropriateness of the methodological approach to both data collection and analysis

(Heale and Twycross 2015). For the present research, construct validity was chosen and aimed to validate the approximate truth of the conclusion that the sample accurately represents the population (Creswell and Poth 2018). Findings from the study were shared with the charities/support organisations and supervisors (SA, TG and PVC) to get feedback about the validity of the results. Additionally, a pilot study was conducted and the findings compared to the main study.

Reliability refers to the consistency of a measure. A participant completing an instrument meant to measure motivation should have approximately the same responses each time the test is completed (Alwin 2013). For the purpose of this research, equivalence was decided the most reliable measure of consistency among responses of multiple users of an instrument, and in this case the questionnaire (Oppenheim 2009).

4.3. Results

4.3.1. Pilot study

The survey started in October 2018 to January 2019 as a pilot study designed and disseminated to collect the knowledge and experiences of the homeless population who are users of NPS. As this survey was the first to specifically explore the knowledge and experiences of NPS among users from the homeless population the pilot study was crucial to determine if any information or knowledge would need to be further investigated in the main study. The pilot study yielded a total of 21 participants. Tables for the pilot study are in Appendix

4.3.1.1. Demographic characteristics

All participants responded to the demography and adverse effects questions in this study. The participants who had never consumed NPS did not answer questions on NPS consumption, motivations and desired effects associated with NPS consumption. Ages ranged from 18 to 64 years old with the majority of participants being male (n=19, 90.5%), white (n=18, 85.7%) and heterosexual (n=17, 80.9%). Duration of homelessness ranged between two months to 30 years and over one-third of the participants slept on the streets. More than half had contact with their family (n=12, 57.1%).

4.3.1.2. NPS consumption

A large majority of participants (n=15, 71.4%) reported they had voluntary consumed NPS where Spice (n=11, 73.3%) was the most frequently reported. Other NPS derivatives reported were Black mamba (n=2, 13.3%) and mephedrone (n=1, 6.67%). Just under one-fifth of the participants reported doses between 0-0.1 grams with the majority of effects lasting no more than two hours (n=10). Slightly over one-quarter (n=6) reported consuming NPS daily, preferring the smoking route to administer the drugs (n=9). When purchasing the NPS compounds, shops was the most frequently reported (n=6) followed by friends (n=5) and dealer (n=3).

4.3.1.3. Motivations behind using NPS

One-third of the participants (n=7) reported they consumed NPS for treatment purposes, which could be emotional trauma, mental or physical health, but was not stated which trauma they were trying to treat. Consuming additional recreational drugs to NPS was reported by just under half of the participants (n=10), where heroin (n=4) and cannabis (n=3) were the largest identified traditional illicit drugs. Homeless individuals who consumed NPS were most motivated to start consuming NPS due to the price (n=4) over traditional abused drugs and motivated to stop due to the side effects associated from NPS consumption. Other reasons for stopping NPS included treatment (n=2) for mental or physical health, the availability of the compounds to the individual (n=1) and the change in legislation (n=1), which came into effect in May 2016 to criminalise psychoactive substances. Desired effects were reported from participants when consuming NPS products, which calming effects (n=6), only associated with Spice were the most frequently reported. Other reported desired effects included hallucinations (n=3,), alertness (n=1) and dissociation (n=1). The participant who reported alertness as a desired effect consumed mephedrone. One participant reported to using Spice for self-treatment to relieve pain in their spine.

4.3.1.4. Adverse events

A total of 15 (71.4%) participants reported adverse events that were associated from NPS consumption and six did not. The nervous system was the most common affected system within the body followed by the cardiovascular system after consuming NPS compounds. The negative responses to the drugs led to nine different adverse effects reported from participants including psychosis (20%), hallucinations(13.3%), loss of motor control (13.3%), anxiety (6.67%), memory loss (6.67%), paranoia (6.67%), sedation (6.67%), tachyphasia (6.67%). Adverse effects of psychosis, memory loss, loss of motor control and anxiety were only reported from participants who used Spice, whereas, paranoia was reported from the user of mephedrone. The reported durations of adverse effects included one hour (n=5), two hours (n=6), three hours (n=1), four hours (n=2) and six or more hours (n=1). Medical treatments were required from over one-quarter of the participants (n=6) to which, one participant who used Spice reported staying in hospital for one day. Furthermore, the participant who used Mephedrone reported hospitalisation on three separate occasions. When asked to give their opinion on how widespread NPS are a total of five categories were reported by participants and included not aware of NPS (n=1), growing (n=1), widespread (n=2), very widespread (n=10) and epidemic (n=1). For receiving drug support, 17 participants reported ‘No’ they do not receive support for drug use and 4 reported ‘Yes’. Of the four participants who reported ‘Yes’ they do received support for drug use were all users of Spice and reported using the support of Charity (n=1), Drug and Alcohol Services (n=1) and Key worker (n=1). A total 16 participants reported they do not want to receive support for drug use and one participant who used Spice reported they would want to receive support.

4.3.2. Sample for the main study

After completion of the pilot study, the main survey started in January 2019 to March 2019, and data collection continued for six months. The participants of the survey were sampled in a variety of hostels, rough sleeper drop-in centres, and health clinics for homeless people. Charities and support organisations throughout the UK (n = 65) that work with the homeless population were contacted via email with information about the study aims and details. Out of the 65, 16 agreed to participate in the research. Then each charity and/or support organisation manager was contacted via phone to advise on what the details of the research procedure, inclusion/exclusion criteria and any information that is required for the participants. The questionnaires were sent through the post and self-administered to participants in each charity and/or support organisation. Homeless people residing in four countries (England, Wales, Scotland and Northern Ireland) were sampled. The questionnaire was distributed to the homeless population (completed questionnaires – 105) and a response rate of 16.2% (105/650*100). The participants read the instructions themselves and centre managers also explained the research and offered support for those with poor literacy. A total of 105 participants completed the questionnaire. All questions on sociodemographic characteristics and adverse effects were completed from all participants. Questions on NPS consumption, motivations behind consuming NPS and desired effects were reported only from the participants who had voluntarily consumed NPS products.

4.3.3. Demographic profile of participants experiencing homelessness across the UK

4.3.3.1. Demographic profile: Gender

The results showed that the majority of participants were of male gender whereas fewer were females or transgender. Of the participants, 61% were males, 34.2% female and 4.76% transgender. Figure 4.2 shows the distribution of gender per country.

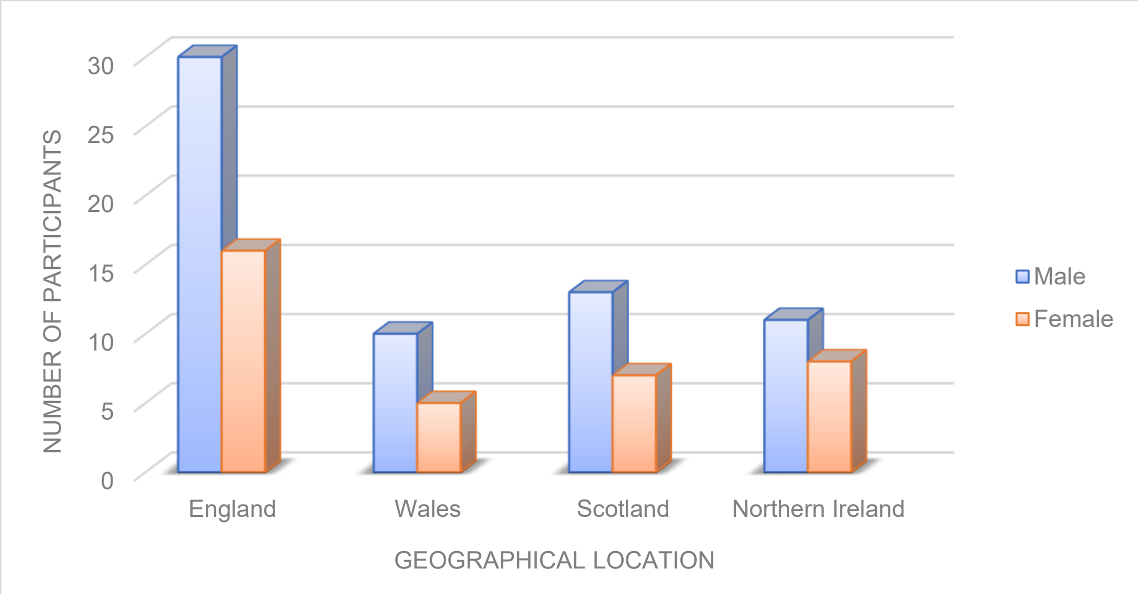


Figure 4.2 Distribution of gender per country

4.3.3.2. Demographic profile: age

The reported age of participants ranged from 18 to 64 years old. Rather than participants reporting their age, they answered to which age group they were part of and a total of seven were reported. The majority of the participants were older than 35 years old (63.0%), with 20% aged between 35 to 39 years, 25.7% aged between 40 to 49 years, 12.4% aged between 50 to 59 years and 2.86% aged between 60 to 64 years old. The remained of the sample (37.0%) were aged between 18 to 34 years old.

4.3.3.3. Demographic profile: ethnicity

Over 85% (90) of the sample was Caucasian, with other ethnic groups being represented as follows: Asian (n=11, 10.5%), Mixed Race (n=2, 1.9%) and Black (n=2, 1.9%). Males were mostly Caucasian (n=62, 93.9%) and less frequently reported ethnic backgrounds were Black (n=2, 3.03%) and Asian (n=2, 3.03%). Females were by a majority, Caucasian (n=27, 79.4%) but Asian ethnic backgrounds were also frequently reported (n=7, 20.5%). For transgender individuals Caucasian (n=3, 60%) and Asian (n=2, 40%) were reported.

4.3.3.4. Demographic profile: occupation

The Standard Occupational Classification 2010 (SOC 2010) was used as a comparator when classifying the stated occupations or previous occupations as described by the survey participants. Five categories of occupation were reported from participants. These categories were classified further into sub-categories informed by the UK Governments Standard Occupation Classification (Elias and Birch, 2010). 66 percent of the sample did not provide information on their current or previous employment and were assumed to be unemployed. The highest percentage of participants who did provide information on their occupation were classified into skilled agriculture and related trades (n=16, 15.2%) or elementary administration and service occupation (n=9, 8.57%). Other less frequently reported SOC were caring, leisure and other service occupations (n=4, 3.81%), sales and customer service occupations (n=4, 3.81%), managers, directors and senior officials (n=1, 0.95%) and transport and mobile machine drivers and operatives (n=1, 0.95%).

4.3.3.5. Demographic profile: living arrangements

92 percent provided information on their living arrangements, where the participants are categorised as 'roofless', 'houseless' or 'other homeless' as primary categories of homelessness. These categories can be further divided into sub or secondary categories such as 'hostels', 'sofa-surfing' or 'rough sleeping'. The most frequently reported locations where participants would sleep included hostel (n=43, 41%) emergency accommodation (n=32, 30.5%), streets (n=27, 25.7%), someone's house (n=25, 23.8%) and sofa-surfing (n=21, 20%). Less reported locations were parks (n=1, 1.02%), tent (n=1, 1.02%), car (n=1, 1.02%) and forest (n=1, 1.02%).

4.3.3.6. Demographic profile: Duration of homelessness

Duration of homelessness ranged between one month and up to 30 years where more than one-third were homeless for one year or less (n=46, 43.8%). Duration of homelessness was categorised into three classes: acute, intermittent and chronic homelessness. Homeless participants were classed as acute if they were homeless for less than one year, intermittent if they were homeless between 1 – 3 years and chronic if their homelessness had lasted for more than three years.

Table 4.4 Sociodemographic characteristics of the homeless participants

Demographic characteristics	**Frequency N**	**(%)**
Age (years)		
18-24	18	17.1
25-29	16	15.2
30-34	7	6.67
35-39	21	20
40-49	27	25.7
50-59	13	12.4
60-64	3	2.86
Sex		
Male	64	61
Female	36	34.3
Prefer not to say	5	4.76
Ethnicity		
White	90	85.7
Asian	11	10.5
Black	2	1.9
Mixed race	2	1.9
Sexual Orientation		
Heterosexual	79	75.2
Homosexual	8	7.62
Bisexual	11	10.5
Duration of homelessness		
0-3 months	15	14.3
4-6 months	7	6.67
7-9 months	3	2.86
10-12 months	2	1.9
1 year	19	18.1
2 years	5	4.76
3 years	9	8.57

4 years	9	8.57
5-10 years	8	7.62
10-15 years	2	1.9
15-20 years	3	2.86
>20 years	2	1.9
Location of sleep		
Hostel	43	41
Streets	27	25.7
Sofa-surfing	21	20
Emergency accommodation	32	30.5
Someone’s house	25	23.8
Tent	1	0.95
Forest	1	0.95
Car	1	0.95
Rented flat	1	0.95
Parks	1	0.95
Family contact		
Yes	60	57.1
No	45	42.9

4.3.4. NPS profile of participants experiencing homelessness across the UK

4.3.4.1. NPS profile: prevalence

Most of the participants who completed this survey had consumed NPS (n=72, 68.4%). NPS prevalence in male and female participants did not differ significantly (71.6% vs 72.7%). On the other hand, participants who identified as transgender were less likely to consume NPS (40%). It is noteworthy to mention that transgender individuals were reported less frequently than male and female. Individuals who were classed as chronic homeless were more likely to consume NPS (80.0%) than both acute (64.3%) and intermittent homeless (66.6%) suggesting that longer periods of homelessness increase the likelihood of NPS consumption.

4.3.4.2. NPS profile: derivative

A total of 72 participants (68.4%) stated that they had used NPS voluntarily. Ninety-three percent of those who reported they had consumed NPS were users of SCRAs and Spice the most popular derivative (n=60, 83.3%). Less frequently reported SCRAs were black mamba, salvia divinorum and mango exodus amnesia. In addition, stimulants were also consumed by the participants but less frequently. 11 percent of homeless NPS users in this survey consumed stimulant products and mephedrone the most reported stimulant product.

4.3.4.3. NPS profile: NPS appearance

Most of the homeless NPS users reported the drugs appearance as herbal (91.7%) followed by powdered form (n=8, 11.1%), tablets (n=5, 6.94%) and crystals (n=1,1.39%). For SCRAs products 90% of the participants reported the substance as herbal in appearance and fewer reported crystals and paper. The participant who consumed Spice on paper reported first consuming Spice in prison.

4.3.4.4. NPS profile: dose

The doses reported in this survey ranged between 0.05 – 4 grams. For SCRAs derivatives the dose's ranged between 0.25 – 4 grams and mostly consumed in doses above 1 gram (44.4%) impregnated into herbal material. Participants who consumed stimulant derivatives consumed in much lower doses ranging between 0.05 – 0.5 grams. When consuming SCRAs in joints the size of the dose was larger (0.25-1.0 grams) than bongs or pipes (0.025-0.5 grams).

4.3.4.5. NPS profile: Onset of action and duration of effects

A rapid onset of action was reported by the majority of NPS users' and was typical of SCRAs consumption. For 81.9% of NPS users the effects were experienced within five minutes after ingestion of a SCRAs, other users reported experiencing their effects 10 minutes after ingestion (11.1%) but less frequently. For stimulant NPS effects were experienced 30 minutes after ingestion but were only reported from one participant (1.39%).

The duration of the effect ranged between one to six hours with the majority of NPS users' reporting effects no more than three hours (83.3%). SCRAs consumption was associated with the aforementioned duration of effects, the stimulant user reported effects that lasted six hours, after repeated consumption.

4.3.4.6. NPS profile: Route of administration

SCRAs were smoked as herbal materials (87.5%) either in 'joints' or 'bongs' by most of the participants. SCRAs were also snorted (4.17%) and consumed orally (1.39%) but much less frequently. In total snorting was reported from more than 10% of NPS users' (n=9, 12.5%) and oral nearly 5% (n=3, 4.17%) but was reported from stimulant NPS users.

4.3.4.7. NPS profile: Frequency of NPS consumption

The majority of NPS users consumed the substances at least once per-week. Half of the homeless population who were users' of NPS were frequent consumers of SCRAs such as Spice. Daily NPS consumption was reported from nearly half of homeless NPS users' (n=29, 40.3%) and eight percent (n=8) consumed three to five days per-week. For thirty percent, NPS consumption would be considered 'social event' and would only consume NPS once per month (n=7, 9.72%) or once per year (n=14, 19.4%).

Table 4.5 NPS prevalence and profile of users from the homeless population

NPS consumption	**Frequency N**	**%**
Yes	72	68.6
No	33	31.4
NPS product		
Spice	50	69.4
Black mamba	4	5.56
Mephedrone	3	4.17
Poke	1	1.39
China white	1	1.39
Cannabis substitute	10	13.9
Salvia	1	1.39
Silly walk	1	1.39
Mango Exodus Amnesia	1	1.39

Burst	1	1.39
Blue stuff	1	1.39
AMT	1	1.39
Snow white	1	1.39
Dose consumed (g)		
0 - 0.25	12	16.7
0.25 - 0.5	7	9.72
0.5 - 1.0	3	4.17
1 - 2	24	33.3
> 2	8	11.1
Drug appearance		
Herbal	66	91.7
Powder	8	11.1
Crystals	1	1.39
Tablet/capsule	5	6.94
Duration for drug to take effect (minutes)		
< 1	42	58.3
5	17	23.6
10	8	11.1
30	1	1.39
duration of effects (hours)		
< 1	30	41.7
2	11	15.3
3	19	26.4
4	3	4.17
6	7	9.72
Route of administration		
Smoking	63	87.5
Snorting	9	12.5
Oral	3	4.17
Injection	1	1.39

Spice, cannabis substitute, Salvia, black mamba, AMT and mango exodus amnesia are all SCRAs. Mephedrone, China white, snow white, poke and silly walk are synthetic cathinone's.

4.3.5. Motivations behind NPS consumption for the homeless population

4.3.5.1. NPS motivations: Motivation behind taking NPS

There were a total of nine reasons participants were motivated to consume NPS but four were reported significantly more than the others. The most popular motivation for using NPS from the homeless population was escapism, also described as 'escaping the realities of homelessness'. Escapism was reported by almost one-third of the homeless population using NPS (27.8%) as their main reason for consumption and was only associated with users of Spice. The effects of Spice often referred as 'the high' followed second after escapism as the main motivator for using NPS. Almost twenty percent (n=13, 18.1%) reported consuming NPS for the effects. Experimentation was reported from a total of 10 participants (13.9%) and were all infrequent users of NPS consuming just once-per-year. Experimentation was also referred to as curiosity and was reported from users who were curious to try or experiment with a new compound that is desired by many others in their social groups. The use of NPS for treatment purposes was the motivator for 10% of the participants. Less frequently reported motivations were boredom (n=4, 5.56%), legislation (n=2, 2.78%), potency (n=2, 2.78%), price (n=2, 2.78%) and experience (n=1, 1.39%). The PSA 2016 also did not appear to have prevented homeless individuals from consuming NPS and three-quarters (n=54, 75%) did not impact consumption.

4.3.5.2. NPS motivations: NPS used for self-medication

The use of Spice to relieve symptoms of pain was desired by forty-five percent (n=33) of the NPS users and included physical pain and psychological trauma. Smoking Spice to relieve physical pain was the most desired effect sought from participants in this study and included pain such as sciatica, prolapsed disks in the spine and arthritis. The use of Spice was also popular to relieve symptoms of psychological trauma from participants. Spice was used to relieve symptoms of anxiety, depression and withdrawal associated with frequent use of Spice. Depression often resulted from bereavement either the death of a family member or losing contact with their family.

Table 4.6 Motivations behind using NPS

Motivations	**Frequency N**	**(%)**
Main reason for consumption		
Escapism	20	27.8
The high	13	18.1
Experiment/curiosity	10	13.9
Treatment	8	11.1
Boredom	4	5.56
Legislation	2	2.78
Potency	2	2.78
Price	2	2.78
Experience	1	1.39
NPS used for pain relief		
Yes	33	45.8
No	39	54.2
Type of pain relief		
Physical	12	16.7
Psychological	8	11.1
Emotional	3	4.17
Withdrawal	2	2.78
NPS used to treat mental health		
Anxiety	19	26.4
Depression	13	18.1
Schizophrenia	6	8.33
Suicidal thoughts	6	8.33
Bipolar disorder	5	6.94
Impact of NPS ban on consumption		
Yes	18	25
No	54	75

4.3.6. Effects desired from NPS consumption for the homeless population

4.3.6.1. NPS desired effects: Positive effects

A total of five different desired effects were reported from participants. The reported positive effects were further divided into three categories: dissociative, stimulation and therapeutic. Both dissociative and therapeutic effects were highly sought after from homeless Spice users where dissociative effects were desired to escape the realities of homelessness and therapeutic effects for pain relief. Dissociative effects were only associated with Spice and included out of body experience and hallucinations. Again, only associated with Spice consumption therapeutic effects included anti-anxiety and calming effects. Stimulation (n=9, 12.5%) was less reported as a desired effect and was associated with stimulant NPS derivatives.

4.3.6.2. NPS desired effects: Enjoyment from using NPS

A total of eleven factors that users enjoyed from NPS consumption were reported from participants in this survey. The most frequently reported factor was 'nothing' and suggested to participants did not like the effects or NPS in general with some stating they were 'dirty drugs'. Additionally, fourteen of those who reported they enjoyed nothing from using NPS reported consuming NPS once per year. It was found that escapism was highly desired and followed second in prevalence as a factor enjoyed by NPS users. Captivating for users to continue NPS consumption escapism was the most prevalent motivation behind use and most desired effect users sought. Participants who used NPS for escapism were frequent daily users. Participants also reported the high (n=6, 8.33%), relaxation (n=4, 5.56%), short on-set of action (n=4, 5.56%), potency (n=3, 4.17%), sleep aid (n=3, 4.17%), price (n=3, 4.17%), legal status (n=1, 1.39%), hallucinations (n=1, 1.39%) and stimulation (n=1, 1.39%) as effects they enjoyed from NPS consumption.

4.3.7. Negative events experienced associated with NPS consumption

4.3.7.1. NPS adverse events: Negative events

In terms of subjectivity, the reported negative events greatly varied between users especially regarding Spice consumption reflecting how different the effects can be between individuals. Negative events resulting from NPS consumption was highly prevalent among the homeless population and a total of thirty-three were reported affecting the cardiovascular, gastro-intestinal and nervous systems.

4.3.7.2. NPS adverse events: Types of negative events

Although the subjectivity of negative events associated with NPS use namely Spice were profound among participants two neurological effects were significantly more frequently reported than other negative events. Loss of motor control (n=23, 31.9%) and paranoia (n=16, 22.2%) were highly prevalent and associated with Spice use. Loss of motor control was described by users as an inability to communicate and feeling paralysed and individuals who witnessed Spice users in this neurological state described their appearance and actions as zombies. Additional neurological effects associated with Spice use included anxiety, disorientation, hallucinations, loss of consciousness, nausea and seizures.

Cardiovascular adverse events were induced by both cannabinoid and stimulant NPS derivatives but varied between NPS classes consumed. NPS cannabinoid derivatives (Spice) induced cardiovascular events such as tachycardia and panic attacks but for NPS stimulant derivatives cardiovascular events such as chest pains, insomnia and tachycardia were reported.

Gastro-intestinal adverse events were only reported from one participant who reported feeling nauseous before vomiting after consuming Spice. Daily Spice use for six participants resulted in overdose requiring medical treatment following hospitalisation and for one individual, rehabilitation for six months in psychiatric care was required.

4.3.7.3. NPS adverse events: Duration of negative events

More than half of the participants who reported negative events stated the effects lasted no more than two hours. The duration of negative events for synthetic cannabinoids ranged between one to more than six hours. The participants who reported their negative event lasting for more than six hours were hospitalised as a result. Negative events associated with NPS stimulant use ranged between three to six hours.

4.3.7.4. NPS adverse events: Hospitalisation

Requirement of medical treatment following hospitalisation was reported from more than 20% of the participants (n=22, 20%) and duration of treatment ranging between two hours to six months in psychiatric care. Typically, both doctor and nurse treated individuals hospitalised after experiencing negative effects associated with NPS consumption (n=18, 78.3%). In some cases just a doctor treated individuals and in one case the individual was treated by a nurse, not doctor. Females were 10% more likely require medical treatment following hospitalisation than males in this study (27.7% vs 19.7%).

4.3.7.5. NPS adverse events: NPS used to treat mental health

A large portion of the homeless population reported issues with their mental health and used Spice to treat symptoms of anxiety, bipolar disorder, depression, schizophrenia and suicidal ideation. It is not surprising that Spice was used to treat mental health problems especially with a large majority of participants using Spice for escapism effects. Spice use was most effective in treating symptoms of anxiety and depression, but less effective in treating bipolar, schizophrenia and suicidal ideation.

4.3.7.6. NPS adverse events: Impact from NPS

A large portion of users were concerned about the impact of NPS on their mental health, physical health, financial stability, criminal behaviour and relationship issues. Continued Spice use affected individuals lives in many ways but the mental health of participants was most affected, and two-thirds reported their mental health debilitating as a result of continued Spice use. Breakdown of relationships either with a spouse or family member was also seriously affected and reported from more than half of Spice users. Only one-third of Spice users reported an increase in criminal or anti-social behaviour as a result from prolonged Spice use and was only reported from daily users of Spice.

4.3.7.7. NPS adverse events: Widespread

With the consumption of NPS among the homeless population highly prevalent, most of the participants described Spice as a widespread and was not localised to certain geographical locations. Some participants referred to the growing problem as an epidemic. Participants who reported Spice as growing, widespread or epidemic were frequent users whose mental health had been substantially affected through continued consumption. Twenty-five percent however did not know about NPS availability and prevalence and the topic of NPS was essentially unknown to the individual. It is noteworthy to mention that individuals who were unaware of NPS availability and prevalence were more likely not to consume NPS.

4.3.7.8. NPS adverse events: Drug support

Thirty percent of the homeless population were receiving drug support at the time of questionnaire completion either traditional drug support or NPS support. Female participants were slightly more likely receive drug support than males or were more open about receiving support for their drug use (33.3% vs 29.5%, respectively).

Table 4.7 Adverse events associated with NPS use

Adverse events	**Frequency N**	**%**
Negative effects from NPS consumption		
Yes	72	68.6
No	33	31.4
Type of adverse event		
Loss of motor control	23	31.9
Paranoia	16	22.2
Hallucinations	6	8.33
Overdose	6	8.33
Seizures	6	8.33
Disorientation	5	6.94
Loss of consciousness	5	6.94
Anxiety	4	5.56
Nausea	4	5.56
Tachycardia	4	5.56
Depression	3	4.17
Insomnia	3	4.17
Mood swings	3	4.17
Near death experience	3	4.17
Panic attack	3	4.17
Addiction	2	2.78
Increased aggression	2	2.78
Lethargic	2	2.78
Psychosis	2	2.78
Agitation	1	1.39

Amnesia	1	1.39
Apnoea	1	1.39
Chest pains	1	1.39
Deep-vein phlebitis	1	1.39
Epistaxis	1	1.39
Mirror-touch synaesthesia	1	1.39
Sedation	1	1.39
Suicidal ideation	1	1.39
Suicide attempt	1	1.39
Vomiting	1	1.39
Duration of adverse event (hours)		
< 1	21	20
2	27	25.7
3	4	3.81
4	3	2.86
5	1	0.95
>6	15	14.3
Medical treatment		
Hospitalisation	22	21
Non-hospitalised medical treatment	1	0.95
No	81	77.1
Impact of NPS consumption		
Mental health	46	63.9
Relationships	38	52.8
Financial issues	36	50
Physical health	33	45.8
Preventing recovery	30	41.7
Criminal offending	26	36.1
Anti-social behaviour	22	30.6
How widespread are NPS		
Unknown	26	24.8
Dying out	5	4.76

Growing	3	2.86
Widespread	60	57.1
Epidemic	6	5.71

4.3.8. Logistic regression

The results of a logistic regression are present in Table 7 below. The dependent variable was a binary outcome - if the homeless participant had consumed NPS either 'Yes' or 'No'. The analysis predicts the likelihood of a homeless participant consuming NPS products. The independent variables included in the logistic regression model were those where all 105 participants had completed a response (sociodemographic and NPS related adverse event questions). The results from the logistic regression model show that Caucasian homeless individuals were nearly five times more likely (Exp(B) – 4.676, p-value 0.013) than individuals of all the other ethnicities to consume NPS products. Male individuals were nearly two-thirds as likely to consume NPS (Exp(B) 0.615) as female and not reported sex. Heterosexuals were less likely to consume NPS than bisexual and homosexuals (Exp(B) 0.5). Homeless individuals in drug support (Exp(B) 0.504) and currently in employment (Exp(B) 0.745) were 50% less likely to consume NPS products and homeless participants in contact with their families were 25% more likely to consume NPS that participants who were not. However, the results mentioned above (apart from ethnicity - p-value <0.05) were all statistically insignificant (p-value >0.05).

Table 4.8 Prediction of NPS consumption among the homeless using logistic regression

Independent variable		**S.E**	**P-value**	**Exp(B)**
Ethnicity	Ref. Asian, Black & Mixed	0.623	0.013	4.676
White				
Sex	Ref. Female	0.49	0.321	0.615
Male				
Sexuality	Ref. Bisexual & homosexual	0.618	0.262	0.5
Heterosexual				
Drug support	Ref. No	0.516	0.185	0.504

Yes				
Employment	Ref. No	0.504	0.559	0.745
Yes				
Family contact	Ref. No	0.453	0.621	1.251
Yes				

S.E: Standard error.

4.4. Discussion

The present study provided a real-world insight into the consumption of NPS among the homeless population. The findings of this research uncovered many information regarding the NPS consumption among the homeless population. In this respect, the consumption of SCRAs showed to be highly prevalent among the homeless population particularly for the escapism effects experienced with SCRAs. In the majority of cases, the homeless people used NPS in order to escape reality in the face of homelessness. However, they suffered extreme paranoia and loss of motor control upon use of NPS. Although NPS consumption was associated with hospitalisation among the homeless population, the majority of the homeless people were not interested in receiving drug support for their NPS use.

The findings of this study confirmed the finding of two studies in the literature that had been conducted by Macleod and Irving (Macleod et al. 2016; Irving 2017). Similar to this study, the latter two studies reported high prevalence of NPS among the homeless population in order to escape reality. Moreover, both of the aforementioned studies established that the homelessness people experienced nervous system related adverse effects similar to the ones found of this study. Nonetheless, both studies were limited to the population used and were not representative of the whole homeless community. Macleod et al. (2016) targeted specific groups of the homeless people. Irving (2017) only included youth homeless between the age of 16 – 25 years old. On the other hand, our study included any homeless individual across the UK within the age group of 18 – 64 years old.

The reason for selection of 18 – 64 years was that youth and elderly have different metabolism to adults and that can interfere with the effects of NPS (Winstock and Barrett 2013). Hence, it will be difficult to predict whether the effect is specific to the drug or to the metabolic profile taking into account the incomplete research about NPS derivatives. By selecting this group, it was more obvious to uncover the sociodemographic of the homeless population using NPS, the motivation of the homeless behind using NPS, their experience of effects and adverse effects, and the associated implications on healthcare system.

The sociodemographic factors showed that the majority of the participants were males, white and heterosexual. Previous research has reported that age and sex of the participants were similar to the ones reported in this study mean ages of 36.5 to 47.6 years old with the majority of participants being males (81% - 82.5%) (Ibabe et al. 2014). Participant ethnicity in this research showed that the majority of the homeless population were white, which is supported in research outside on London. It is noteworthy to mention that none of the participants in this study lived in London. The Ministry of Housing (MoH) reported that 38% of the homeless population in London were non-UK nationals and that the homeless population in London has seen a decrease in UK nationals but an increase in non-UK nationals (Ministry of Housing 2018). Location of family has no yet been extensively researched into with the homeless population, however, O'Flaherty, Scutella and Tseng 2018 showed that the only 5% of participants were migrants from outside the country, supporting the result obtained in this study. Duration of homelessness ranged between two months and 30 years in this study, with the majority of participants reporting a duration of homelessness below three years. Despite the large range, it was consistent with the findings of another study (Ibabe et al. 2014) that showed duration of homelessness ranging between 2 months – 30 years. The majority of the homeless population in this research reported they would sleep indoors (hostel, emergency accommodation & sofa-surfing) compared to outdoors (streets, forest, car, tent). This is expected for countries with a strong economy as higher prevalence of rough sleeping is normally associated with developing countries where 80-90% of the homeless population report they sleep rough.

In relation to NPS consumption, the majority of homeless participants had voluntarily consumed NPS that were mainly SCRAs. These results agreed with the findings from MacLeod (2016) who had shown in a report to the Scottish government that 74% of homeless participants consumed NPS and mostly were users of SCRAs. Dose and duration of effects from the homeless population has not yet been explored in research, however, clinical studies on human participants who were administered SCRAs showed that the average herbal mixture dose was 0.3 grams (Casteneto et al. 2014) and effects that lasted one hour after ingestion (Winstock and Barrat 2013). The preferred route of administration reported in the study was smoking, which is usually associated from consumption of cannabinoid compounds because they are volatile and lipid soluble. Research into NPS use amongst homeless youths showed that NPS are usually smoked and is likely due to the high prevalence of SCRAs used amongst the homeless population (Irving 2017). Accessibility of NPS products and their location of purchase were most frequently reported to be in a shop or friends. One study use reported that several shops 'bulk purchased' NPS products prior to the ban and others still buying them online, highlighting that NPS can still be imported. Particularly concerning is the use of 'runners' to provide a doorstep delivery, who are typically paid in the form of another NPS (Macleod et al. 2016; Irving 2017). Although the most reported price paid for NPS products in this study was £10, almost 10% of participants reported their NPS products were 'free of charge', which could be due to social consumption, free samples given by dealers or drug-running. The use of drug runners has been reported (Macleod et al. 2016) where dealers will give free drugs to individuals for distributing or 'running' the drugs to their clients.

Characteristics usually associated with NPS consumption such as experience, experimentation, legislation and price were all reported significantly less than escapism. Although the majority of research reports that drug users consume drugs for pleasure and enjoyment, interviews conducted with homeless youths (Irving 2017) discovered that participants 'wanted to escape' and feeling hopeless' in the face of homelessness and would consume NPS to forget about their problems. It has been documented that up to 93% of SCRAs users would rather consume cannabis but were motivated to consume SCRAs due to their legal status, price and non-detectable in drug screening tests, thus establishing their position as a substitute to cannabis (Castaneto et al. 2015). This research has highlighted the change in motivations for the homeless population are different to other populations who are using NPS products.

The high prevalence of mental health issues among the homeless population has been extensively documented throughout literature, but the consumption of NPS to treat mental health symptoms is of particular concern. Almost half of the participants in this study who were users of NPS consumed the drugs to treat symptoms of pain and reported out of body experience as their most desired effect. Out of body experiences were usually reported as adverse effects and associated with ketamine and hallucinogen derivatives (Harris and Ossei-Gerning 2015; Langford and Bolton 2018; Mohr et al. 2018; Costa et al. 2019). The documented change in user motivations and desired effects could highlight why the homeless population disengage with support services to self-treat their conditions. Lack of secure storage has been identified as one of the key barriers faced in retaining medicines to treat their mental health. Some local authorities in the UK have developed medicines management policies for homeless individuals living in temporary accommodation (Paudyal et al. 2017), but this is not available to all homeless individuals. Rough sleepers were exempt from this management policy and could suggest that individuals experiencing homelessness resort to NPS consumption to treat symptoms of discomfort and pain.

The most frequent adverse events experienced by the homeless population were psychosis, paranoia and loss of motor control. The aforementioned adverse effects were typical of hallucinogenic stimulants (Davidson et al. 2017; Bae et al. 2018). Psychosis was stated as an adverse event resulting from the consumption of cannabinoid compounds. Repeated long-term use of cannabis has been implicated in the development of schizophrenia and psychosis and the age of onset appears to predict the risk (Castaneto et al. 2015). Therefore, the psychosis was most likely induced by Spice (Benford and Caplan 2011).

4.4.1. Strengths and limitations

Prior to the completion of this study, knowledge and experiences of the homeless population who use NPS had not been explored. Results from this study increase the awareness of the experiences the homeless population with NPS, particularly the adverse effects associated with their consumption and disengagement from service providers. The results from this study illuminated the additional costs to society when the homeless population experience adverse effects from NPS. The costs were evident by the large proportion of the homeless population who have required medical treatment as a result from their NPS consumption. Data gathered from this study could help create cost-effective healthcare delivery models to improve the assessment, plan of care and additional support services.

Few limitations were encountered in this study, The questionnaire response proved to be difficult in this population. Immense efforts were made to contact charity and support organisations, contacting and scheduling meetings with the service managers to help facilitate the dissemination of the questionnaire. Even with the efforts made 105 questionnaires were completed over a six-month period across the UK. Although the response can be regarded as low, for this given vulnerable population 105 completed questionnaires was a good number especially among vulnerable populations. Further limitation was encountered with validating the NPS use. Although the homeless reported the use of 'Spice' or other derivatives; there was no way to confirm that Spice was used or any other derivative.

4.5. Conclusion

In conclusion, the majority of the homeless population were white, male and heterosexual. NPS consumption remains very high among the population and almost 70% have consumed NPS voluntarily. The SCRAs Spice, usually prepared as a herbal mixture that is smoked and effects present within five minutes was the most popular derivative. Spice could also contain multiple compound in addition to synthetic cannabinoids which is unknown to the consumer. The homeless population were motivated to consume NPS due to escaping the reality of homelessness and self-treatment of conditions, highlighting how users use NPS for pain relief. Although there were therapeutic benefits reported from the homeless population, the adverse events outweighed the positive and more than 20% of the population had required medical treatment following hospitalization. Although there has been a significant decrease in the consumption of these compounds among the general population, this study shows that the high prevalence of NPS among the homeless population and are easy to acquire in the underground market. This research also informed about male and female homelessness differences and the new routes of administration (smoking Spice on paper in prison). The use of qualitative in-depth interviews with chronic NPS users was not done in this thesis due to COVID-19 complications. However, future work should explore the knowledge and experiences of NPS among chronic users from the homeless population and explore public and service provider attitudes regarding NPS use and homelessness.

Chapter 5. Understanding the perceptions of the public regarding the services provided to the homeless population who use NPS

5.1. Introduction

New psychoactive substance (NPS) is the umbrella term to define any synthetically designed substance that mimics the effects of commonly abuse drugs (cannabis, cocaine heroin) but avoids national and international criminalisation (Johnson et al. 2013). The emergence of these compounds has been documented and reported from the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and United Nations Office on Drugs and Crime (UNODC) since 2005 and was continuous until December 2018 where 888 substances had been reported to the UNODC Early Warning Advisory (EWA) (UNODC 2019). The rate of emerging NPS increased annually from 2005 until 2014 where 101 substances were reported to the EMCDDA between January to December 2014 (EMCDDA 2018). With over 800 different NPS derivatives NPS pose a significant danger to the public health and safety. NPS are understood to have associated negative effects and potentially additive and as they are still understudied, the long-term effects are not always clearly understood (Davey et al. 2010). The advertisement of NPS increased public desirability by marketing the products under names such as “legal highs”, “herbal incense” and “bath salts” (Brandt et al. 2010). Media organisations reported numerous deaths associated with NPS under names “legal highs” and created significant strain on governments and international organisations to control the sales, distribution and consumption of the substances (The Mirror 2016; Independent 2017; Smyth et al. 2017).

With the introduction of the Psychoactive Substance Act in 2016 completely banning all NPS products, a noticeable decrease of NPS consumption was reported in the adult population but has also seen an unprecedented growth of NPS consumption among the homeless population (Giese et al. 2015; Macleod et al. 2016; Ralphs and Gray 2018). The synthetic cannabinoid Spice has caused significant increases in public intoxication in UK city centers as reported by media and researchers (Ralphs et al. 2021). National and international media have frequently draw attention to ‘Spice Epidemics’ in UK city centres (Chatwin et al. 2017; Gray et al. 2021) and a growing concern is shown in homeless populations globally (Alexandrescu 2018). High prevalence of synthetic cannabinoid use has shown to render homeless physically vulnerable to crime and causes a number of mental and physical health issues (Macleod et al. 2016; Gray et al. 2021). However, research conducted into NPS and homelessness has focused on examining the prevalence, motivations and negative effects and not into understanding public and stakeholder perspectives of this issue. Qualitative interviews have previously assessed and evaluated stakeholder perspectives regarding homelessness and NPS consumption, however, knowledge is limited when trying to understand the publics perspective on their views on homelessness and NPS consumption (Macleod et al. 2016; Ralphs and Gray 2018. A useful method that this type of information in real-time is social media analysis on platforms such as Twitter, Facebook and YouTube (Zeng et al. 2010; Fan and Gordon 2014).

Social media networks have transformed the sources of information. Recent years have seen a significant increase in academic interest in the possibility of using social media as a tool to examine and evaluate information (Buckingham and Willett 2013; Gebremeskel et al. 2014). In particular, the microblogging service Twitter has been used as a learning tool in the fields of medicines as well as for disease surveillance and management and public health concerns (Triple 2011; Sinnenberg et al. 2017; Osagie et al. 2020;). This ability was demonstrated in predicting influenza cases and surveillance for an Ebola outbreak in 2014. However, both studies collected large amounts of data and analysed the data quantitively. Research from Talbot at al (2020) and Sandhu et al (2019) has shown how focusing on specific populations can provide an understanding of the attitudes and behaviors towards the specific populations. More generally, research into how social media is used to discuss homelessness and new psychoactive substances and other health risk behaviors is still in its infancy, but research has been carried out into drug use among the general population for both cannabis and alcohol use (Grant and O'Mahoney 2016; Unger 2020). To date, only one paper has been used to the understand the issues of homelessness through social media analysis confirming that the topic is discussed on Twitter for the purposes of raising awareness, soliciting the support of stakeholders and engaging external stakeholders (Jung and Valero 2016). In our research, we seek to extend the understanding of the general public and stakeholder's attitudes and behaviors towards NPS consumption among the homeless population by presenting thematic analysis of the extracted Twitter data.

5.1.1. Aim

The aim of this study was to explore public and service provider attitudes regarding NPS use and homelessness. More specifically, this study provided better understanding of the impact NPS use and homelessness from the perspectives of the public and service providers. It further allowed the voice of the general public and service providers to emerge as their knowledge and experiences regarding homelessness and NPS have been frequently missing from the literature. The study objectives were:

1. Characterise tweets regarding homelessness and NPS consumption.
2. Uncover the themes and sub-themes regarding homelessness and NPS consumption and describe the content.
3. Understand the content of the tweets about the effects of NPS consumption among the homeless population from the perspectives of the general public and service providers.

5.2. Methods

5.2.1. Sample

Using the Advanced Search tab in Twitter, tweets referencing NPS and homeless were searched from 1st March 2020 to 30th August 2020. The tweets extracted from Twitter using Ncapture, a free web-browser extension for chrome that allows individuals to gather web content to import into NVivo 12.

5.2.2. Inclusion and exclusion strategy

The approach in this study is similar to other studies (Gebremeskel et al. 2014; Grant and O'Mahoney 2016; Jung and Valero 2016), and that this current research did not examine retweets as there is a risk of only examining popular content on the platform. This also reduced the chance of analysing spam. Tweets only in English from the UK were included. A limitation to this approach is that by only including English tweets and it may not offer a complete picture of the tweets regarding homelessness and NPS consumption. Excluded tweets were those relating to intervention among homeless NPS users conducted by service providers. Moreover, tweets with personalised information, photos, videos and emoji were excluded. Initially 5,068 tweets were extracted from Twitter, but after removal of retweets, initial screening for relevant content and removal of duplicate tweets the final total of analysed tweets was 512. The full diagrammatic representation is below in figure 5.1

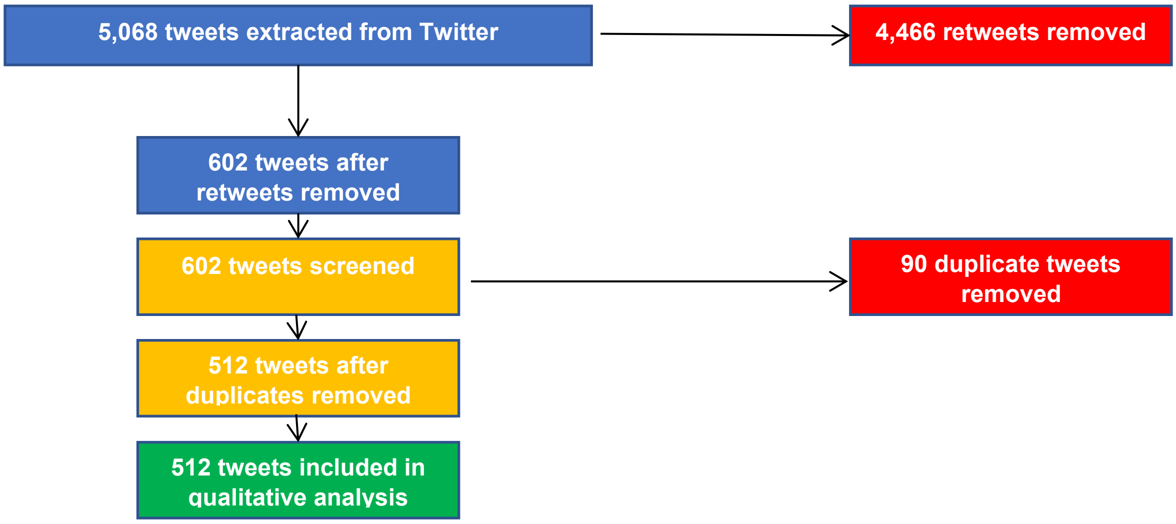


Figure 5.1 Inclusion and exclusion of tweets in this research

5.2.3. Data analysis

Thematic analysis conducted using NVivo 12 was chosen because it provides rich and detailed results that may be lacking in quantitative research methods. Thematic analysis is defined by Braun and Clarke as ‘a method for identifying, analysing, organising, describing and reporting patterns (themes) within a dataset’. This method provides flexible and rich research tool that provides rich and detailed, yet complex accounts of the data. Deductive coding was undertaken using the coded qualitative information in the semi-structured questionnaire of this thesis in Chapter 4, where participants could write their opinions about NPS and their experiences with support services. Inductive coding was also chosen and used to allow flexibility and to included new codes that emerged from the Twitter data as little research has been conducted on Twitter analysing information on homelessness and NPS. Figure 5.2 shows example of the coding process.

"You left out the health of those addicted to substances that are contributing to homelessness. 1500+ overdose fentanyl deaths in BC in a year"

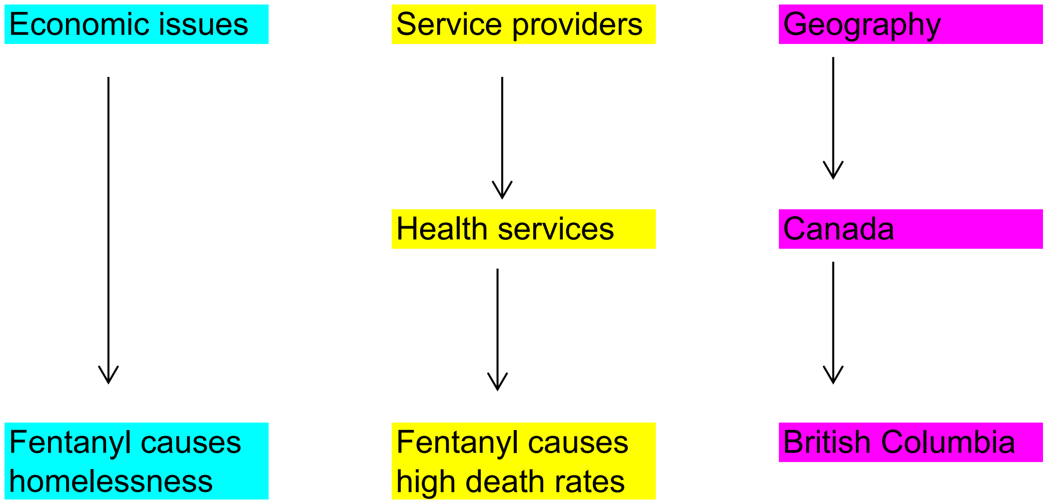


Figure 5.2 Example of thematic analysis of a quotation used in this research

5.2.4. Data validation and reliability

A technique is usually applied to content and thematic analysis is intercoder reliability. Intercoder reliability refers to how much coders will agree when coding content based on the same coding scheme. The procedure for undertaking intercoder reliability consists of a second independent coder coding data in order to compare their results with those of the original coder. Neuendorf (2002) noted that researchers would rarely need to code more than 300 units when producing intercoder reliability as the statistics would not change as the number increases. Two project supervisor were provided with verbal instructions, and trained to code 300 tweets in order to produce an intercoder reliability statistic. Then the researchers met and discussed coding where any disagreement was resolved by discussion.

Test-retest reliability is calculated in a similar manner to intercoder reliability, however, it involves using the same researchers who coded the initial dataset to code a subset of tweets from the same data after suitable length of time has passed. This form of reliability rose to prominence for experimental work in the fields of psychology and sociology in order to assess the level of variation if the experiment was to be repeated. The test-retest reliability is to be measured using Cohen's kappa coefficient (Cohen 1960). The author who originally coded the initial study (TC), also will re-code a subset of data after a three-month period in order to assess test-retest reliability. Almost perfect level of agreement was achieved from the three researchers (k=0.932).

5.3. Results

A total of two synthetic NPS derivatives containing five themes and 21 sub-themes emerged from this dataset. The two synthetic NPS were fentanyl and Spice. It is noteworthy to mention that Spice can include a combination of SCRAs, not one.

- Theme A: **Fentanyl economic issues**

Tweets discussing the associated problems of fentanyl consumption and homelessness in relation to economic stability.

- Theme B: **Social issues associated with fentanyl**

Tweets expressing emotion, opinions and information about the social challenges of fentanyl use among the homeless population.

- Theme C: **Services provided to address issues linked to fentanyl**

Tweets discussing the services provided for the homeless population who use fentanyl

- Theme D: **Social issues associated with Spice consumption**

Tweets expressing emotion, opinions and information about the social challenges of Spice use among the homeless population.

- Theme E: **Services provided to address issues linked to Spice**

Tweets discussing the services provided for the homeless population who use Spice

These themes, alongside the identified sub-themes, are described in Figure 3.. Below, and then individually discussed in the remaining part of the chapter. To generate themes and sub-themes, nodes were exported into NVivo 12 and then grouped together according to similarities and/or differences of content.

5.3.1. Fentanyl

Of the two NPS drug classes that were reported being SCRAs and synthetic opioids, Fentanyl, a synthetic opioid derivative was discussed more frequently on the Twitter platform. Three main themes were discussed on Twitter regarding fentanyl and homelessness and consisted of economic issues, social issues and discussions about the services provided to homeless fentanyl users (Figure 5.3)

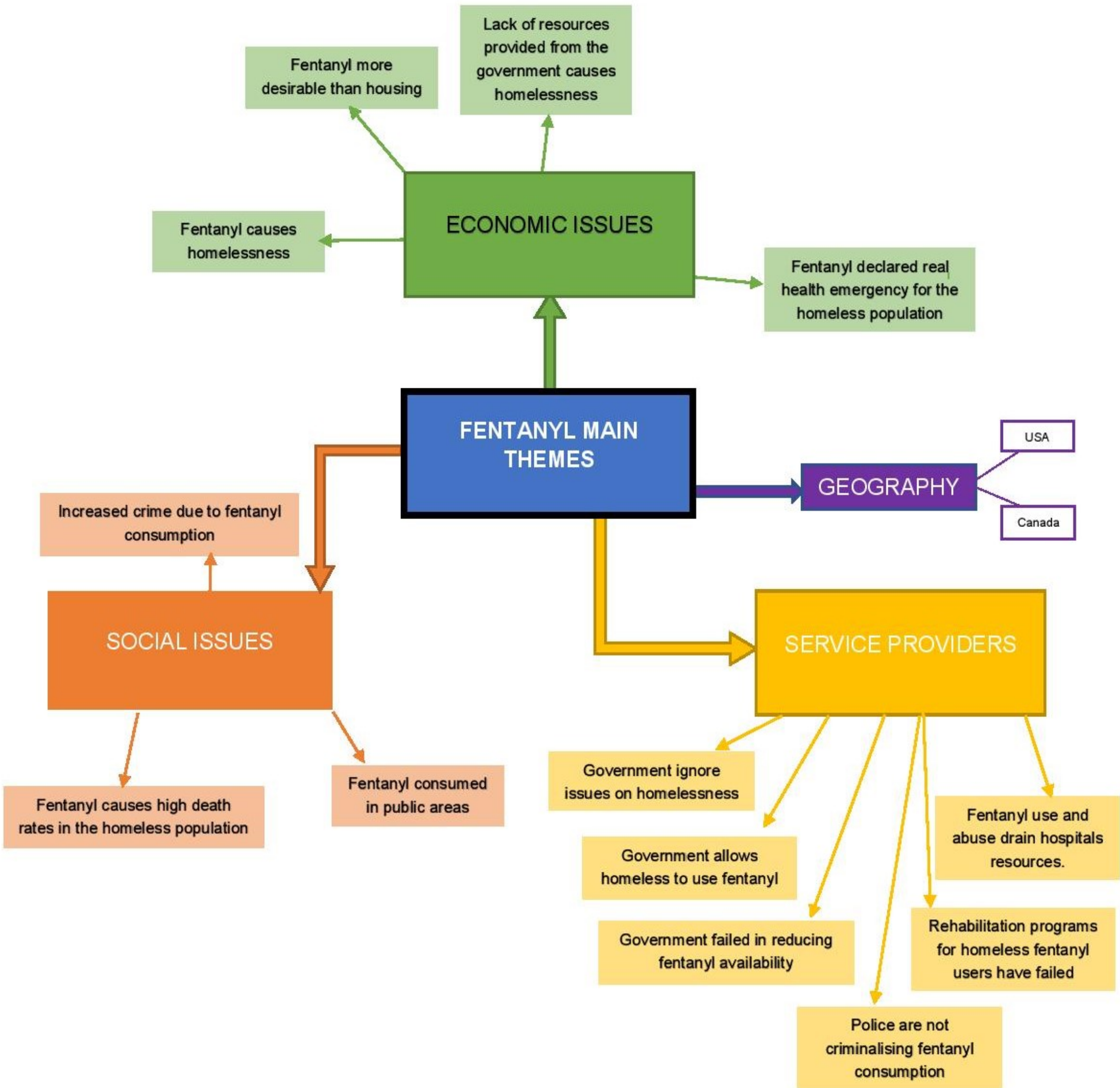


Figure 5.3 Diagrammatical overview of fentanyl themes and subthemes

5.3.1.1. Geography of homeless fentanyl users

The consumption of fentanyl in the US and Canada was reported to be highly prevalent. In the US one state was more frequently reported by Twitter users being California. The state of California was plagued by fentanyl consumption and homelessness in cities such as San Francisco, Los Angeles and Hollywood. The state of California accounts for 12% of the homeless population and 28% of the unsheltered population within the US (Jarpe et al. 2019). Additionally, California recently reclassified drug possession from a felony to a misdemeanour through Proposition 47: The Safe Neighbourhood and Schools Act 2014 (Bartos and Kubrin 2018). In the last eight years, homelessness in California has grown by 75% and is due the migration of homeless individuals to a warmer climate and reduced penalties for drug possession (Tung 2020). However, since the COVID-19 pandemic mass-migration out of California has been documented and is likely why Twitter users reported the high prevalence of fentanyl use among the homeless population in public places.

Fentanyl use among the homeless population in Canada was also a serious issue. Vancouver in British Columbia was the most frequently reported location Twitter users discussed information regarding fentanyl use among the homeless population (Karamouzian et al. 2018; Rowe et al. 2019; Oh et al. 2020). The high prevalence of homeless in British Columbia is the result of low income and high cost of housing. The high prevalence of fentanyl was the result of increased levels of homelessness and fentanyl was the cause of death in two-thirds of the illicit drugs deaths with the homeless population most at risk. The use of fentanyl was not reported in any other country through Twitter discussions.

A. Economic issues

This theme contained tweets which contained references to fentanyl consumption and how it leads to economic instability based on the following sub-themes: a narrative suggesting fentanyl consumption causes housing instability, using fentanyl is more desirable than housing, lack of resources provided from the government causes homelessness and discussion regarding fentanyl causing a real health emergency among homeless individuals.

Table 5.1 Sub-themes of economic issues associated with fentanyl consumption

Theme	Sub-theme
A. Economic issues associated with fentanyl	A.1. Fentanyl causes homelessness
	A.2. Fentanyl more desirable than housing
	A.3. Lack of resources provided from the government cause homelessness and fentanyl use
	A.4. Fentanyl consumption declared health emergency

A.1. Fentanyl causes homelessness

In this sub theme Twitter users are certain that fentanyl is a major cause of homelessness. The ‘epidemic’ with drugs such as meth, heroin and fentanyl have all been ignored during the time of COVID-19 and global lockdowns and fixing them would reduce the problem of homelessness. With the price of fentanyl decreasing and its availability increasing the potential to develop addiction of the highly potent opioid compared to other opioid derivatives have all contributed to an increase in homelessness:

“*How come no one talks about the huge epidemic with meth, heroin and fentanyl. Fixing that problem would help a lot of things in this country like homelessness for one*” (A1: 1)

“*In the US cheap meth and fentanyl are causing a homeless crisis much like this and decriminalisation has made it much worse*” (A1: 9)

“*You left out the health of those addicted to substances that are contributing to homelessness. 1500+ overdose fentanyl deaths in BC in a year*” (A1: 4)

One individual on Twitter reported how his drug addiction to prescription opioids turned into an addiction to heroin then fentanyl, which caused him to become homeless within a year:

"*I was able to maintain my government job while popping pills, but I couldn't function when I turned to Heroin/Fentanyl and became homeless within a year*" (A1: 12)

The aforementioned reflected how tweeters were actively trying to increase the awareness of fentanyl causing homelessness. In addition, tweeters perspectives in this sub-theme attracted negative attitudes towards the government. Tweet A1: 12 highlighted the progression from opioid drug addiction to homelessness is the US, currently described as a epidemic (Buresh et al. 2019; Lambdin et al. 2019). In the US of all recorded opioid fatalities, more than 50% are the result of prescription opioids and not opioids manufactured by criminal organisations (Mallama et al. 2019). Moreover, researchers have established that opioid addiction causes longer periods of homelessness and disengagement from services (Pitt et al. 2018). Although Twitter users were promoting awareness with the ongoing fentanyl and homelessness problem, this did not necessarily mean that fentanyl causes homelessness or that the government are not acting on this problem. It is possible that Twitter users who were tweeting at this time were overloaded with information about fentanyl and homelessness, and this finding may be of potential interest to health authorities and service providers who provided support for the homeless.

A.2. Fentanyl more desirable than housing

A number of tweeters also shared information regarding homeless individuals disengaging from services due to addiction. As mentioned previously, fentanyl was blamed for being a major cause of homelessness and one individual stated that his progression from prescription opioids to fentanyl caused him to become homeless. The desire to consume fentanyl means that the homeless abandon housing issues, and instead will get their next 'fix'. Housing affordability was also discussed as a main cause of homelessness where the price of rent increases as well as the availability of fentanyl have concomitantly caused an increase in homelessness.

"*Baltimore City Keep Playing With Your Life and Your Freedom Dealing With Our Democratic Party. The Homelessness Abandon Houses Issues" (A2: 1)*

"Yep, our last point in time count showed 30% increase in homelessness. Affordability, skyrocketing rents & displacement were largely to blame. Also yes, an increase in fentanyl" (A2: 7)

"*80% of our homeless are addicts and would choose heroin/fentanyl/meth over housing*" (A2: 14)

This may be of some interest to service providers and medical professionals working with the homeless. If homeless individuals are choosing to consume fentanyl rather than engage with housing authorities and service providers, then it suggests further support is required to reduce fentanyl through rehabilitation and increase engagement with housing authorities. Various researchers have documented how the homeless population disengage from service providers when abusing substances (Krawczyk et al. 2020). More importantly, researchers have reported that addiction to opioids substantially increases the risk of disengagement with service providers and increase periods of homelessness (Pitt et al. 2018).

A.3. Lack of resources provided from the government causes homelessness and fentanyl use

The poor management and lack of services provided from the government are both thought to have increased homelessness. With some areas in the US going into complete economic shutdown during the COVID-19 pandemic, empty homes, rampant homelessness and fentanyl use and businesses collapsing was described as an apocalyptic vibe. If the vibe was not described as apocalyptic, individuals feared becoming homeless in the near-future and quoted saying that it was one pay-check away. If individuals did not blame the governments lack of resources for causing homelessness, political officials were blamed for allowing China to flood the streets with fentanyl and illicit money, which caused an increase in the price of rent and thus, contributed to an increase in homelessness.

"*rampant homelessness, Oppenheimer, an affordability crisis, the DTES, empty homes, empty retail, and fentanyl, is not awesome*" (A3: 3) "*the opioid and fentanyl overdoses, suicides, 70% one paycheck away from homelessness, Walmart & Amazon destroying small business...etc*" (A3: 1)

"*China, and our corrupt politicians enabling them, right up to the PMO, is the cause of many of our problems today including fentanyl, homelessness, stratospheric housing, unaffordable education*" (A3: 8)

It was found that tweeters were concerned and outraged at the services provided from government both before and during COVID-19 pandemic. In certain US states it was illegal to use federal funds for syringe exchange programmes until Scott County experienced an outbreak of HIV infections, causing a lift of the ban in 2015 (Gonsalves and Crawford 2018). Lifting the ban however, did not include any new funds but permitted state governments to re-allocate federal funds to support expenses. However, many of the programs in the US remained underfunded and due to the COVID-19 pandemic, most programs were expected to continue remaining underfunded (Hsu et al. 2020). Moreover, each local government is required to address the challenges experienced by homeless individuals and facilitate the improvement of facilities in addition to reducing homelessness (Benavides and Nukepezah 2020). Depending on the economic stability of the given location, the amount of funding the homeless population receive will vary between each location. For this reason, certain geographical locations will have more funding and other not so much and could explain why some individuals experienced more issues regarding homelessness and fentanyl consumption.

A.4. Fentanyl consumption among the homeless population declared a health emergency

There were tweeters, who reported on the use of fentanyl causing a health crisis for the homeless population. The health crisis issues ranged from defecation in public places, overdose's and fatalities and public intoxication.

Health emergency related tweets regarding homelessness and fentanyl were typically focused on issues on local economies. The high prevalence of fentanyl has been blamed not only on increases in homelessness but also defecation on the public streets. Faecal matter was reported from two Twitter users:

"*Homeless, Feces, people nodding out from Heroin/Fentanyl. I'm bummed*" (A4: 2)

The noticeable homeless encampments on the streets, high prevalence of fentanyl and streets covered in faeces have all contributed to a real health emergency in Vancouver, Canada.

"*They're in the midst of three simultaneous crises -- homelessness, fentanyl-overdose deaths and COVID*" (A4: 11)

The concern shown from Twitter users regarding health emergency due to homelessness and fentanyl consumption has also been shown for the exact number of fentanyl deaths in homeless population. The lack of trust in statistics provided from the government regarding deaths in the homeless population from fentanyl appeared evident from one user:

"*Okay, and how many fentanyl related deaths in the homeless population in that time*" (A4: 7)

tweeters who took a critical stance towards government and health care systems may have done so out of a wish to see health organisations provide more effective care and rehabilitation programs and the government providing more financial support. With three crisis's occurring simultaneously and the negative attitudes shown towards the government and healthcare systems, the analysis of this type of data could provide better guidance from the government and health care organisations to help combat the health emergency resulting from the consumption of fentanyl in the homeless population. Additionally, local governments in the US were obligated to reduce homelessness with regards funding rehabilitation programs, homeless shelters and increasing housing affordability (Jarpe et al. 2019). However, each local government receives different quantities of money depending on the economic stability and income of the given area.

B. Social issues

This theme encompasses tweets which expressed information, emotion and opinions about the social issues associated with homelessness and fentanyl use. Three main sub-themes were discussed on the Twitter platform and included (1) fentanyl causes high death rates among the homeless (2) fentanyl consumed in public places, and (3) increase in crime due to fentanyl consumption.

Table 5.2 Social issues associated with fentanyl consumption

Theme	Sub-theme
B. Social issues associated with fentanyl	B.1. Fentanyl causes increased mortality rate
	B.2. Public intoxication
	B.3. Increased crime due to fentanyl intoxication

B.1. Fentanyl causes high death rates among the homeless population

There were a large number of tweeters who reported a worryingly high level of homeless fatalities as the result from fentanyl consumption. Twitter users who were previously homeless reported that they would wake up next to friends that had overdosed from fentanyl. This sub-theme received only negative opinions and the majority of tweets focused on the high prevalence of fentanyl deaths in the US and Canada.

"*1500+ overdose fentanyl deaths in BC in a year and that many grieving families*" (B1: 3)

"*Homeless addicts given hotel rooms during Covid-19 are offered the complete range of drug paraphernalia. Boxes of needles, glass pipes for meth and crack, and Fentanyl supplies are laid out in the lobbies like a breakfast buffet. Fatal overdoses, not surprisingly,have spiked*" (B1: 34)

"*The homeless are doing fentanyl and dying of overdoses in the hotel rooms*" (B1: 26)

Two locations reported significantly high fentanyl death rates and included San Francisco and Vancouver, British Columbia. Both locations had seen an increase in fentanyl deaths since 2018 and is not expected to have decreased in 2020 (Karamouzian et al., 2018; Rowe et al., 2019; Oh et al., 2020). A few tweeters even suggested that the homeless were only dying of fentanyl consumption and none had died from COVID-19 during the global pandemic. Even when put into accommodation during the COVID-19 outbreak, homeless fentanyl users were still overdosing and dying. Although scientific information about the homeless population and COVID-19 is lacking researchers suggest that some local governments were prepared for COVID-19 whilst others were not (Tsai and Wilson 2020). Moreover, the locations of San Francisco and Vancouver have both reported an increase in opioid related deaths and homelessness in the last few years, prior to COVID-19 (Mayer et al. 2018; Rowe et al. 2019; Oh et al. 2020).

B.2. Fentanyl consumed in public areas

There were tweets that discussed the consumption of fentanyl in public areas, such as visible intoxication, and human contact. Illustrative examples of tweets include:

"*Recently in Kamloops a toddler found a baggy of suspected fentanyl in a park*" (B2: 1)

"*We are in crisis. This is one of addiction. Local advocates estimate 85% of our homeless population is severely addicted to Fentanyl, Meth, Heroin & Alcohol*" (B2: 7)

The tweets collected only derived from US and Canadian citizens. Both countries, especially the US, have reported increasing levels of opioid abuse over the past decade due to over-prescribing opioid medications and organised crime and cartels using synthetic opioid derivatives to increase potency (Tung 2020). Twitter users either were critical, made general comments or disseminated information regarding fentanyl being consumed by the homeless in public areas regarding this sub-theme. Visibility intoxicated and fentanyl being found by a toddler, the consumption of fentanyl from the homeless population is reported to be occurring in public areas. Ellsworth (2019) highlighted how the rapid intoxication associated with substances rendered homeless people physically vulnerable to crime, particularly theft of money and drugs from other homeless individuals and usually when under the influence substances. It appears that local advocates in San Francisco estimate that up to 85% of the homeless population are users Fentanyl, methamfetamine, heroin and alcohol. One ex-homeless individual reported that when on the train he watched a homeless man ‘nodding off’, which is an effect of an opioid such as heroin and fentanyl that causes the user to fall in and out of consciousness (Ersek et al. 2004). One Twitter user even blames the closure of safe injection sites on the increase in consumption of fentanyl in public areas, however, its now obligatory for US state governments to fund needle exchange programs to prevent occurrence of disease after the HIV outbreak in Scots county (Gonsalves and Crawford 2018).

B.3. Increased crime due to fentanyl consumption

Four types of crimes were associated with the consumption of fentanyl among the homeless population and included arson, assault, drug dealing and theft:

"*homeless kids paid with #Meth and #Fentanyl from COVID/Border shutdown related overstocks. #Riots, #Looting and #Fireworks are #ANTIFAKids high AF on free drugs. If they talk... no more drugs*" (B3: 20)

"*My mom & I were homeless by the pier in Seattle for 2 years. I was abused and sexually assaulted*" (B3: 4)

"*The corner of Golden Gate and Hyde is the largest open-air drug market in San Francisco.*

The northwest corner is controlled by Honduran street gangs. The southwest corner is controlled by black dealers. Everything is for sale: heroin, fentanyl, meth, crack, klonopin, weed" (B3: 9)

Arson was related to the riots across the US and was completely accidental and occurred when the individual was under the influence of fentanyl. Assault occurred when homeless users would fight over a bag of fentanyl or when the supply of fentanyl had decreased. Tweets reported that the homeless would become aggressive and even demanded money of peaceful citizens. Intoxicated homeless individuals are more likely engage in risky activities including theft crime and assault (Ellsworth 2019). However, open air drug markets were more commonly reported on Twitter by tweeters. Fentanyl availability was blamed on Honduran gangs, but also the how the police respond to open air drug sales with one Twitter user suggesting they are not bothered and 'smile' when alerted. These tweets show how the public are distressed with the crime that is associated with fentanyl and homelessness. Moreover, the tweets also contain elements of stigma and anti-homelessness that suggested the homeless accept drug payment to commit crimes. It's common for criminal organisations to pay vulnerable individuals with drugs as payment for them to commit crime on their behalf, such as drug-running, victim surveillance and potency testing (Syvertsen et al. 2017). This information could potentially be used by policing authorities to locate crime and disseminate advise to the public on social media platforms such as Twitter.

C. Services provided to the homeless population using fentanyl

This theme encompassed tweets which expressed emotions and reported information from personal experiences regarding the services provided to the homeless fentanyl users. The sub-themes that emerged from this theme are presented in the Table 5.3 below:

Table 5.3 Services provided to the homeless population who use fentanyl

Theme	**Sub-theme**
C. Services provided to fentanyl users	C.1. Government ignore issues on homelessness
	C.2. Government allows homeless to use fentanyl
	C.3. Government failed in reducing fentanyl
	C.4. Rehabilitation programs have failed
	C.5. Fentanyl use and COVID-19 drain hospital resources
	C.6. Fentanyl potency increases the risk of hospitalisation
	C.7. Policing of fentanyl sales has failed
	C.8. Public support shown towards reducing fentanyl consumption

C.1. Government ignores issues on homelessness

Individuals on Twitter expressed negative opinions when information was encaptured regarding the government's actions towards homelessness. Twitter information collected for this sub-theme showed that users on the social media platform were concern that political figures were addressing criteria that will gain political advantage and ignoring issues such as homelessness, high housing prices and rampant fentanyl use.

“*Democrats only address things that gain political advantage. Media ditto. Homelessness, child trafficking, fentanyl and opium addiction, are completely ignored. I wish I could say Republicans do better, but they don’t*” (C1: 1)

“*endless homeless encampments, fentanyl being handed out by the government and corruption at every level*” (C1: 25)

Tweeters reported that homelessness and fentanyl use were increasing and that the government’s actions on the matter is essential to gaining political advantage and reducing negative stigma towards their party. However, continued defunding of addiction and rehabilitation services, the COVID-19 economic crisis and endless homeless encampments have all created a negative stigma for the government. Additionally, some local governments were prepared for the effects of COVID-19, whilst other were not (Dzigbede et al. 2020). For this reason some tweeters heavily criticised the government’s ability to deal with homelessness as the levels were visibly increasing during the COVID-19 pandemic. There was, however, little evidence to suggest that the levels of homelessness were increasing and could be individual experiences of recent events. In fact the US reported the homeless rates were stable since 2017 (Hanratty 2017). The points identified in this sub-theme could be used housing authorities to identify those at-risk from homelessness and liaise with the government to provide short-term accommodation.

C.2. Governments allows homeless to use fentanyl

Some tweets referred to the change in legislation that enabled users to consume drugs without criminalisation and the state of California has recently made the possession of fentanyl, heroin, methamfetamine and cocaine a misdemeanour.

“*The problem is that G**** and K**** made possession of fentanyl/meth/heroin a misdemeanor in California (Prop47). This is why there’s record homelessness, theft and overdoses*” (C2: 3)

This sub-theme received only a negative response and some individuals claimed it increased homelessness and the overdose risk. This was evident by tweets focused on how the San Franciscan government provided hotel rooms for the homeless during lockdown and supplied them with drug paraphernalia. Although providing rooms for the homeless during COVID-19 pandemic received positive feedback from Twitter users, it was the accusations of illicit drug and drug paraphernalia being supplied to the homeless that was heavily criticised with user's claiming it increased overdose's and fatalities. Providing accommodation was done differently by each local government during the pandemic. In Las Vegas, tents were erected in car parks to provide emergency accommodation for rough sleepers, Los Angeles is using recreational vehicles and trailers to house homeless individuals infected with COVID-19 (Tsai and Wilson 2020). Cities such as Austin, New Orleans, New York, Philadelphia and San Francisco are renting 6,500 empty hotel rooms and Boston partnered with Suffolk University to use some available dorm rooms (Benadives and Nukpezah 2020). The introduction of Prop 47 was to reduce a drug possession charge down to just a misdemeanour (Bartos and Kubrin 2018). Prop 47 aimed to reduce prison recalls and processing substance use charges. Tweeters in this sub-theme heavily criticised how the government and service providers supplied drug paraphernalia during lockdown and reduced fentanyl possession to a misdemeanour, essentially allowing consumption. This information relating to users' emotion and opinions regarding fentanyl possession becoming a misdemeanour could be used by the government to examine the public sentiment about changes to drug laws and regulation.

C.3. Government failed in reducing fentanyl availability

There were tweets that encaptured the opinions and emotions of tweeters which reported specific blame towards the government about fentanyl availability. Additionally, tweeters who lived in the rural parts of the US were still experiencing high fentanyl availability, as illustrated below:

"*Rural parts of this country can't stop smoking meth and injecting Fentanyl but we don't blame Republicans*" (C3: 6)

With the use and abuse of fentanyl on the rise the public view that the government have not provided the correct resources and thus have in reducing the availability of fentanyl. As mentioned in the previous sub-theme, some of the state governments have reduced the penalty for fentanyl possession to a misdemeanour through introduction of Prop 47 (Bartos and Kubrin 2018). This has been blamed for increases in fentanyl use in urban areas such as San Francisco and California. However, a few individuals reported that there is noticeable increases of fentanyl use in rural areas also, highlighting the national increase in consumption of fentanyl.

C.4. Rehabilitation programs for homeless fentanyl users have failed

There were tweets that reported the US rehabilitation programs have failed to reduce fentanyl consumption within the homeless population. One user reported that no treatment was available, and needles were still handed out:

"*Seriously bold reporting here. 130 needles handed out in a few hours to E*** without a single mention of treatment. So much for needle "exchange" Not a single hotel was designated for sober people or for those trying to kick their habits. SF is funding a lot of drug use*" (C4: 3)

"*80% of our homeless are addicts and would choose heroin/fentanyl/meth over housing*" (C4: 10)

Tweeters reported that the increases in homelessness and fentanyl could be solved by introducing more effective rehabilitation services, including mental health and first responders (ambulance service) for the homeless population. Ex-homeless individuals even reported that when they did turn up to receive rehabilitation treatment they would get turned away from treatment. Homeless individuals were even reported to consume fentanyl to ensure they tested positive for fentanyl yet still declined access to rehabilitation. Rehabilitation programs in the US are funded by federal funds which are controlled by local governments (West 2008). Researchers have reported that states have reduced funds for addiction treatment programs during a time when opioid overdoses and unemployment rates have increase (Dhumal et al. 2021). Twitter users have voiced their opinions regarding the decrease in funds for addiction support and left individuals outraged due to over 100 needles being handed out without a single mention of treatment.

C.5. Fentanyl use and COVID-19 pandemic drain hospital resources

During the start of COVID-19 pandemic lockdown, the government's failure to provide essential resources left individuals homeless and increased rate of mortality. Public criticism towards the government's ability to deal with the COVID-19 crisis left hospitals without ventilators and the correct resources to cope with the on-going homelessness and fentanyl epidemic. Moreover, homeless addicts given hotel rooms during the pandemic received a box of drug paraphernalia in the hotel lobby, causing an increase in fatal overdoses. The purpose was to reduce harm to the homeless by providing them with clean needles reducing the risk of transmission of virus or bacteria.

"*48 people experiencing homelessness in San Francisco died between March 30 and May. Public health officials say the deaths are more likely due to overdoses from fentanyl and indirect impacts from the coronavirus pandemic*" (C5: 7)

Although the purpose was to reduce harm to the homeless by providing them with clean needles reducing the risk of transmission of virus or bacteria, the views of the public were negative. Much of the information in this sub-theme is derived on the belief that hospitals and rehabilitation services could not cope with increasing levels of homelessness and fentanyl consumption. This belief may have stemmed from individuals feeling that the concurrent issues of fentanyl consumption among the homeless and COVID-19 greatly increases the burden on the health services. A study from Hsu et al (2020) in Boston reported that hospitalised individuals admitted with COVID-19 symptoms were likely to be experiencing homelessness (16.4%) and have a substance use disorder (14.5%).

C.6. Fentanyl potency increases the risk of hospitalisation

Some tweeters reported on the risk of hospitalisation and fatality through using fentanyl and its derivatives.

"*Drug cartels are widely producing fentanyl and the homeless are being used as guinea pigs*" (C6: 8)

"*B****** M****, 18, was found dead at a homeless camp in Echo Park, Los Angeles, after using cocaine laced with opioid epidemic drug Fentanyl while helping at the camp*" (C6: 16)

There were variations in the tweets above as different geographical locations were reported, but the information collected was consistent with fentanyl being used to increase drug purity leading to an increased risk in hospitalisation. Fentanyl being used to increase drug purity is not a new concept and has been documented since 2014 and aided in the opioid crisis experienced in the US (O'Donnel et al. 2017). The potency of fentanyl creates a number of associated health risks and with cartels 'cutting' heroin with fentanyl to increase the potency due to fentanyl being 50-100 times more potent than morphine it improves the strength of poor-quality heroin (Stanley 1992). However, as one user tweeted fentanyl is being mixed with stimulants such as cocaine leading to fatality. San Francisco's department of public health released a health alert regarding fentanyl overdoses among persons using cocaine as at least 7 patients had been hospitalised due to using cocaine laced with fentanyl (San Francisco Department of Health 2021). This health alert outlined how Twitter could be used to map discussions of fentanyl overdoses, and also provided links to number of potential fentanyl outbreaks.

C.7. Policing of fentanyl sales and consumption has failed

Tweeters criticised the policing of fentanyl and received negative comments and discussion from tweeters. As previously mentioned, the high prevalence of fentanyl was observable by many members of the public and caused significant distress. However, the police's ability to reduce the sale and supply of fentanyl is heavily criticised, as illustrated below:

"*they could get free drugs that are actually research chemicals like 5 Meo PCP, DOC, fentanyl etc. too bad the homeless love me and talk to me*" (C7: 4)

The information reported by tweeters in this sub-theme focused on an inability to police the fentanyl epidemic. Understandably, stigma and negative attitudes were shown towards the police for their lack of criminal investigations into fentanyl overdoses and sales. The users above did not disclose their location, and it may be that they were tweeting from a region that has more open-sales drug markets or California, where the introduction of prop 47 has decriminalised drugs (Bartos and Kubrin 2018). Information collected in this dataset could be useful for the legal authorities by identifying areas known for fentanyl availability and further taking criminal action to reduce supply.

C.8. Public support towards reducing homelessness and fighting addiction

A small number of tweets showed public support for homeless individuals. One ex-homeless individual used Twitter to provide support and information about how they were rehabilitated and now, drug free. The user reported:

"*I started homeless and addicted to fentanyl in Philly, NYC, DC & Baltimore. Now I am clean and prepared. Took a while. It's a process*" (C8: 6)

This was the only sub-theme in the service provider theme that encaptured only positive comments and discussion. Two ex-homeless individuals promoted how they were rehabilitated from fentanyl abuse and that harm reduction works, but it is a long and difficult process.

5.3.2. Spice

SCRAs were also mentioned in tweets with Spice the main SCRAs emerging (Figure 5.4). Two main sub-themes were discussed on Twitter regarding Spice and homelessness and consisted of social issues and discussions about service providers, which typically contained the emotion and personal feelings on homeless population using Spice.

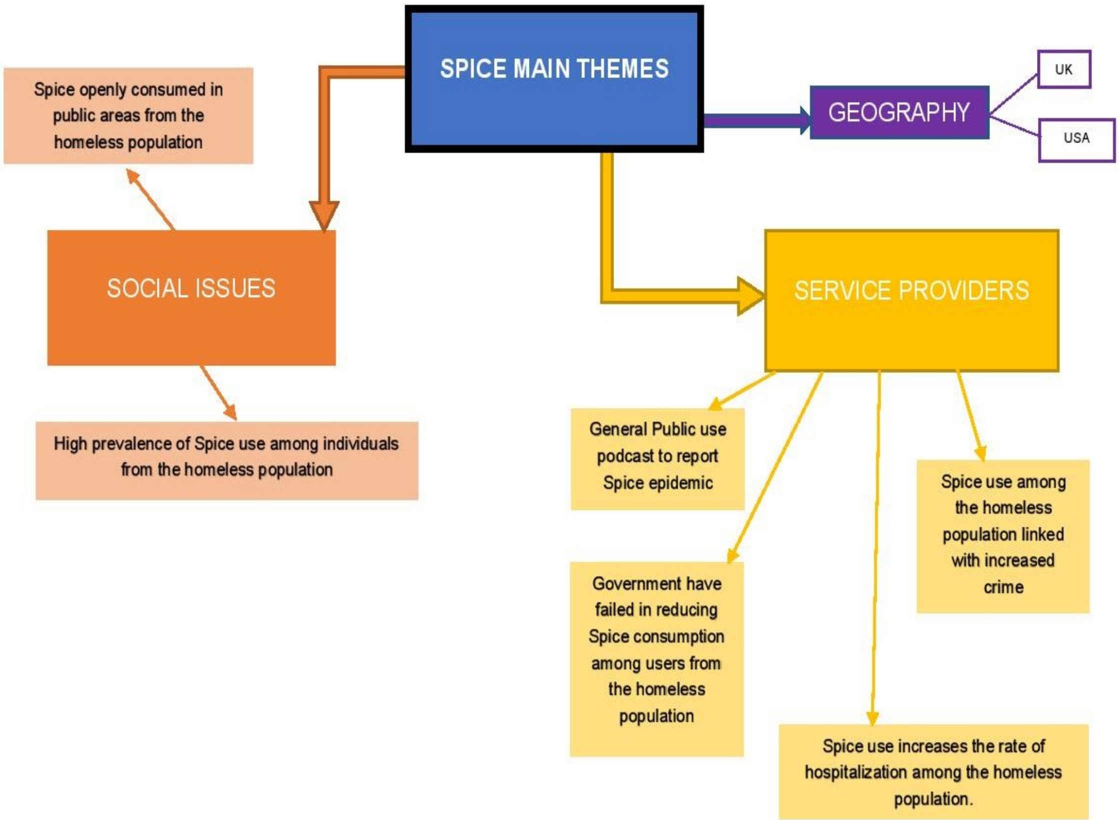


Figure 5.4 Diagrammatical overview of Spice themes and subthemes

5.3.2.1. Geography of homeless Spice users

Twitter users often reported the location where they had seen homeless individuals using Spice in the US and UK. Although both the US and UK were discussed in tweets from Twitter users the consumption of Spice in the UK is much more prevalent than in the US. For the UK, Manchester and London were the main locations at which the homeless were known to consume Spice in public. It was found that the Northern mill towns were plagued by homelessness and Spice consumption resulting from lack of employments and grooming gangs. Although, northern parts of the UK were affected the most by homelessness and Spice consumption, both were much more prevalent in Manchester that was in turn, the focus for most media articles and research reports about the two concurrent issues (Ralphs and Gray 2018). Additional UK locations reported but less frequently include Doncaster, Birmingham, Bristol, Cardiff, Chester and Lincoln and all locations had higher national prevalence of homelessness than national rate (Seely et al. 2012; Gray et al. 2021). For the US, only Florida was reported from the public as a known location for Spice use among the homeless population.

D. Social issues associated with the homeless population using Spice

This theme encompasses tweets which expressed information, emotion and opinions about the social issues associated with homelessness and Spice use. Two main sub-themes were discussed on the Twitter platform and included (1) high prevalence of Spice among homeless, and (2) public intoxication.

Table 5.4 Social issues associated with Spice consumption

Theme	**Sub-theme**
D. Social issues associated with Spice	D.1. High prevalence of Spice among homeless
	D.2. Public intoxication

D.1. Very high prevalence of Spice use among homeless population

A very popular discussion on Twitter regarding homelessness and Spice use was the high prevalence consumed from individuals in the homeless population. Homeless Spice users were described as zombies who acted crazy and made the city centre a threat as illustrated below:

"*The homeless have more complications than it being that simple, they all don't want help and unfortunately they are not all homeless, yes they really need help but we need to find another option for them than getting wasted on spice and alcohol*" (D1: 11)

"*Spice use within the homeless population remains a serious issue. P*** G***, R** R**** and L*** W***** analyse motivations, harms and the implications for developing a response*" (D1: 24)

Examining the tweets in this section it appears that Twitter users held the belief that the homeless were left no choice other than to consume Spice and alcohol and is the reason for the high prevalence. The high prevalence of Spice consumption within the homeless population has been documented by researchers in the UK and US (Zarifi and Vyas

2017; Ellsworth 2019; Gray et al. 2021). Most of the comments and opinions in this sub-theme were negative and accusing the homeless as intimidating members of the public:

"*The city centre is a threat to walk through on a good day. Lots of spice heads, homeless and crazies*" (D1: 5)

The desire to consume spice from homeless individuals have left members of the public to express opinions that the homeless population would rather consume spice than have a job or be housed. However, some Twitter users advise that the public need to be educated on spice use among the homeless population to help understand homeless drugs users and non-homeless drug users. This information could be used by local authorities to warn the public about drug use in certain areas, also it could provide guidance to service providers to reduce Spice consumption among the homeless population.

D.2. Spice consumed in public places

There were tweeters who described the issue of Spice being consumed in public as an epidemic and was perceived as dangerous and intimidating. When under the influence of Spice, users sometimes exhibit physical characteristics that have been described to imitate a zombie, as illustrated below:

"*So many homeless in Manchester it's like a scene from the Walking dead*" (D2: 6)

"*A homeless man comes up to me and offers me spice, in which i said no to*" (D2: 16)

Tweets regarding Spice being consumed in public places might reflect anxiety and distress, as people with these symptoms act in an aversive state and is unable to completely adapt to stressors resulting in a maladaptive behaviour (Alexandrescu 2020). Manchester city centre was described as scene from the "Walking dead" and raised concern about the homeless spreading COVID-19 during national lockdown. Additional, users reported homeless individuals offering Spice after engaging in conversation. Although many researchers have documented the effects loss of motor control (Seely et al. 2012; Zarifi and Vyas, 2017; Ellsworth 2019; Alexandrescu 2020; Gray et al. 2021), none have reported the homeless offering Spice. Additionally, no support shown towards the homeless in this sub-theme and it encaptured only negative opinions and emotions about personal experiences with the consumption of Spice in public areas. Like previous sub-theme, the consumption of Spice in public areas remains a serious issue and public health problem. Notably, information contained in this sub-theme only captured the negative attitudes of the public shown towards the homeless population. The findings in this sub-theme and the previous sub-theme (high prevalence of Spice) further add to existing evidence on how the homeless population are consuming Spice.

E. Services provided to homeless Spice users

This theme encompasses tweets which expressed information, emotion and opinions about the social issues associated with homelessness and Spice use. Two main sub-themes were discussed on the Twitter platform and included (1) very high prevalence of Spice use among the homeless population, and (2) Spice openly consumed in public area.

Table 5.5 Sub-themes of discussion regarding services provided to homeless Spice users

Theme	Sub-theme
E. Services provided to homeless Spice users	E.1. Public support for reducing Spice consumption among homeless
	E.2. Government failed in reducing Spice consumption
	E.3. Spice consumption increases rate of crime among homeless
	E.4. Spice increases the rate of hospitalisation

E.2. Government failed in reducing Spice consumption

The majority of tweets in this sub-theme was the result negative responses to the government’s actions regarding homelessness and Spice. A large portion of the tweets focused on how governmental neglect has been the cause for an in the increase in homelessness and Spice consumption, as illustrated below:

“*My point was we had a pandemic with the opioid and Spice abuse and we did nothing except give our first responders Narcan to revive the addicted. A decade of neglect cost the lives of 500k and a homelessness crisis*” (E2: 1)

Larger cities such as Manchester, Doncaster and Birmingham were susceptible to more prevalent homelessness and Spice consumption. A reason for this explained by tweeters was that the desperation of the homeless population in combination with political corruption and lack of services provided created ‘hopeless’ homeless with no other option other than to get ‘wasted’. Researchers at Manchester Metropolitan University (MMU) have documented a high prevalence of Spice consumption among the homeless population with some estimates up to 95% of the population (Ralphs and Gray 2018).

“*lived in Birmingham centre since I was born. We need to be honest and admit their is a problem with the youth culture and homelessness / spice addicts in the city centre*” (E2: 11)

“*yes they really need help but we need to find another option for them than getting wasted on spice and alcohol*” (E2: 5)

There were variations in the tweets above, as different geographical locations were mentioned alongside different age groups reported. However, the majority of tweets contained stigma and negative attitudes towards the government and homeless population. Twitter users criticised the homeless for their consumption of Spice, but also how the government have neglected the issue and blamed the increase in consumption due to decreased funding to service providers.

Additionally, this is a form of prevalence monitoring and can be used by the local Police to identify key areas of Spice use and advise the public to avoid the area until further policing has been conducted.

E.3. Spice consumption among homeless linked with an increase in crime

A mix of crime in this sub-theme was reported and included drug dealers facing prison time for selling Spice to the homeless and the homeless committing crime when under the influence of Spice.

"*Jailing him for 18 months and banning him from Chester city centre for three years, Judge S**** E****** said he had "no doubt" W**** L****** was selling spice to vulnerable members of the homeless community*" (E3: 1)

"*Spoke to a homeless chap this morning and he pointed out a favourite hiding spot for a spice dealer and his stash. It's not their now. 22 packets of misery now in safe custody and awaiting destruction*" (E3: 5)

The consumption of Spice among the homeless population has created an underground black market for dealers to exploit and make profits. The underground black market has seen dealers stash their Spice in a variety of public places to avoid being caught with it in their possession. It was anticipated by researchers and governmental officials that NPS sales would move underground after introducing the PSA (2016) whereby drug dealers distribute NPS instead of headshops (Shafi et al. 2017). The media outlined recent drug convictions about how drug dealers specifically target the homeless population to consume Spice, making thousands in process. On July 17th 2020 an article was published by the UK broadsheet newspaper The Daily Telegraph, which questioned why Spice dealers are given low sentences when prosecuted highlighting how if affects the homeless population (The Daily Telegraph 2020).

Although the tweets from the media regarding the prosecution of Spice dealers were sympathetic towards the homeless population, other Twitter users reported that the homeless cause public disturbances when smoking Spice.

"*Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog*" (E3: 10)

Its worthy to mention that the media were sympathetic towards the homeless and the public not so much. Members of the public were terrified of the homeless when under the influence of Spice and avoided areas known for heavy use.

E.4. Spice use has increased the rate of hospitalisation

The addiction potential, unknown potency and composition has increased the likelihood of hospitalisation for individuals from the homeless population.

"*Tackle Spice use among the homeless by prioritising improved services addressing mental health needs and access to detox and rehabilitation argues @MMU*" (E4: 2)

"*I started the Crisis Intervention Team when I was mayor, where SLC police were trained to recognize and deal with mental illness. I called police when a homeless friend violently reacted to Spice and the CIT responding officer was terrific, got him med help*" (E4: 10)

Manchester Metropolitan University (MMU) argued through a podcast that prioritising services that address mental health needs and faster access to detox facilities would help tackle the Spice use among the homeless population. This was further elaborated by a previously homeless individual explaining that after a six-month detox program one individual relapsed and overdosed as a result, as illustrated below:

"*but this guy was in rehab with me! His drugs of choice were Meth and Spice. He graduated the 6 month program, relapsed, and this is the result*" (E4: 3)

The reasons blamed for an increased rate of hospitalisation is that Spice is too strong and a significant reduction in price. The information collected revealed that the majority of homeless Spice users failed to completely finish their rehabilitation program and if completed, there was a high chance of relapse. Additionally, a number of users shared information about improving rehabilitation programs and prioritising mental health needs on an individual case-by-case scenario. This information could be useful for health services to provide a guidance in treating Spice users in a more holistic approach, rather than focusing on just the drug use.

5.4. Discussion

It is important to note that previous studies examining homelessness and NPS consumption discussions on Twitter aimed to validate the potential of Twitter as a tool to monitor previously homeless individuals, and none of these studies used an in-depth qualitative approach to analyse data (Grant and O'Mahoney 2016; Sandhu et al. 2019; Talbot at al. 2020; Unger 2020). The aim of this study was to explore in-depth the content of tweets using thematic analysis and to examine the types of conversations that were taking place. In doing so, the study developed new knowledge on the types of conversations that were shared by users and which had not been reported in previous literature. Two primary NPS themes emerged out of the tweets and included fentanyl and Spice, which to the authors knowledge, have not been reported in previous studies (Talbot at al. 2020; Unger 2020). Hence, this study developed new knowledge related to potential popular culture influencing how tweeters were understanding and speaking about homelessness and NPS use. For example, some tweeters made references to zombies and to a zombie apocalypse, and these tweets were categorised within the Spice theme and public intoxication sub-theme. Another interesting finding was that Twitter users who were previously homeless were using the platform to promote awareness and support services, by tweeting information and opinions regarding support services, as reported in a previous study (Jung and Valero 2016).

This study also developed new knowledge on how tweeters would refer to fentanyl and Spice consumption among users from the homeless population. For example, fentanyl consumption among homeless individuals is an issue in the US and Canada and not in the UK. Additionally, Spice consumption is an issue in the UK and reports of homeless using Spice in the US is also reported, but less frequently. This study found that fentanyl consumption was only an issue for the US and Canadian homeless populations. The results from fentanyl discussions on Twitter revealed 15 new emerging themes, and to the authors knowledge have not been reported in previous research (Mackey et al. 2017; Mackey et al. 2018; Al-Rawi 2019). The 15 fentanyl sub-themes were further categorised into three themes including economic issues, social issues and service providers.

Four sub-themes were reported from the economic issues associated with homelessness and fentanyl use. For example, a number of users blamed fentanyl for causing homelessness and being more desirable than housing and constructed negative tweets towards government officials who were accused of causing homelessness and fentanyl consumption.

This study also developed new knowledge on the social challenges associated with homelessness and fentanyl consumption and found that tweeters were negative about public intoxication, high mortality rate, and increased crime. Although public intoxication and high mortality rate have both been reported by researchers in literature (Slatkin et al. 2007), tweets regrading increased crime due to fentanyl consumption was of interest. It was found that tweets contained specific information about the crime committed by the homeless were under the influence of fentanyl, which to the best of authors knowledge, is not yet reported in literature.

The theme regarding the services provided to the homeless population contained eight sub-themes which all but one was negative towards service providers. The government received most of the criticism from tweeters and was blamed for ignoring homeless and fentanyl issues, allowing homeless to use fentanyl, and failing to reduce fentanyl availability. It was also found that tweeters blamed the government for failing rehabilitation programs and a shortage in hospital resources. The views most likely influenced the beliefs people held, specifically that the government are solely responsible for homelessness and rampant fentanyl use. This is a serious issue, and with the COVID-19 pandemic state financing of service providers has significantly decreased (Eren et al. 2020). Previous studies have noted the reduction in state funding for service providers due to the COVID-19 pandemic (Johnson et al. 2020; Maani and Galea 2020) and the potential for mainstream media to influence conversations on Twitter (Li et al. 2016).

This study also developed new knowledge on how tweeters would report Spice consumption among the homeless population. The UK and US homeless populations were both reported to consume Spice, which could contain more than one SCRAs. Previous studies in the UK and US have documented the high prevalence of Spice consumption among the homeless population with most of the research originating from the UK (Ellsworth 2019; Macleod et al. 2016; Ralphs and Gray 2018; Alexandrescu 2020). The results from Spice discussions on Twitter revealed six new emerging sub-themes, and to the authors knowledge have not been reported in previous research. The six sub-themes were further categorised into two themes, including social issues and services provided. Two sub-themes emerged from the social issue theme that were discussed on Twitter and were public intoxication and high prevalence of spice. For both sub-themes extracted, tweeters constructed negative tweets towards the homeless population, although not all tweets were negative in sentiment. This study also found that tweeters blamed Spice use for increasing the rate of crime and hospitalisation within the homeless population. For example, the increase in crime and hospitalisation due to Spice consumption was blamed on the homeless population's boredom, whereas tweeters blamed the government for failing to reduce Spice. Another interesting find was that tweeters were using the platform to promote awareness during the COVID-19 pandemic by tweeting media articles and scientific reports. Previous studies have noted the potential of the mainstream media to influence conversations on Twitter, but not scientific research conducted by Universities (Li et al. 2016). It was found that the mainstream media were not mentioned frequently, but often reported criminal proceeding associated Spice distribution among the homeless population.

5.4.1. Limitations

This study analysed tweets from a six-month period, hence the findings are not applicable to all Twitter activity related to homelessness and NPS consumption during 2020, and hence was not sufficient to compare pre and post COVID-19. When analysing tweets and Twitter data, a known limitation among the research community is that Twitter data does not reflect the offline population or even the online population to an extent. However, the aim of the study was to examine content that was shared on Twitter to generalise the findings to the offline population. As was noted in the results presented in this chapter, certain NPS (fentanyl and Spice) and geographical locations (i.e., the US) may be over-represented (Pew Research Centre 2016). It must also be noted that people might behave differently on Twitter compared to what they might say in a research interview: for example, views in tweets may be exaggerated as a reaction to an event. However, one strength of Twitter analyse it avoid the bias of the interviewer. Due to the qualitative nature of this research study, there might be slight variations in the themes and sub-themes that could have emerged if the study was repeated by another researcher. This is because the tweets could be interpreted differently by different researchers. Measures were taken to avoid this by performing intercoder and test-retest reliability. Furthermore, as this study only examined tweets that were written in the English-language and excluding tweets in other languages, this study was limited as it may not represent the homeless populations in non-English speaking countries. One further limitation was no confirmatory analyses to establish identity of NPS derivative used was conducted.

5.5 Conclusions

In summary, several interesting and original results across the themes and sub-themes were identified from the data. For instance, fentanyl related information was more frequently reported than Spice and report mainly in the US and Canada. Fentanyl related information caused tweeters to tweet negative information towards the government and their ability to reduce fentanyl consumption among the homeless population, which has caused high death rates public intoxication. Moreover, it is interesting to note that Twitter users did not promote awareness or support unless they were previously homeless. Potentially, it may have been better for ex-homeless individuals to promote awareness and support rather than media organisations as it reflects how previously homeless individuals succeeded in becoming rehabilitated. Spice related information was only reported from two geographical locations being the UK and US, however, the UK had most Spice related tweets. It emerged that the high prevalence of Spice was the cause for public intoxication and an increase in crime and hospitalisation for which the governments were named. It was interesting to note that University researchers would promote their research through the Twitter platform in order to help the public understand the problem.

Further discussions will take place in Chapter 8, which discusses the results of the individual research studies in comparison to one or another. These findings will be of interest the service providers and public health organisations to be in a better-informed position when disseminating information on Twitter. The methodology of extracting smaller qualitative datasets used in this study may serve as a useful guide for service providers and health organisations that wish to sample and analyse tweet content about the homeless using NPS. Moreover, the result presented in this chapter are likely to inform public health strategies and homeless service providers for future NPS use.

Chapter 6. Detectability of NPS impregnated into paper using IR spectroscopy

6.1. Introduction

Infrared (IR) spectroscopy is the measurement of light interacting with molecules by absorption, emission or reflection. The IR portion of the electromagnetic spectrum us usually divided into three regions (near, mid and far), and named for their relation to the visible spectrum. The most widely used application of IR spectroscopy is for qualitative analysis of organic compounds as the IR spectrum of a sample provides a unique fingerprint revealing the chemical and physical properties of the sample of interest (Baker et al. 2014).

Herbal mixtures containing synthetic cannabinoids have appeared under the denomination of “Spice” being sold anywhere from the Internet to a variety of specialised shops, known as headshops (Vandrey et al. 2012). The market for synthetic cannabinoids is quickly changing in order to circumvent international control and criminalisation by changing the molecular structures, usually by the addition or removal of a functional group to the molecular structure (Hermanns-Clausen et al. 2013; ElSohly et al. 2014). The constantly changing market implies a challenge for the identification of cannabinoids in samples and a threat to public health as the side effects are unknown, and generally, toxic. Synthetic cannabinoids have been linked to multiple fatalities and mass poisonings (Hermanns-Clausen et al. 2013; Shaefer et al. 2013; Adamowicz et al. 2019). Before international control of NPS the profile of users was typically vulnerable young adults (Alexander 2012*).* More broadly, NPS have been said to increase levels of anti-social behaviour, disengagement from services and homelessness (Ralphs et al. 2017).

Although the emergence of NPS is continuous, it was not until 2016 that the UK banned all psychoactive compounds (excluding nicotine, alcohol, caffeine and food products) under Psychoactive Substance Act 2016 (PSA). The legislative framework was introduced in the UK and implemented to ‘blanket’ ban the supply, importation and exportation of these drugs. The Home Office has identified that the consumption in the adult population has considerably reduced since the PSA, mainly driven by the reduction of use among those aged 16 to 24 years old (Al-Banaa et al. 2020). The prevalence of NPS among vulnerable populations appear to be different, with evidence that the NPS use remains the same and has been unaffected by the PSA, especially in the homeless population (UNODC 2019). Obviously, crucial questions for policy makers and service providers are addressed when designing and delivering interventions to this area (Narendorf 2017).

An impact of international control and regulation of psychoactive substances is the new and novel ways of smuggling drugs that has been reported in a variety of settings including prisons and homeless populations making it harder to detect NPS (Blackman and Bradley 2017). Such new method for smuggling includes impregnating NPS into paper usually covered in writing or drawing from children to avoid susceptibility (Duke 2020). This is done by dissolving cannabinoids in organic solvents, usually in acetone or ethanol and spraying or soaking onto paper (Ford and Berg 2018). This new method for users to smuggle and consume NPS in UK prisons has now been encountered in the UK homeless population residing on the streets. Researchers in the UK and local Police agencies reported that NPS dealers are now soaking paper or cigarettes in a NPS solvent mixture that potentially contains cutting agents and selling the product to the homeless population in an attempt to avoid suspicion from the police when searched (Lloyd et al. 2018).

Most analytical methods include the use of destructive instruments and toxic chemicals thus destroying the sample. The most common drug-testing practises are based on two-tier approaches of rapid on-site screening methods followed by a confirmatory testing in official laboratories. In this sense, the UNODC lists the attenuated total reflectance-Fourier transform infrared (ATR-FTIR) techniques as one of the viable alternatives for qualitative analysis of cannabinoids (UNODC 2016). The infrared spectra of the residues of herbal mixture extracts, after evaporation of the solvent onto an ATR element, is to be used for simple and fast identifications of synthetic cannabinoids. However, as previously mentioned NPS are now being smuggled and consumed on pieces of paper to avoid on-site detection. Hence, the use of portable spectroscopy and in this case ATR-FTIR is a desirable choice for law enforcement personnel to use in the field. When Ralphs (2018) reported that the Police had started to discover NPS impregnated into paper and cigarettes via homeless informants, it raised serious concern over the safeguarding from NPS and thus the need for on-site field testing is a crucial step to reduce the consumption.

6.1.1 Aim

This research aimed to detect and predict different concentrations of NPS impregnated into paper matrices using portable ATR-FTIR spectroscopic instruments. The information collected in the literature review and results collected in the exploratory studies informed the design of this research. Hence, detecting and predicting NPS and cutting agents impregnated into paper was a crucial final stage of this research as it could provide to be a useful tool for service providers and law enforcement agents when trying to identify NPS in the field. The specific objectives for this research study include:

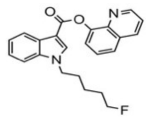
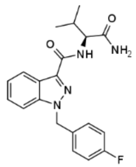
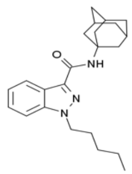
1. Identify what functional groups are detectable when the four NPS and four cutting agents are impregnated into paper
2. Interpret the functional groups present for the four NPS and cutting agents measured using ATR-FTIR spectroscopy
3. Determine If partial least squares regression can quantify different concentrations of the substances that are impregnated into paper
4. Explore chemometric techniques for differentiating between different impregnated substances

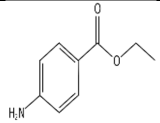
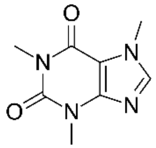
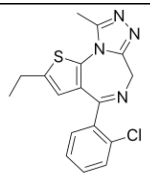
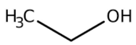
6.2. Method

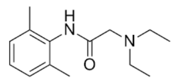
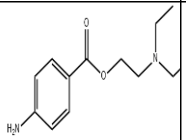
6.2.1. Materials

Samples of paper, NPS, cutting agents and solvents were used. The samples were measured either in raw form (as purchased) or after impregnation into paper. The NPS and cutting agents were measured in powdered form and impregnated into paper after dissolving in a solvent. Although the majority of NPS are produced and manufactured in China (EMCDDA 2019; UNODC 2020) the four NPS used this research were of analytical grade and purchased from Kinesis. The reason for purchasing NPS of analytical grade (~99.9% purity) and not acquiring in confiscated drug-form was due to the nature of the research and where impregnating the substances would render them from being used again. Additionally, acquiring the NPS through purchasing from Kinesis was easier and cost-effective. The four NPS were chosen from research conducted by Ford and Berg (2018) that identified NPS impregnated into paper in seized prison mail. The four NPS included three synthetic cannabinoids (5F-PB-22, AB-FUBINACA and AKB-48) and one synthetic benzodiazepine (etizolam). The cutting agents consisted of four compounds that were identified in impregnated paper found in Ford and Berg’s study and included benzocaine, caffeine, lidocaine and procaine (Ford and Berg 2018). All cutting agents were purchased from Sigma Aldrich and were of analytical grade (purity ~99.9%). A total of five different densities of paper were used for this study (75, 80, 90, 100 and 120 g/m^2) and purchased from Navigator. Ethanol of analytical grade was purchased from Sigma Aldrich. All samples used in this study were manufactured in the UK. For the purpose of impregnation, only 80 g/m^2 was used as this is the most commonly used weight of paper.

Table 6.1 Chemical properties of NPS and solvents used in the study

Chemical name	**Chemical formula**	**Chemical structure**	**Molecular weight (g/mol)**	**Physical form**	**solubility**	**stability**
5F-PB-22	$C_{23}H_{21}FN_2O_2$		376.4	White crystalline	Partially soluble in ethanol	>3 years
AB FUBINACA	$C_{20}H_{21}FN_4O_2$		368.4	White crystalline solid	Low solubility in H_2O	>3 years
AKB-48	$C_{23}H_{31}N_3O$		365.5	White crystalline powder	Ethanol 30mg/mL	>2 years

Benzocaine	$C_9H_{11}NO_2$		165.19	White crystalline powder	Ethanol 200 mg/mL	>2 years
Caffeine	$C_8H_{10}N_4O_2$		194.19	White crystalline powder	Ethanol 15mg/mL	>3 weeks
Etizolam	$C_{17}H_{15}ClN_4S$		342.1	White crystalline powder	Ethanol 30mg/mL	>4 years
Ethanol	C_2H_6O		46.1	Colourless liquid	Soluble in water	>2 weeks

Lidocaine	$C_{14}H_{22}N_2O$		234.34	White crystalline powder	Soluble in ethanol (50 mg/mL)	>2 years
Procaine	$C_{13}H_{20}N_2O_2$		236.31	White crystalline powder	Soluble in ethanol (30mg/mL)	>2 years

6.2.2. Instrumentation

6.2.2.1. ATR-FTIR Spectrometer 1

ATR-FTIR measurements were collected using Bruker Alpha Attenuated Total Reflectance (ATR-FTIR) equipped with solid diamond crystal and controlled pressure anvil (Figure 6.1). Each sample spectrum was collected over the wavenumber range of 650-4000 cm^{-1} at a resolution of 4 cm^{-1} and high-performance dTGS (deuterated triglycine sulphate) detector. Each spectrum contained 1768 spectral data points.

Figure 6.1 Bruker Alpha ATR-FTIR spectrometer

6.2.2.2. ATR-FTIR Spectrometer 2

ATR-FTIR measurements were collected using Agilent 4500 series ATR-FTIR spectrometer equipped with triple reflection diamond crystal and controlled pressure anvil (Figure 6.2). Each sample spectrum contained 1798 spectral datapoints collected over the wavenumber range of 650-4000 cm^{-1} at a resolution of 4 cm^{-1} using a thermoelectrically cooled dTGS detector.

Figure 6.2   Agilent 4500 series ATR-FTIR spectrometer

6.2.3. Procedure

NPS and cutting agent samples were measured without any sample treatment by direct contact with the instrument, underneath the anvil. Paper samples were also measured without any sample treatment. First, determining the rate of evaporation of the solvent after impregnation into the paper was conducted. Paper samples were soaked in a bath of ethanol for 5 minutes and measured at different interval during drying. This initial analysis was to determine how long it would take ethanol to evaporate completely from the paper sample. For each sample comparison, a single spectrum was taken over the wavenumber region of 650 – 4000 cm^{-1}. For correlation and PCA datasets, 10 spectra were taken from each sample. The four NPS compounds and four cutting agents were dissolved in ethanol in four different concentrations (10, 15, 20 and 25 mg/mL) and impregnated onto five different densities of paper (75, 80, 90, 100 and 120 g/m^2) through soaking. Paper samples of each density were cut into 1cm^2 segments and then soaked into each of the of the four NPS solutions for one minute per sample and left to dry at ambient room temperature and humidity for 60 minutes. Ten spectra were collected for each sample and each spectrum was the sum of 32 scans. For identification, the optimum methods used were correlation in wavenumber space (CWS) and principal component analysis (PCA). For concentration prediction, partial least squares regression (PLSR) was applied.

6.2.4. Data analysis

The spectra were analysed using Microsoft Excel 2016 and Matlab 2020b. No spectral treatment was performed before importing the spectral data to either of the programs. Multivariate statistics tools such as principal component analysis (PCA) was applied to classify the variances between each NPS and cutting agents and to cluster the spectral properties, which are selective for the structure of the NPS and cutting agents. Additionally, the use of partial least squares regression (PLSR) was applied for quantitative analysis of different concentrations impregnated into the paper matrix. By using PLSR the different concentrations of NPS and cutting agent are predicted by using a calibration dataset, where the relation between the spectra and NPS/cutting agent concentration is deduced from a set of reference samples. PLSR has been used predicted different concentrations of NPS (Pereira et al. 2017; Vera and Yira 2019) and traditional drugs (Hughes et al. 2013; Eliaerts et al. 2017; Stevanovic et al. 2021). Root mean square error (RMSE) is the measure of how concentrated the data is around the line of best fit and is calculate by the standard deviation of the residuals (prediction errors). R-sqaured (R^2 or coefficient of determination) shows how well the data fits the regression model and is the statistical measure in a regression model that determines the proportion of variance in the dependant variable that can be explained by the independent variable.

6.3. Results

A total of four NPS and four cutting agents were impregnated into paper at four different concentrations, as described in the materials section above. ATR-FTIR spectroscopy was then applied to detect the NPS/cutting agent, calculate the concentration, and classify variances between each detected compound. Spectral analysis of paper was a necessary first step in order to gain an understanding of functional group information regarding paper which would then help identify peaks attributing to impregnated compounds.

6.3.1. Spectral analysis of paper using ATR-FTIR

The paper spectra were examined over the wavenumber ranges 650-4000 cm^{-1}. Characterisation was made by examining the functional groups in the papers in reference to the available literature. Some of the paper samples were easily discriminated on the basis of their IR spectra. Most of the paper samples show prominent peaks at fingerprint regions around 870, 893, 979, 996, 1099, 1153, 1311, and 1414 cm^{-1} and some other peaks 2886 cm^{-1}, 3281 cm^{-1} and 3330 cm^{-1}. These peaks are mainly due to two components, cellulose that is organic in nature and an inorganic filler such as calcium carbonate ($CaCO_3$). Table 6.2 shows the differences in absorbance between the different densities of paper measured using ATR-FTIR spectroscopy. The spectral bands in the fingerprint region show that increasing the density of paper increases the spectral band intensity (absorption units). This trend is not observed for spectral bands outside the fingerprint region where the peak intensity is not correlated with paper density.

Table 6.2 Spectral band position and intensity for the different densities of paper

Position (cm-1)	**Vibrational mode**	**Band intensity (absorbance units)**						
		60 g/m2	**70 g/m2**	**75 g/m2**	**80 g/m2**	**90 g/m2**	**100 g/m2**	**120 g/m2**

3200-3400	O-H stretch	0.04	0.09	0.11	0.05	0.1	0.09	0.06
2890	CH stretch	0.01	0.06	0.05	0.02	0.05	0.05	0.04
1600-1650	H_2O bending	0.01	0.04	0.01	0.03	0.02	0.03	0.05
1420	CH_2-COH bending	0.08	0.05	0.07	0.12	0.12	0.11	0.11
1414	CO_3 stretch	0.09	0.05	0.07	0.12	0.12	0.11	0.11
1370, 1335, 1316	CCH-COH bending	0.07	0.06	0.06	0.1	0.1	0.09	0.1
1150	COC stretch	0.05	0.08	0.07	0.08	0.08	0.08	0.1
1099	CO_3 stretch	0.09	0.12	0.11	0.12	0.12	0.12	0.14
1050	C-OH stretch	0.12	0.18	0.15	0.19	0.2	0.21	0.22
996, 979	C-O stretch	0.16	0.22	0.24	0.22	0.26	0.24	0.27
895	C-O-C in-plane stretch	0.12	0.11	0.09	0.09	0.09	0.09	0.12
870	CO_3 deformation	0.11	0.09	0.1	0.13	0.13	0.13	0.16
710	CO_3 deformation	0.07	0.1	0.08	0.1	0.12	0.1	0.12

Spectral bands assigned to cellulose were observed at 3400 cm^{-1}, 2830 and 2886 cm^{-1} and attributed to the hydroxyl group stretch (O-H) and symmetric and asymmetric stretching CH in cellulose, respectively. The bands in the fingerprint region around 1420 and 1311 cm^{-1} are due to the symmetric bending of C-H and methylene group (CH_2) wagging, respectively. A band present at around 1200 cm^{-1} is the stretching of the carbonyl group (C-O) and sharp bands at 1153 cm^{-1} depict the asymmetric stretching of the ether group (C-O-C) and ring breathing of C-C. The sharp band around 1050 cm^{-1} is from the stretching vibration of an alcohol group (C-OH) and band observed near 895 cm^{-1} is the in-plane stretching vibration of (C-O-C) of cellulose. A strong absorption band around 1415 cm^{-1} and 870 cm^{-1} are from the inorganic filler calcium carbonate and a small band at 1632 cm^{-1} are from bending vibration of adsorbed water (H_2O bending). The spectrum of blank paper is shown below in Figure 6.3.

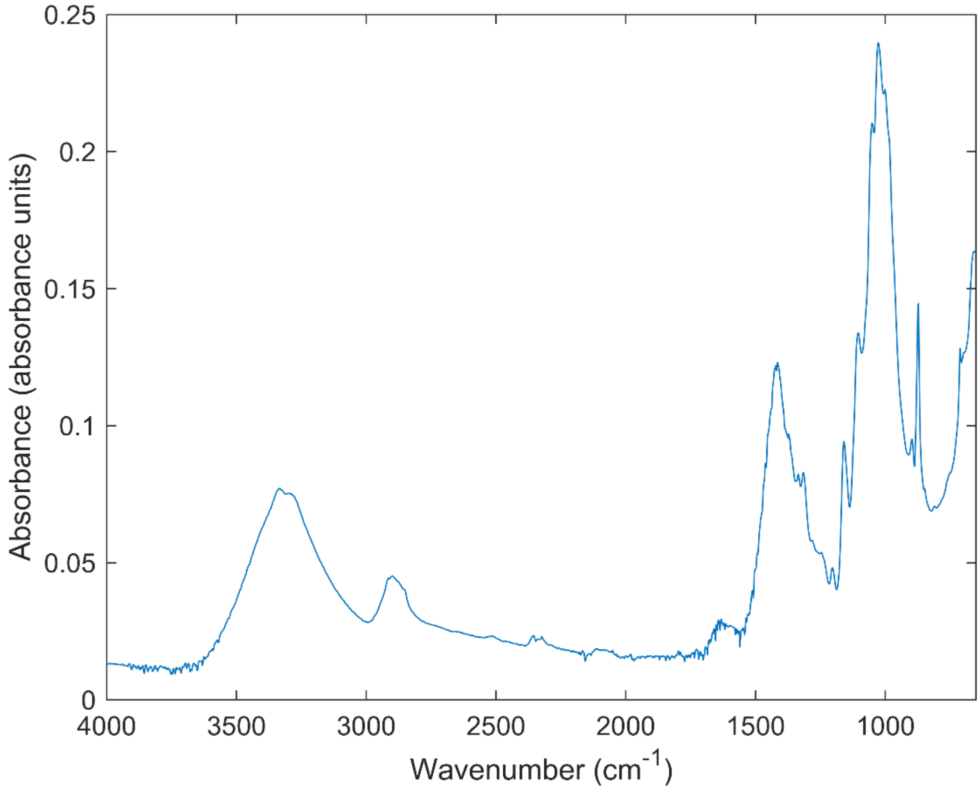


Figure 6.3 Raw ATR-FTIR spectrum of blank paper measured using Alpha Bruker ATR-FTIR spectrometer

6.3.2. NPS spectral analysis interpretation using ATR-FTIR

6.3.2.1. 5F-PB-22

Typical absorption bands of 5F-PB-22 were observed at at 607, 752, 809, 846, 958, 1050, 1154, 1191, 1360, 1454,1525, 1713 and 2918 cm^{-1} in the ATR-FTIR spectrum. For 5F-PB-22 the most intense IR bands are located at 752, 958, 1050, 1160 and 1713 cm^{-1} and related to C-H bending, C=C bending of an alkene, C-O stretching, C-N stretching of an amine and C=O stretching, respectively.

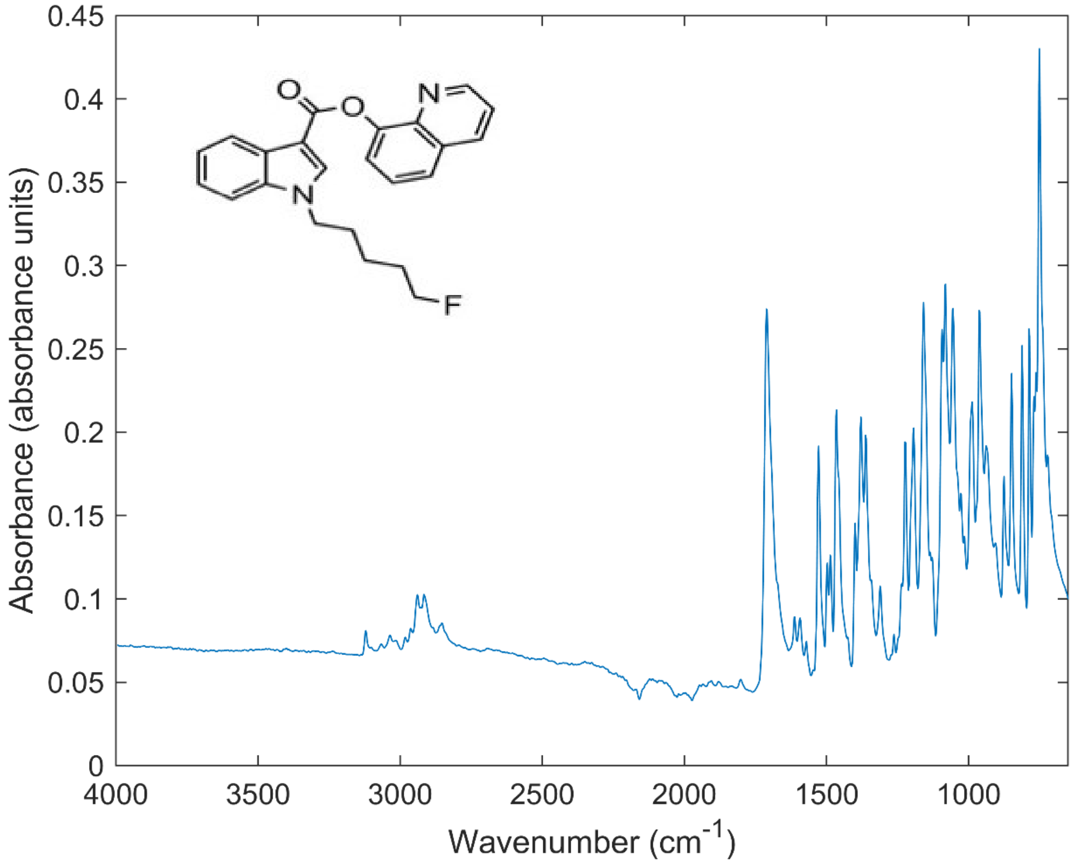


Figure 6.4 Raw ATR-FTIR spectrum of 5F-PB-22 measured using Alpha Bruker ATR-FTIR spectrometer

6.3.2.2. AB-FUBINACA

AB-FUBINACA absorption bands at 616, 748, 791, 1150, 1227, 1299, 1401, 1542, 1627, 2931 and 3290 cm^{-1} were observed for the ATR-FTIR spectrum of AB-FUBINACA (Figure 6.5). The strongest absorption bands were observed at 616, 748, 1227, 1542 and 1627 cm^{-1}, and were attributed to C-H bending, C=C bending of an alkene, C-N stretching of the aromatic amine, C=C stretching of the indazole group and aliphatic primary amine (N-H) bending, respectively. Generally, the absorption bands reported have strong and sharp spectral peaks.

The strong and sharp absorption band at 616 cm^{-1} is attributed to C-H bending, a strong sharp band at 748 cm^{-1} is C=C bending of an alkene, a strong and sharp band at 1227 cm^{-1} is C-N stretching of an aromatic amine, a strong sharp band at 1542 cm^{-1} is C=C stretching of a cyclic alkene and a strong sharp band at 1627 cm^{-1} is the aliphatic primary amine (N-H) bending.

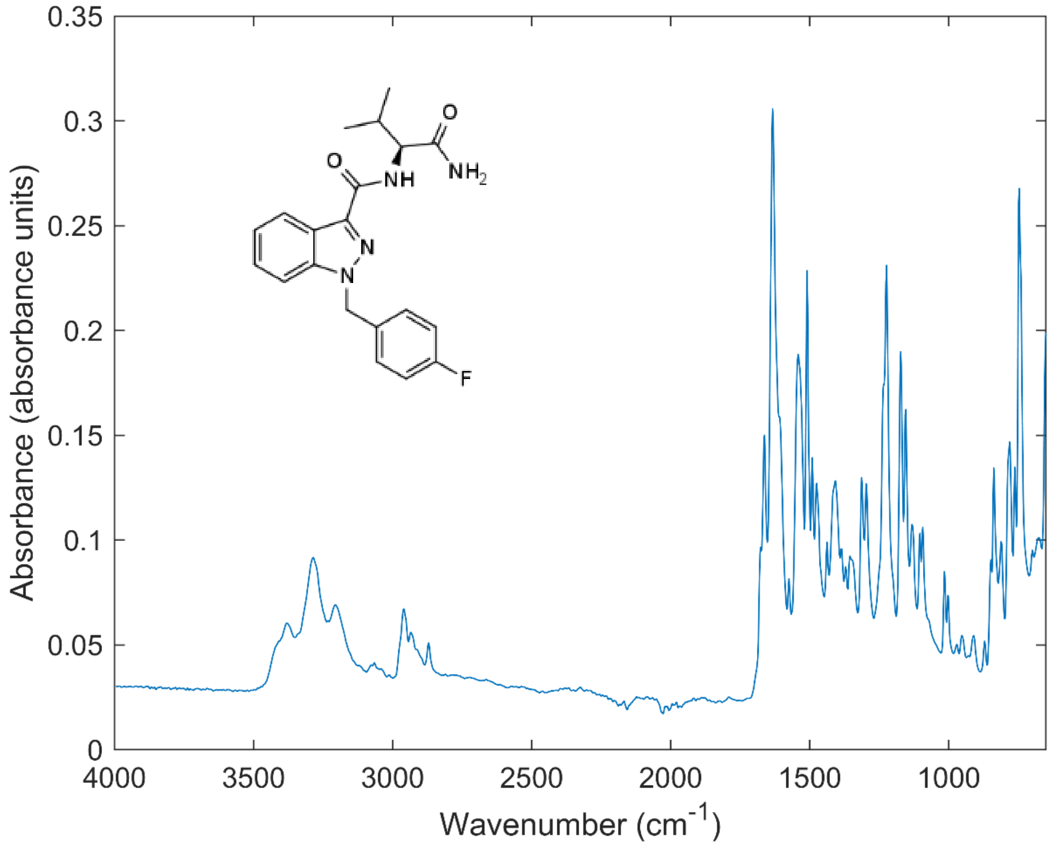


Figure 6.5 Raw ATR-FTIR spectrum of AB-FUBINACA measured using Alpha Bruker ATR-FTIR spectrometer

6.3.2.3. AKB-48

Absorption bands at 744, 862, 1003, 1189, 1287, 1454, 1525, 1646, 2849, 2902 and 3294 cm^{-1} were observed in the IR spectrum of AKB-48 (Figure 6.6). The strongest absorption bands were observed at 744, 1525, 1646 and 2902 cm^{-1}. The strong and sharp absorption band observed at 744 cm^{-1} is attributed to C=C bending, strong and sharp absorption band observed at 1525 cm^{-1} is N-H bending of an amine, a strong and sharp absorption band at 1646 cm^{-1} is C=C stretching of a cyclic alkene and a strong sharp band observed at 2902 cm^{-1} is C-H stretching of an alkane.

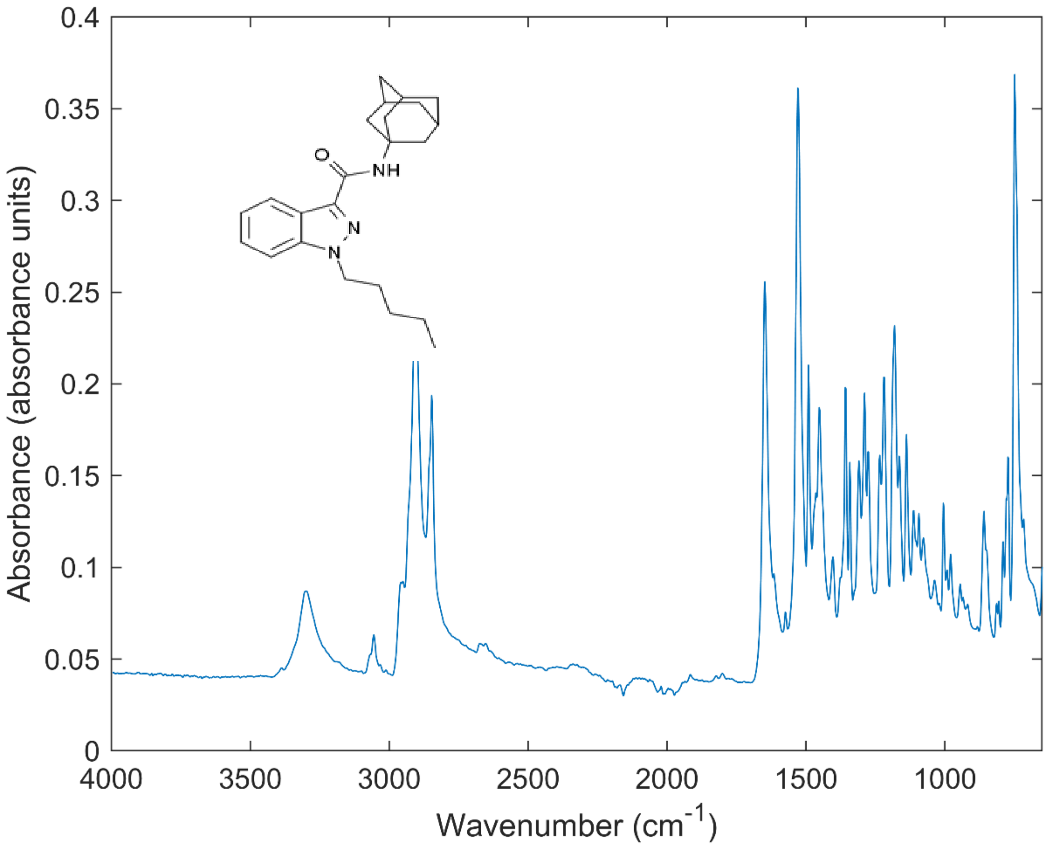


Figure 6.6 Raw ATR-FTIR spectrum of AKB-48 measured using Alpha Bruker ATR-FTIR spectrometer

6.3.2.4. Etizolam

Absorption bands at 525, 654, 701, 760, 832, 977, 1030, 1056, 1293, 1415, 1527, 1615 and 2931 cm^{-1} were observed for the IR spectrum of etizolam (Figure 6.7). Strong absorption bands were observed at 525, 701, 760, 1030, 1415 and 1615 cm^{-1}. The strong and sharp band observed at 525 cm^{-1} is attributed to C-Cl stretching of a halo compound, the strong and sharp absorption band at 701 cm^{-1} is C-H bending, the strong sharp band at band at 760 cm^{-1} is C=C bending, a strong sharp band at 1030 cm^{-1} is C-N stretching of an aromatic amine, a strong sharp band at 1415 cm^{-1} is C-H bending of a methyl group and a strong sharp band at 1615 cm^{-1} C=C stretching of a cyclic alkene.

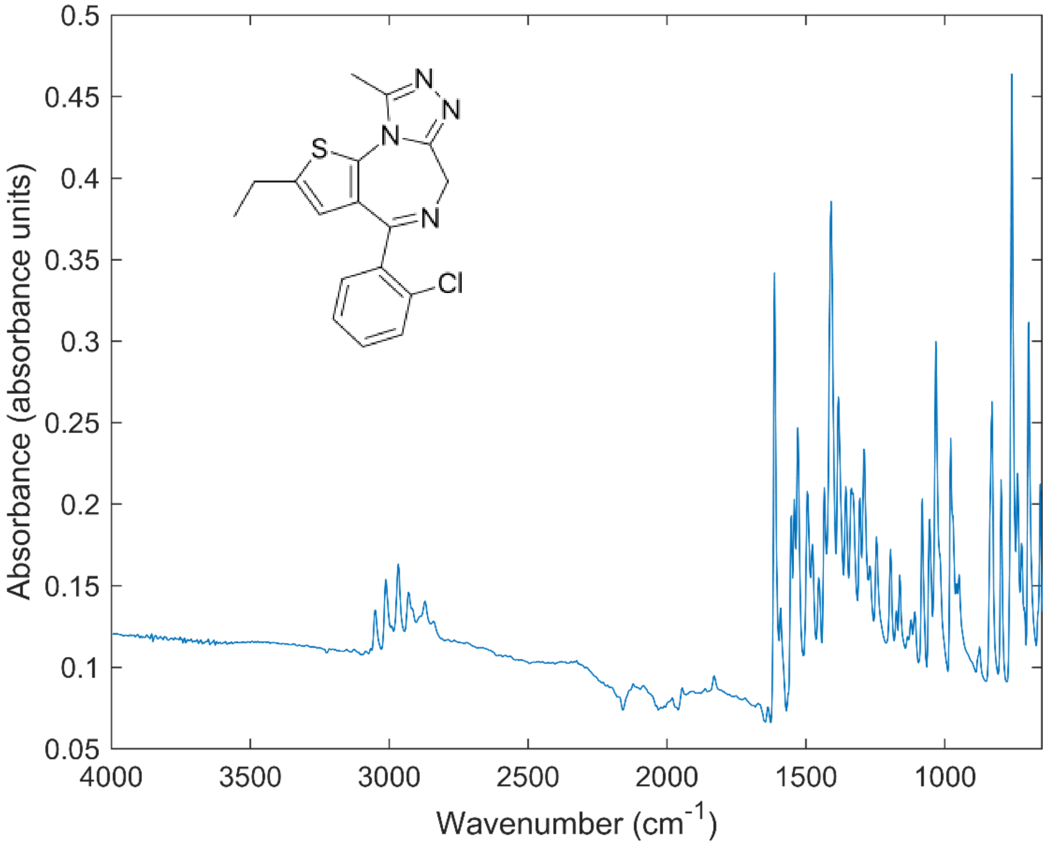


Figure 6.7 Raw ATR-FTIR spectrum of etizolam measured using Alpha Bruker ATR-FTIR spectrometer

6.3.3 Cutting agent interpretation

6.3.3.1. Benzocaine

The spectrum of benzocaine (Figure 6.8) consists of a doublet sharp N-H stretching bands at 3340 cm^{-1} and 3320 cm^{-1}, a NH_2 scissoring band at 1594 cm^{-1} and NH_2 wagging and twisting bands in the 850-750 cm^{-1} spectral range. The spectrum also shows a C-N stretching band in the 1360 – 1240 cm^{-1} spectral range, characteristic of aromatic amines. The C=O and C-O bonds in the aromatic ester produce distinctive bands at 1679 cm^{-1} and 1253 cm^{-1}, respectively.

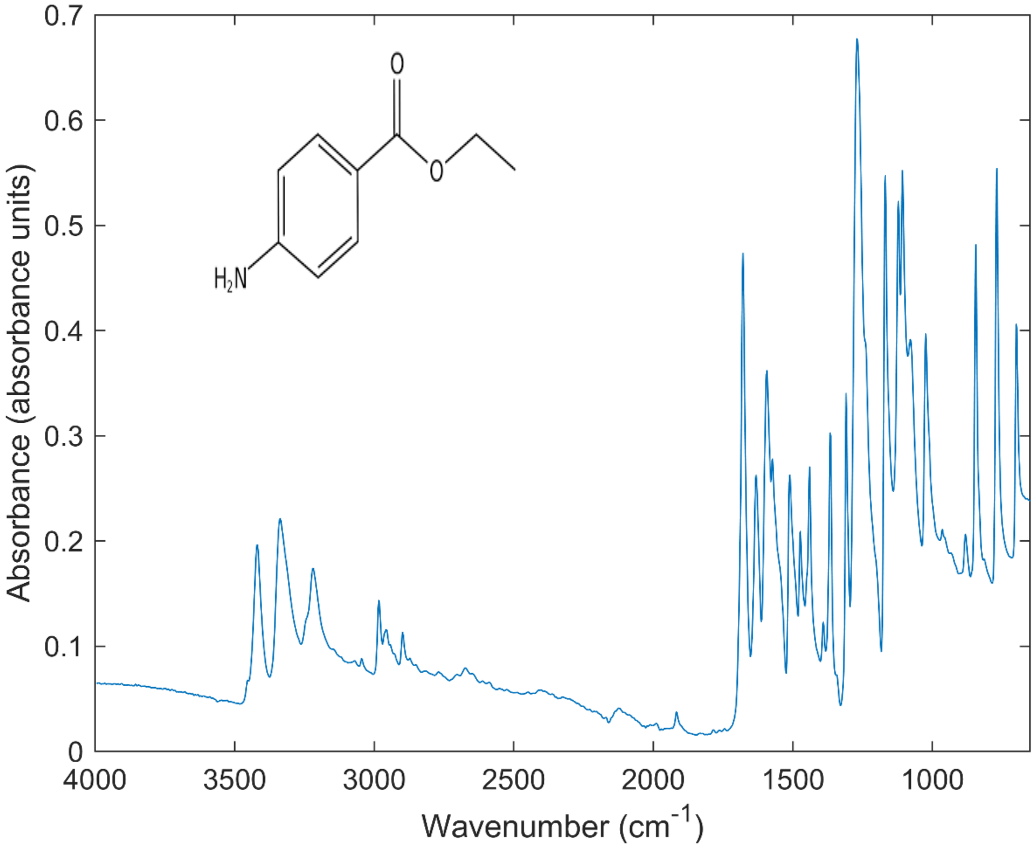


Figure 6.8 Raw ATR-FTIR spectrum of benzocaine measured using Alpha Bruker ATR-FTIR spectrometer

6.3.3.2. Caffeine

The caffeine molecule presented in Table 6.1 comprises of ten C-H bonds (including nine C-H bonds from methyl groups), ten C-N bonds, two C=O carbonyl groups in the ring position, one C=C bond, one C=N bond, and one C-C bond. The spectra of pure caffeine within the spectral range from 4000 cm^{-1} to 650 cm^{-1} and corresponding band assignments are presented in figure. The caffeine ATR-FTIR spectrum showed the characteristic two peaks of the vibrations of the C-H (2950-2850 cm^{-1}) methyl groups. This asymmetric vibration of caffeine enables for the quantification of caffeine in coffee. Spectral features in caffeine bands at 1705 cm^{-1} and 1664 cm^{-1} assigned to the stretching vibration of conjugated C=O(2) and C=O(6) carbonyl groups. In the spectrum range of 1600 cm^{-1} to 1400 cm^{-1} there are vibrations of C=N and C=C bonds, while in the spectrum range from 1330 cm^{-1} to 1000 cm^{-1}, there were bending vibrations in the plane from C-H, C-N, and C-C bonds. A medium peak is observed at 1350 cm^{-1} and may be attributed to the stretching of C-N bonds of caffeine. Moreover, peaks at 1200 cm^{-1} were in the spectral region of a stretching vibrations of ketonic carbonyl groups (C=O) and C-N bonds. A minor peak observed at 860 cm^{-1} and 1025 cm^{-1} is due to the stretching of C-C bonds in caffeine.

6.3.3.3. Lidocaine

Similar in structure to benzocaine, lidocaine ATR-FTIR spectrum (Figure 6.9) shows similarities to both benzocaine and procaine. The spectrum of lidocaine consists of OH stretching and bonding intermolecular H at 3500 cm^{-1}, aromatic CH stretch and alkene at 3000 cm^{-1}, CO stretch acid group at 1750 cm^{-1}, NH bending present in quinolones at 1500 cm^{-1}, OH bending at 1250 cm^{-1} and CF stretching at 1050 cm^{-1}.

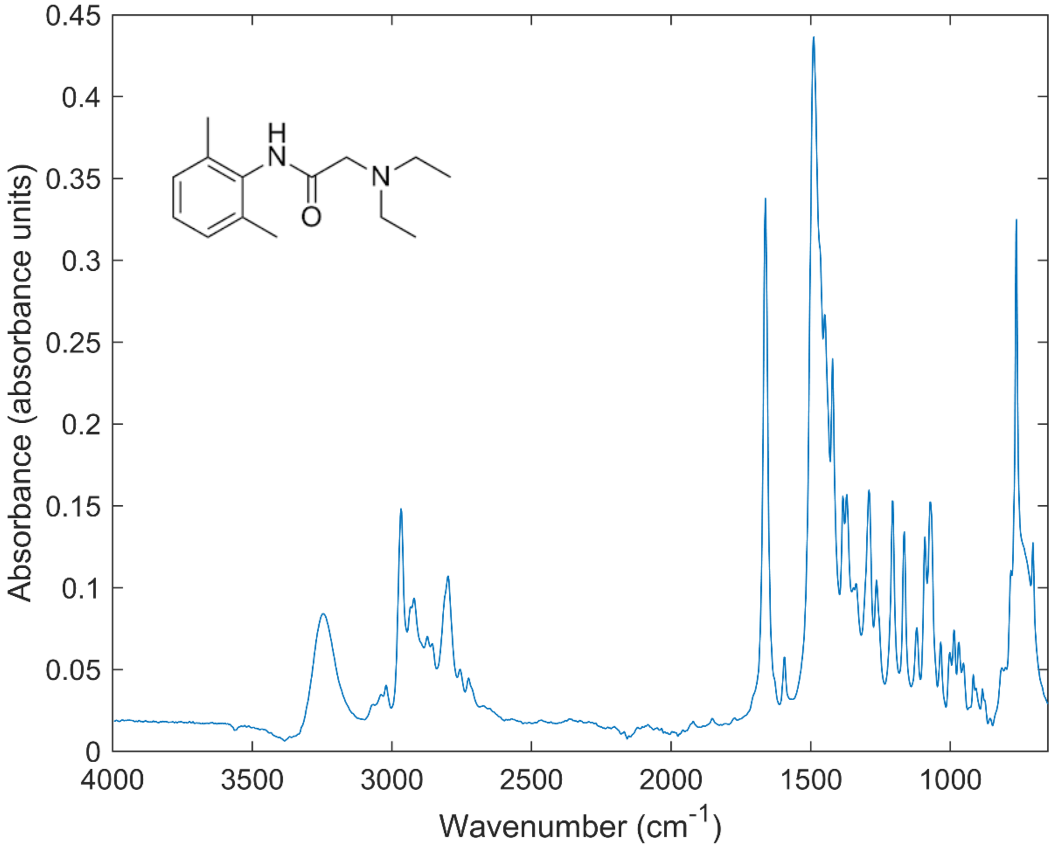


Figure 6.9 Raw ATR-FTIR spectrum of lidocaine measured using Alpha Bruker ATR-FTIR spectrometer

6.3.3.4. Procaine

The FTIR spectrum of procaine hydrochloride (Figure 6.10) shows several distinct peak characteristics. Interpreting the FTIR spectra of pure procaine it can be noticed that there are several distinct peak characteristics of functional group vibrations as followed: a doublet consisting of two sharp N-H stretching bands at 2245 cm^{-1} and 3314 cm^{-1}, a NH_2 scissoring band at 1604 cm^{-1} and NH_2 wagging and twisted bands in the 850-750 cm^{-1} spectral range. The spectrum also shows a C-N stretching band in 1360-1250 cm^{-1} range characteristic for aromatic amines. The presence of a tertiary amino group is sustained by the -N-CH_2 stretching band around 1170 cm^{-1}. The two most polar bonds in esters are the C=O and C-O respectively, which produce distinctive bands in the spectrum around 1700 cm^{-1} and 1200 cm^{-1}, respectively. Being an aromatic ester, it is expected that aromatic C=O stretching appears at lower wavenumbers than the ones characteristic for aliphatic ones (which absorb near 1750 cm^{-1}), in this case at 1692 cm^{-1}.

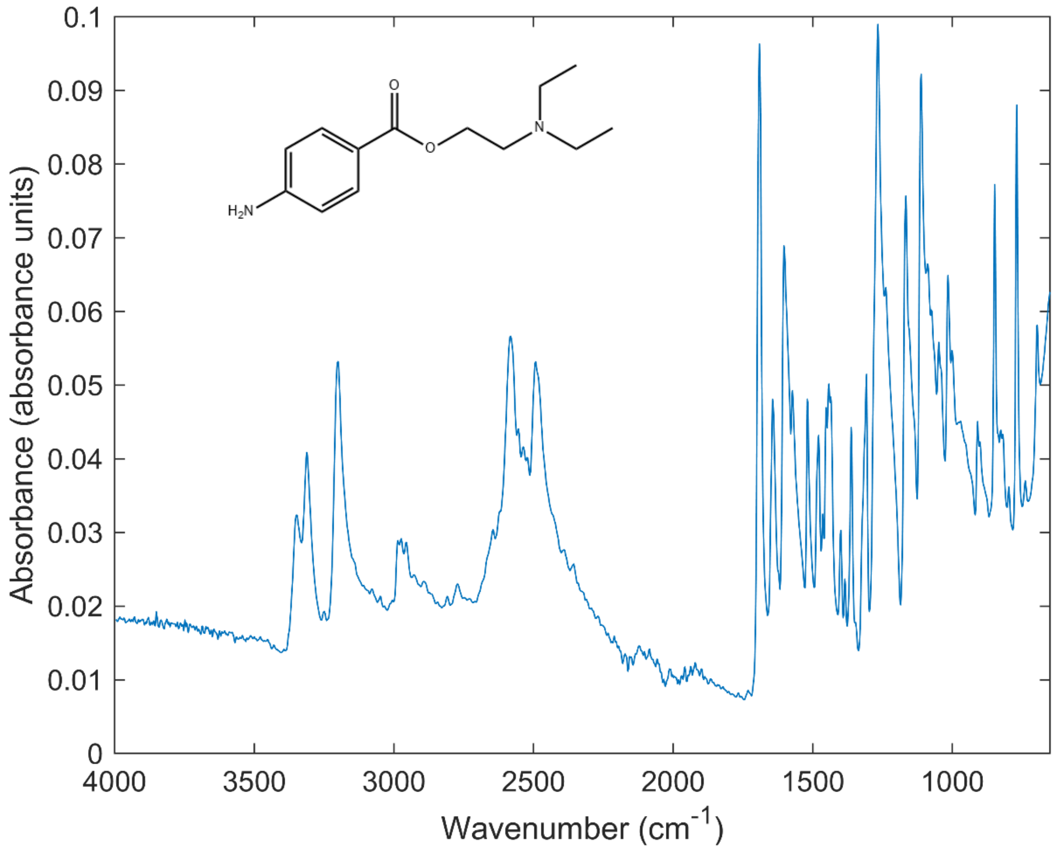


Figure 6.10 Raw-ATRFTIR spectrum of procaine measured using Alpha Bruker ATR-FTIR spectrometer

Table 6.3 IR functional group interpretation for NPS and cutting agents included in this study

Product number	Product name	Type of vibration	Corresponding functional group	Peak position (cm^{-1})	Peak intensity (absorbance units)	FTIR activity (strong, medium or weak), broad or narrow	Potential constituent(s)
1	5F-PB-22	Rocking	C-H	752	0.43	strong and sharp	Methylene
		Out-of-plane bending	C-H	809	0.252	medium and sharp	Aromatic ring
		Out-of-plane bending	C-H	846	0.235	medium and sharp	Aromatic ring
		Vibrations	C=C	958	0.272	strong and sharp	Skeletal vibrations
		Symmetric stretching	C-O	1050	0.288	strong and sharp	Primary alcohol
		Symmetric stretching	C-F	1154	0.277	strong and sharp	Aliphatic fluoro compounds
		Symmetric stretching	C-N	1191	0.198	medium and sharp	Tertiary amine
		in-plane bending	O-H	1360	0.198	medium and sharp	Secondary alcohol
		Scissoring in the plane	C-H	1454	0.213	medium and sharp	Methyl
		bending	C=N	1525	0.191	medium and sharp	Aromatic nitro compound
		Asymmetric stretching	C=O	1713	0.273	strong and sharp	Carboxylic acid
		Asymmetric stretching	C-H	2918	0.102	weak and sharp	Methylene
2	AB-FUBINACA	Rocking	C-H	748	0.269	strong and sharp	Methylene
		Vibrations	C-C	791	0.148	medium and sharp	Skeletal vibrations
		Symmetric stretching	C-N	1150	0.082	weak and sharp	Secondary amine
		Symmetric stretching	C-F	1227	0.232	strong and sharp	Aliphatic fluoro compounds
		bending	N-N	1401	0.128	medium and sharp	Aromatic nitro compound
		bending	N-H	1542	0.23	strong and sharp	Secondary amine
		Symmetric stretching	C=O	1627	0.308	strong and sharp	Conjugated ketone

		Asymmetric stretching	C-H	2931	0.066	weak and sharp	Methylene
		Symmetric stretching	N-H	3290	0.09	weak and sharp	Aliphatic primary amine
3	AKB-48	Rocking	C-H	744	0.371	strong and sharp	Methylene
		Out-of-plane bending	C-H	862	0.131	weak and sharp	Aromatic ring
		Vibrations	C-C	1003	0.136	weak and sharp	Skeletal vibrations
		Asymmetric stretching	C-N	1189	0.231	medium and sharp	Tertiary amine
		Symmetric stretching	C-N	1287	0.196	medium and sharp	Aromatic secondary amine
		bending	N-H	1525	0.365	strong and sharp	Secondary amine
		stretching	C=O	1646	0.258	strong and sharp	Conjugated ketone
		Symmetric stretching	C-H	2849	0.196	medium and sharp	Methyl
		Asymmetric stretching	C-H	2902	0.251	strong and sharp	Methyl
4	Etizolam	Out-of-plane bending	C-H	701	0.309	medium and sharp	Aromatic ring
		stretching	C-Cl	760	0.463	strong and sharp	Aliphatic chloro compound
		stretching	C-S	1030	0.299	medium and sharp	Sulphate ion
		Symmetric stretching	C-N	1056	0.196	weak and sharp	Secondary amine
		Asymmetric stretching	C-N	1193	0.231	medium and sharp	Tertiary amine
		stretching	C=C	1527	0.246	medium and sharp	Aromatic ring
		bending	C=N	1613	0.342	strong and sharp	Carbonyl amide
		stretching	C-H	2931	0.159	weak and sharp	Methyl
5	Benzocaine	Out-of-plane bending	C-H	699	0.406	Medium and sharp	Aromatic ring
		Rocking	C-H	769	0.554	Strong and sharp	Methylene
		Vibrations	C-C	844	0.481	Strong and sharp	Skeletal vibrations
		stretching	CO-O-CO	1023	0.396	Medium and sharp	Secondary alcohol
		Symmetric stretching	C-N	1107	0.551	Strong and sharp	Primary amine
		Asymmetric stretching	C-N	1168	0.547	Strong and sharp	Primary amine

		Symmetric stretching	C=C	1586	0.676	Strong and sharp	Aromatic ring stretch
		Bending	N-H	1595	0.358	Medium and sharp	Primary amine
		Symmetric stretching	C=O	1678	0.473	Strong and sharp	Conjugated ketone
		Asymmetric stretching	C-H	2986	0.135	weak and sharp	Methyl
		Symmetric stretching	N-H	3218	0.173	Medium and sharp	Aliphatic primary amine
		Asymmetric stretching	N-H	3343	0.209	Medium and sharp	Aliphatic primary amine
6	Caffeine	Vibrations	C-C	1020	0.307	medium and sharp	Skeletal vibrations
		Symmetric stretching	C-N	1197	0.267	medium and sharp	Secondary amine
		Asymmetric stretching	C-N	1240	0.487	strong and sharp	Tertiary amine
		bending	C=N	1359	0.215	medium and sharp	Aromatic tertiary amine
		Asymmetric stretching	C=C	1590	0.3023	Medium and broad	Aromatic ring stretch
		Symmetric Stretching	C=N	1630	0.197	Medium and sharp	Open-chain imino
		Symmetric stretching	C=O	1690	0.56	Strong and broad	Carbonyl amide
		Asymmetric stretching	C-H	3134	0.098	Weak and sharp	Methyl
7	Lidocaine	Out-of-plane bending	C-H	762	0.325	Strong and sharp	Aromatic ring
		Vibrations	C-C	983	0.065	weak and sharp	Skeletal vibrations
		Asymmetric stretching	C-N	1289	0.156	Medium and sharp	Tertiary amine
		bending	N-H	1489	0.436	Strong and sharp	Secondary amine
		Symmetric stretching	C=O	1662	0.337	Strong and sharp	Conjugated ketone
		Symmetric stretching	C-H	2798	0.107	Medium and sharp	Methyl
		Symmetric stretching	N-H	3317	0.148	Medium and sharp	Aliphatic secondary amine
8	Procaine	Out-of-plane bending	C-H	771	0.088	Medium and sharp	Aromatic ring
		Vibrations	C-C	856	0.077	Medium and sharp	Skeletal vibrations
		Symmetric stretching	C-N	983	0.092	Medium and sharp	Tertiary amine
		Symmetric stretching	C-O	1289	0.098	Medium and sharp	Secondary alcohol

		bending	N-H	1489	0.068	Medium and sharp	Primary amine
		Symmetric stretching	C=O	1662	0.096	Medium and sharp	Carbonyl Ester
		Symmetric stretching	C-H	2798	0.056	Medium and sharp	Methyl
		Symmetric stretching	N-H	3317	0.051	Medium and sharp	Aromatic amine

6.3.4. Spectral interpretation of NPS impregnated into paper

The NPS samples were impregnated at the four different concentrations into paper and measured using ATR-FTIR spectroscopy. The three synthetic cannabinoids (Figure 6.11) were detected and etizolam was not.

6.3.4.1. Synthetic cannabinoids

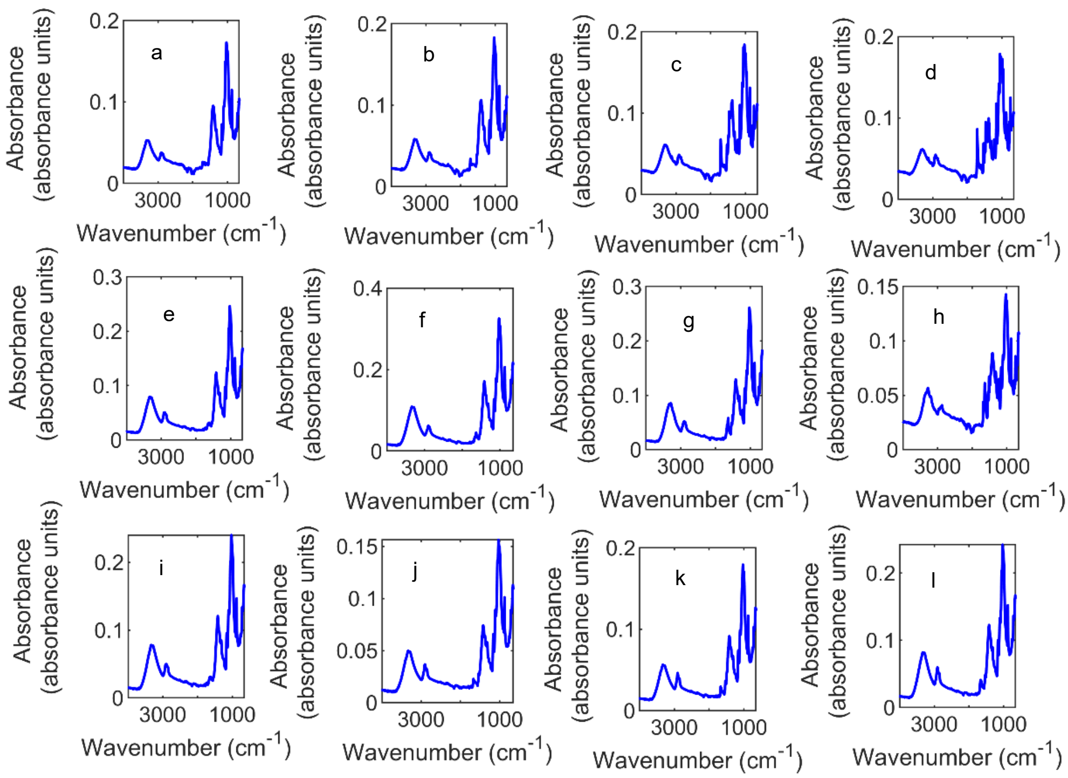


Figure 6.11 Raw ATR-FTIR spectra of (a) 5F-PB-22 impregnated into paper at 10 mg/mL (b) 15 mg/mL (c) 20 mg/mL (d) 25 mg/mL, AB-FUBINACA impregnated into paper at (e)10 mg/mL (f) 15 mg/mL (g) 20 mg/mL (h) 25 mg/mL and AKB-48 impregnated into paper at (i) 10 mg/mL (j) 15 mg/mL (k) 20 mg/mL (l) 25 mg/mL

6.3.4.1.1. 5F-PB-22

The synthetic cannabinoid 5F-PB-22 was detected impregnated into paper at concentrations of 15 mg/mL and above using ATR-FTIR spectroscopy. Spectral interpretation was applied to the impregnated paper substrate and was evaluated at each concentration. At the lowest concentration of 15 mg/mL, a small sharp peak is observed at 1715 cm^{-1} and is attributed to symmetrical stretching of carboxyl (C=O) functional group. Increasing the concentration of 5F-PB-22 from 15 mg/mL to 20 mg/mL allowed for the detection of fluoro (C-F), methyl (C-H), and amine (N-H) functional groups. For 25 mg/mL the only new functional group detected was attributed to the breathing of benzene (C=C) present in the indazole moiety. At the highest concentration of 25 mg/mL the number of spectral bands attributing to 5F-PB-22 significantly increases. Spectral bands observed at 752, 1154, 1525, 1715 and 2918 cm^{-1} are attributed to functional groups present in 5F-PB-22 and not paper.

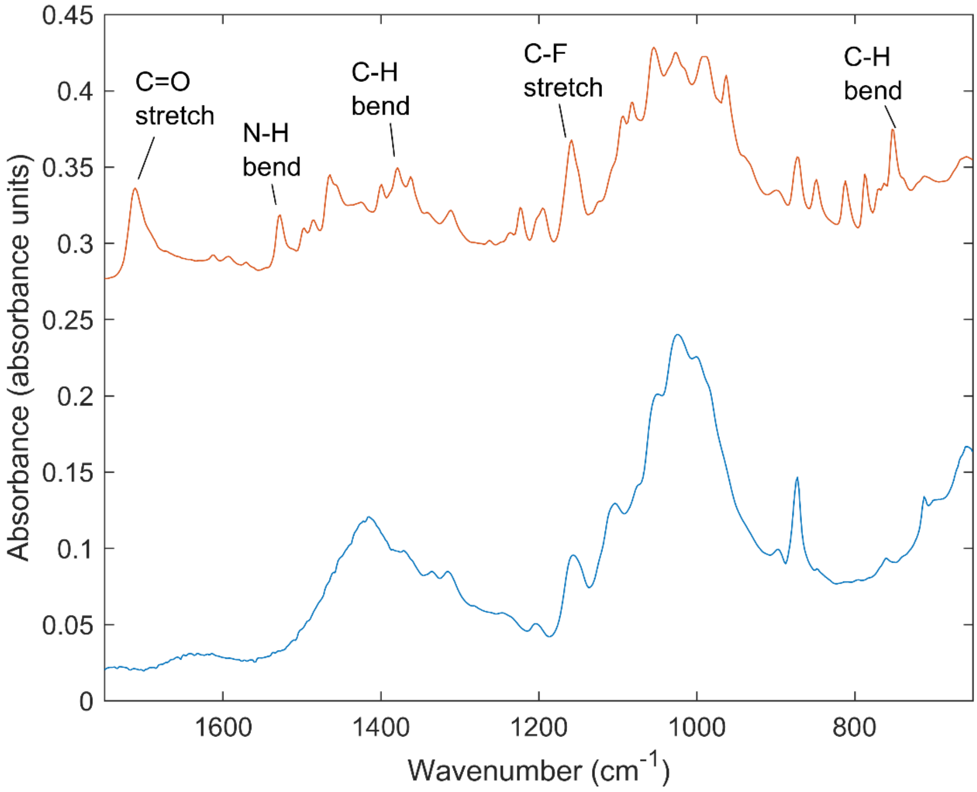


Figure 6.12 Stacked ATR-FTIR spectra of 5F-PB-22 impregnated into paper (red spectrum) and blank paper (blue spectrum) measured in the wavenumber region 700 – 1800 cm^{-1}.

Major differences were observed between the two spectra in figure 6.12 in the spectral region 700 – 1800 cm^{-1}. Narrow peaks at 752, 1154, 1407, 1525 and 1715 were all attributed to the synthetic cannabinoid 5F-PB-22: the peaks at 752 and 1407 cm^{-1} are characteristic of the C-H out-of-plane and in-plane bending of the styrene component, respectively; the peak at 1154 cm^{-1} is attributed to the stretching of fluoro compound attached to the fatty acid chain; the peak at 1525 cm^{-1} is associated with N-H bending (scissoring) of primary amines.

6.3.4.1.2. AB-FUBINACA

The synthetic cannabinoid AB-FUBINACA impregnated into paper was detected in concentrations of 15 mg/mL and above using ATR-FTIR spectroscopy. At 15 mg/mL only the carbonyl functional group of a conjugated ketone (C=O) at 1650 cm^{-1} was detected using ATR-FTIR spectroscopy. By increasing the concentration to 20 mg/mL from 15 mg/mL it allowed for the detection of the aliphatic fluoro (C-F) and aromatic ring stretch of (C=C) the benzene ring. The peak intensity of the conjugated ketone functional group at 1650 cm^{-1} increases with concentration.

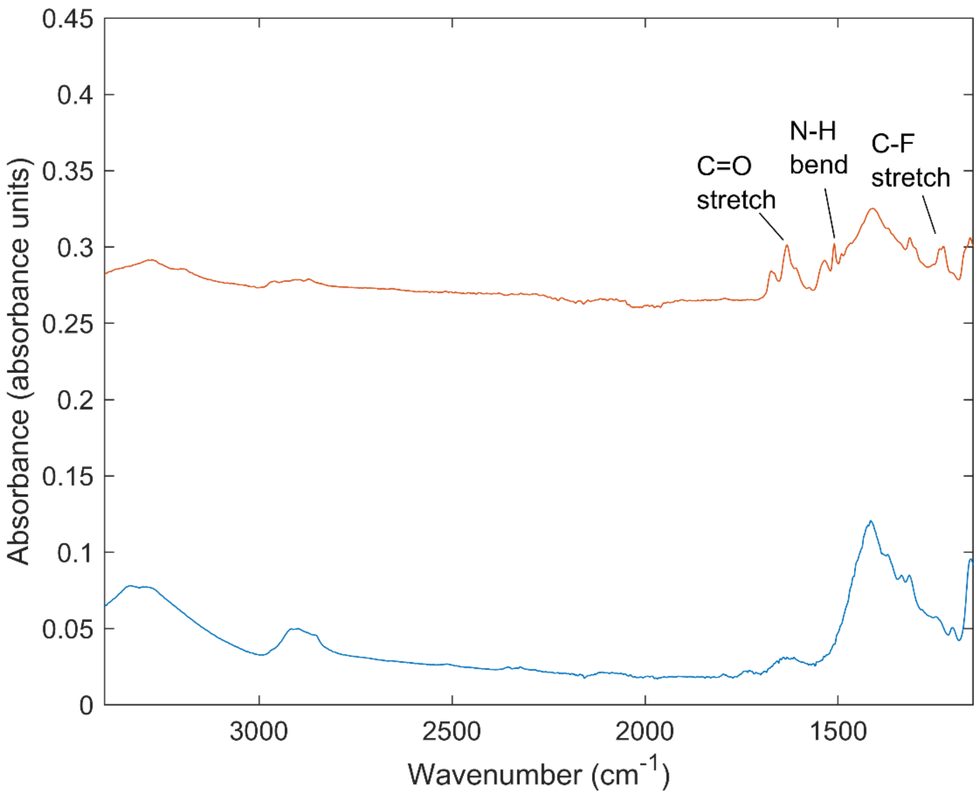


Figure 6.13 Stacked ATR-FTIR spectra of AB-FUBINACA impregnated into paper (red spectrum) and blank paper (blue spectrum) measured in the wavenumber region 1000 – 3000 cm^{-1}.

The most distinctive peaks associated with AB FUBINACA and not paper were observed at 3367 cm^{-1}, 3306 cm^{-1}, 1662 cm^{-1}, 1643 cm^{-1}, 1525 cm^{-1}, 1512 cm^{-1}, 1227 cm^{-1} and 1173 cm^{-1} (Figure 6.13). Two weak and broad peaks at 3367 cm^{-1} and 3306 cm^{-1} are attributed to N-H stretching of a primary amine and a carboxyl asymmetrical and symmetrical stretch (C=O) of an amide at 1662 cm^{-1} and 1643 cm^{-1}. The carboxyl functional group stretches of aldehydes, carboxylic acids, esters and ketones are usually found in the wavenumber range from 1750 – 1700 cm^{-1}, however, for amides or carboxylates the bands are observed between 1770 – 1630 cm^{-1}. Secondary amine (N-H) bending is observed at 1525 cm^{-1}, whereas the band at 1227 cm^{-1} is attributed to stretching of aromatic secondary amine (C=N). The medium sharp band observed at 1173 cm^{-1} is attributed to aliphatic fluoro stretching (C-F).

6.3.4.1.3. AKB-48

The synthetic cannabinoid AKB-48 impregnated into paper was detected in concentrations of 15 mg/mL and above using ATR-FTIR spectroscopy. Unlike the two synthetic cannabinoids reported previously (5F-PB-22 and AB-FUBINACA) only one functional group was detected using ATR-FTIR spectroscopy (Figure 6.14). A total of three peaks attributing to only two functional groups were present in paper impregnated with AKB 48 and included carboxylic acid (C=O) and amine (N-H) functional groups. A weak sharp peak at 1540 cm^{-1} and a medium sharp peak at 2960 cm^{-1} attributes to primary amine functional group at the carboxamide linkage. A medium sharp peak at 1650 cm^{-1} attributes to the stretching of carboxylic (C=O) functional group.

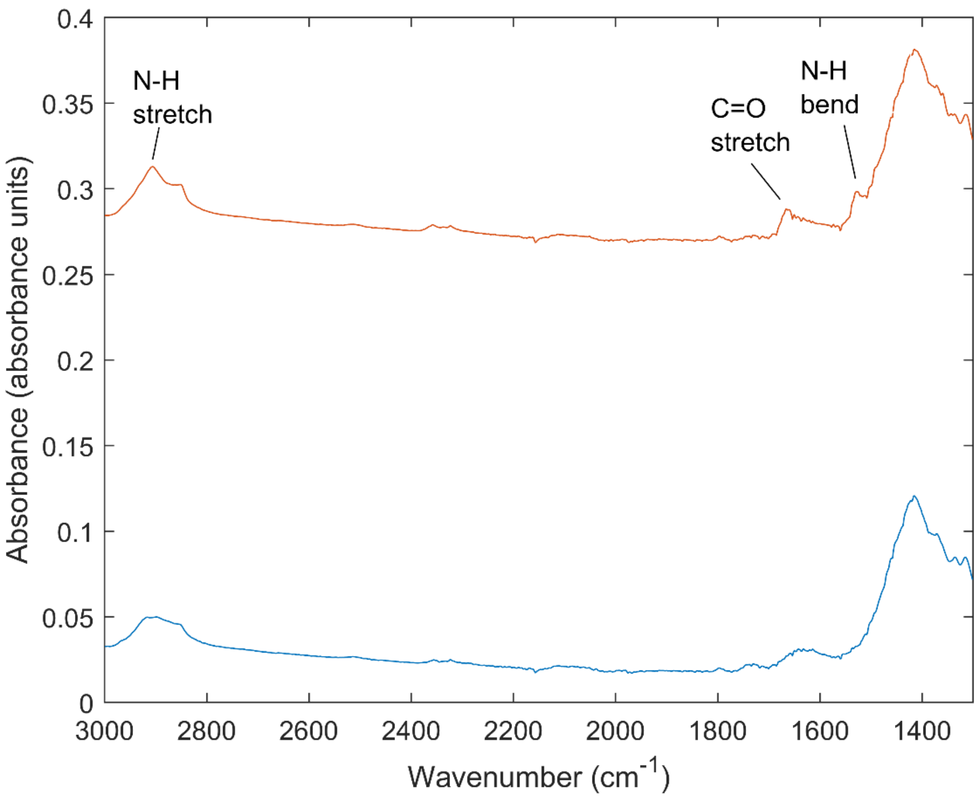


Figure 6.14 Stacked ATR-FTIR spectra of AKB-48 impregnated into paper (red spectrum) and blank paper (blue spectrum) measured in the wavenumber region 1300 – 3000 cm^{-1}.

The most distinctive peaks associated with AKB-48 and not paper were observed at 1528, 1705 and 2956 cm^{-1}. The peaks at 1528 and 2956 cm^{-1} are attributed to N-H bending and N-H stretching of the secondary amine at the carboxamide linkage connecting the adamantyl group and indazole moiety. The peak observed at 1705 cm^{-1} is attributed to carbonyl stretching at the carboxamide linkage attached to the secondary amine observed at 1528 and 2956 cm^{-1}. A clear pattern has shown that the carboxamide linkage connecting the adamantly group and indazole moiety can be used to interpret paper impregnated with AKB-48.

The synthetic benzodiazepine etizolam was not detectable using ATR-FTIR spectroscopy when impregnated into paper in concentrations between 10 to 25 mg/mL. The spectral interpretation revealed that functional groups for etizolam especially the fluoro functional group (C-FI) was not detected using ATR-FTIR spectroscopy. A reason for this is that etizolam was carried into the bulk of the paper and the ATR accessory only collects spectral information on the surface of the sample.

6.3.4.2. PLSR of SCRAs impregnated into paper

Considering the number of impregnated samples that were detectable using ATR-FTIR spectroscopy, PLSR models were first developed to quantify the three synthetic cannabinoids. The dispersion graphs of the models estimate values are shown in Figure 6.15, where acceptable R^2 values were achieved. The model validity was characterized with RMSEC, RMSEP, R_{cal}^2 and R_{pre}^2 with VIP-selecting variables under 10 factors had the best performance. These results demonstrated that the PLSR models for the aforementioned SCRAs had good performance. Taking the calibration model of the 5F-PB-22 dataset as an example it showed that the PLSR model had good performance with RMSEC and R_{cal}^2 of 0.3202 mg/mL% and 0.9052, respectively. The RMSEP and R_{pre}^2 were very similar to the calibration set being 0.5451 mg/mL% and 0.8938. The residual plot showed a random pattern indicating a good fit for the PLS linear model.

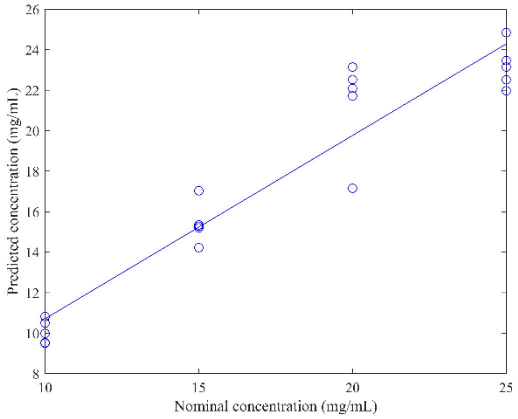


Figure 6.15 PLSR model of 5F-PB-22 impregnated into paper.

Similarly, a PLSR model for AB-FUBINACA with VIP selecting variables under three factors was performed. The RMSEC and R_{cal}^2 of the calibration set were 0.4197 mg/mL% and 0.9163, respectively. The RMSEP and R_{pre}^2 of the prediction set were close to the calibration values being 0.5361 mg/mL% and 0.8997. Similar values between the calibration and prediction sets and a randomly distributed residual plot demonstrates a PLSR model fit.

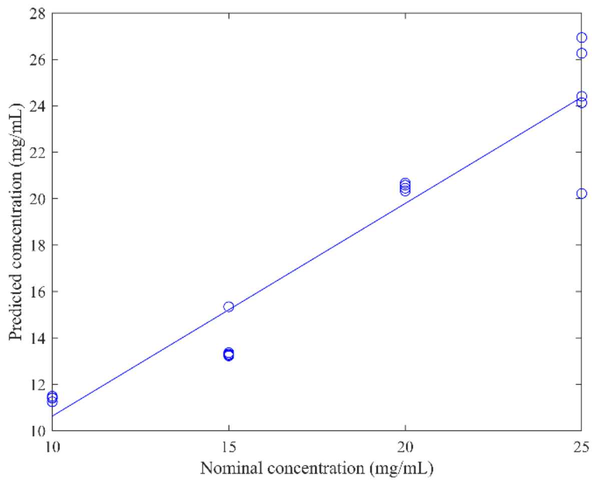


Figure 6.16 PLSR model of AB-FUBINACA impregnated into paper.

The best performance of PLSR for SCB derivatives used was AKB-48. The RMSEC and R_{cal}^2 of the calibration set were 0.5640 mg/mL% and 0.9209, respectively. The RMSEP and R_{pre}^2 of the prediction set were 0.8398 mg/mL% and 0.9067. The RMSEC was 0.8398% and is very close to the RMSEC. Additionally, the residual plot for AKB-48 shows a fairly random pattern and indicates a good fit for a PLS linear model. These results demonstrate that the PLSR model of AKB-48 had a good performance.

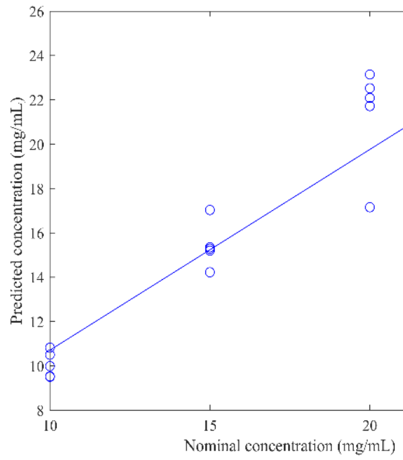


Figure 6.17 PLSR model of AKB-48 impregnated into paper.

6.3.5. Spectral interpretation of cutting agents impregnated into paper

The four cutting agents were also impregnated into paper at four concentrations and measured using ATR-FTIR spectroscopy and caffeine and procaine are presented below (Figure 6.18). Benzocaine and lidocaine were not detectable impregnated into paper in concentrations of 25 mg/mL and below.

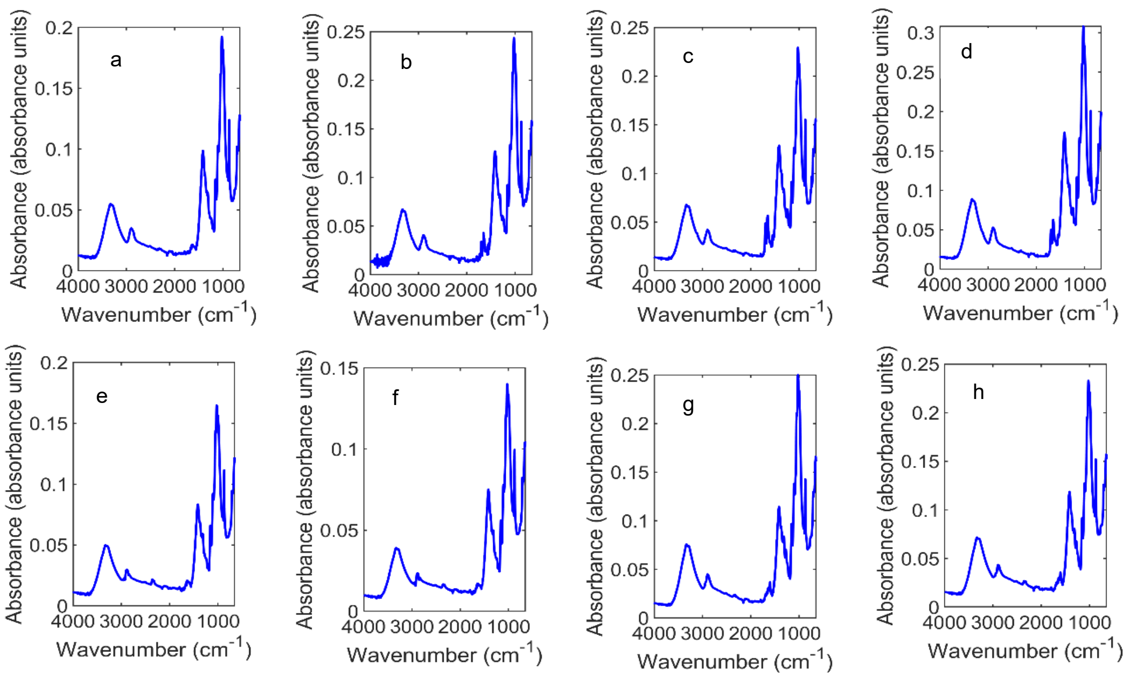


Figure 6.18 Raw ATR-FTIR spectra of caffeine impregnated into paper at (a) 10, (b) 15, (c) 20 and (d) 25 mg/mL and procaine impregnated into paper at (e) 10, (f) 15, (g) 20 and (d) 25 mg/mL measured using Alpha Bruker ATR-FTIR spectrometer

6.3.5.1. Caffeine

Caffeine impregnated into paper was detected in concentrations of 15 mg/mL and above. The FTIR spectrum showed two characteristics peaks attributing the symmetric and asymmetric stretching of carbonyl group (C=O) at 1676 and 1704 cm^{-1}. Two additional functional groups attributing to caffeine are detected at concentrations of 15mg/mL including N-H and C=N, both primary amines. Increasing the concentration of caffeine did not increase the number of peaks attributing to caffeine but rather the peak intensities of all previously detected functional groups.

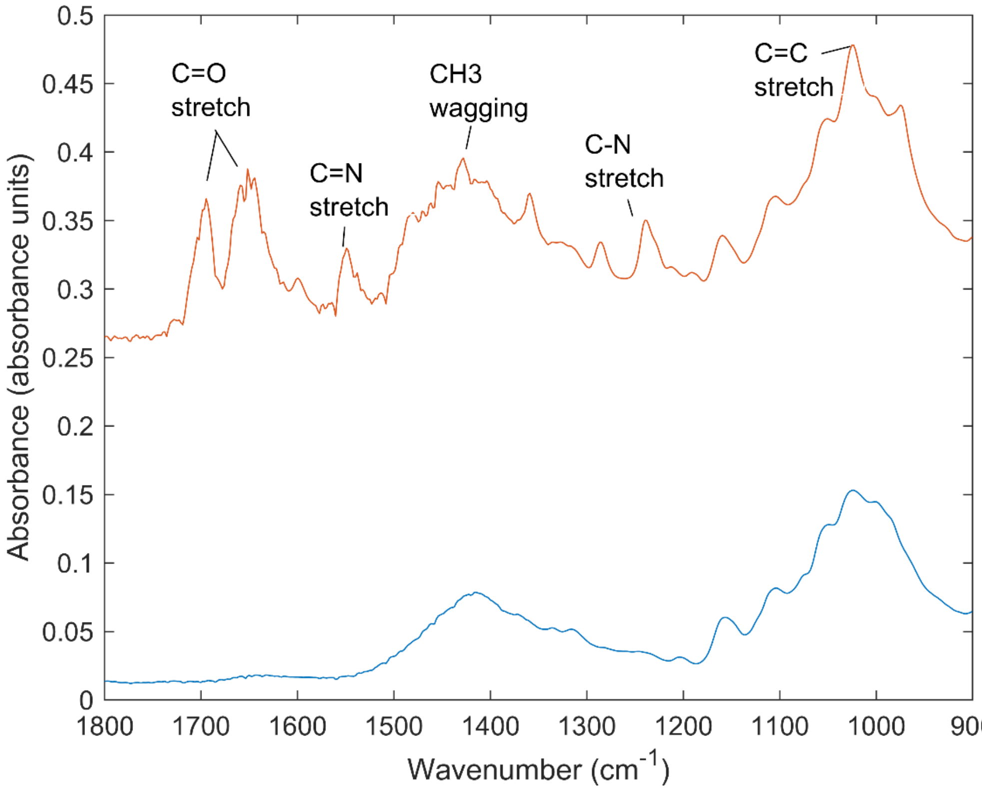


Figure 6.19 Stacked ATR-FTIR spectra of caffeine impregnated into paper (red spectrum) and blank paper (blue spectrum) measured in the wavenumber region 900 – 1800 cm^{-1}.

The most prominent peaks attributing to caffeine and not paper were in the fingerprint region between 900 to 1800 cm^{-1} (Figure 6.19). Interesting features concern the caffeine bands at 1703 and 1676 cm^{-1} assigned to the stretching vibration energy of conjugated C=O (carbonyl) groups. In the spectrum range from 1600 to 1400 cm^{-1}, there are vibrations of C=N and C=C bonds, while in the spectrum range from 1330 cm^{-1} to 1000 cm^{-1}, there were bending vibrations in the plane from C-H, C-N, and C-C bonds.

6.3.5.2. Procaine

Procaine impregnated into paper was detected in concentrations of 15 mg/mL and above. The FTIR spectrum showed two characteristics peaks attributing the bending of amine (N-H) and stretching of carbonyl functional group (C-O) at 1614 and N-H bending at 1614 cm^{-1}. Increasing the concentration of procaine did not increase the number of peaks attributing to procaine but rather the peak intensities of all previously detected functional groups.

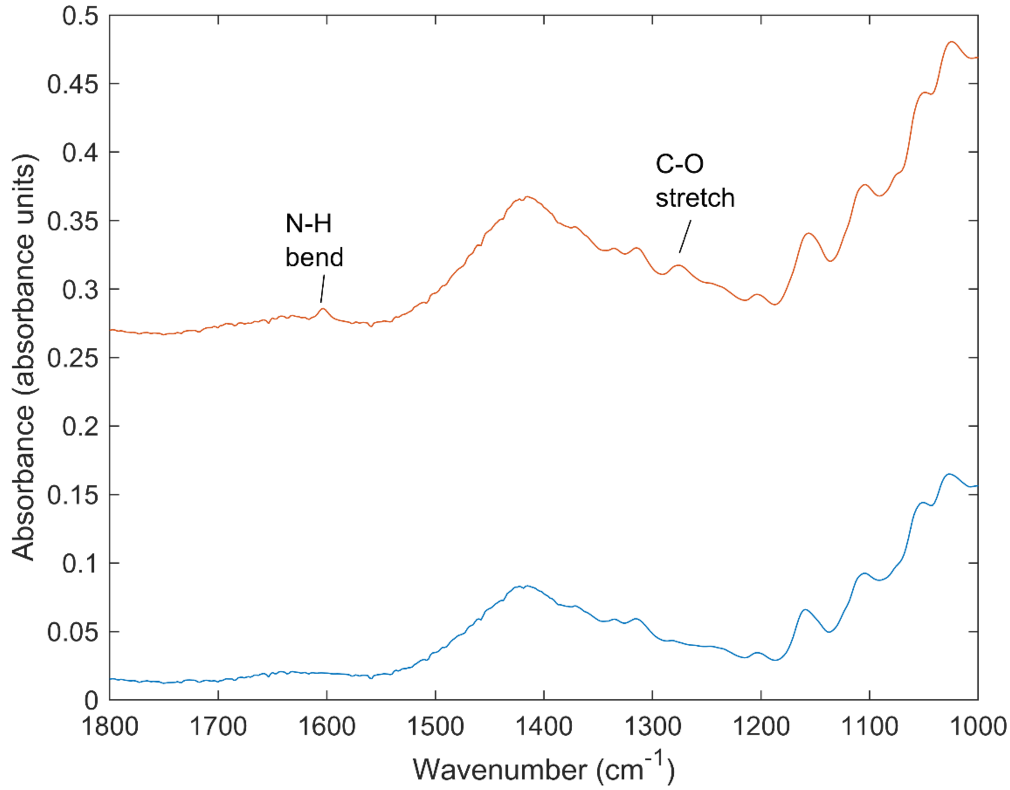


Figure 6.20 Stacked ATR-FTIR spectra of procaine impregnated into paper (red spectrum) and blank paper (blue spectrum) measured in the wavenumber region 1000 – 1800 cm^{-1}.

Figure 6.20 shows the area of spectral interest for procaine impregnated into paper in the wavenumber region of 1000 – 1800 cm^{-1}. Two characteristic peaks are observed that are attributed to procaine and not paper. The small sharp peak observed at 1614 cm^{-1} is attributed to $-NH_2$ scissoring band and a small peak at 1270 cm^{-1} is secondary alcohol stretching of C-O. No other spectral bands were observed for procaine impregnated into paper at concentrations up to 25 mg/mL.

6.3.5.3. PLSR of cutting agents impregnated into paper

After quantification of the three synthetic cannabinoids PLSR models were developed for the two cutting agents detected on paper, caffeine and procaine. The R^2 values for both cutting agents were acceptable and the model validity was characterised the same as the synthetic cannabinoids reported above. The best performance of all PLSR model was from caffeine. The RMSEC and R_{cal}^2 of the calibration set were 0.3076 mg/mL% and 0.9926, respectively. Similar values were seen for both the RMSEP and R_{pre}^2 being 0.5601 mg/mL% and 0.9751 indicating a good performance by the PLSR model.

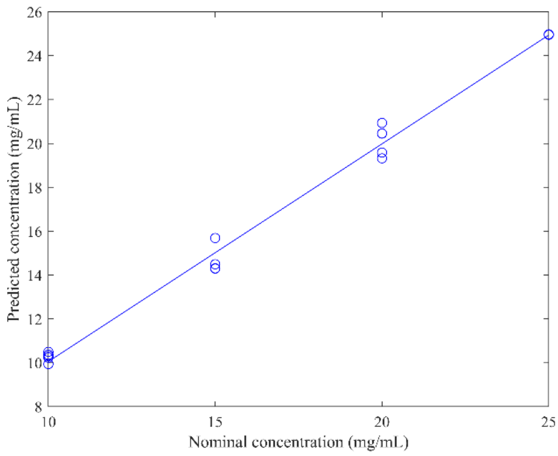


Figure 6.21 PLSR model of caffeine impregnated into paper.

The PLSR model for procaine also had good performance and the prediction values were close to the calibration values. The RMSEC and R_{cal}^2 of the calibration set were 0.3902 mg/mL% and 0.9895, respectively. The RMSEP and R_{pre}^2 of the prediction set were close to the calibration values being 0.5361 mg/mL% and 0.9697. Similar values between the calibration and prediction sets and a randomly distributed residual plot demonstrates a PLSR model fit.

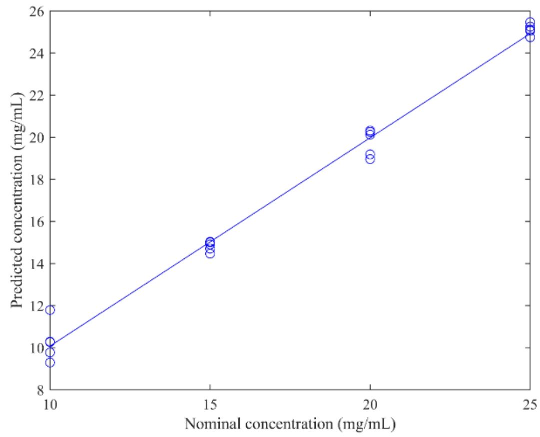


Figure 6.22 PLSR model of procaine impregnated into paper.

Figures 6.21 and 6.22 present the data for the PLSR models using the caffeine and procaine datasets. The prediction values were close to the calibration values and all residual plots were randomly distributed, indicating good PLSR models.

6.3.6. PCA of all NPS and cutting agents impregnated into paper at 25 mg/mL

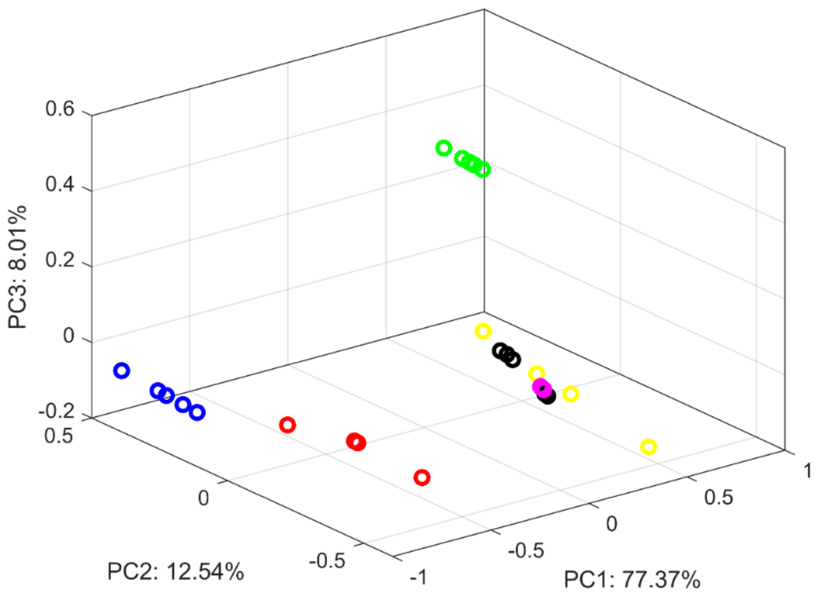


Figure 6.23 PC scores of 5F-PB-22 (blue), AB-FUBINACA (red), Caffeine (green), AKB-48 (black), Procaine (pink) and blank paper (yellow) plotted on a three dimension PC plot

PCA was then applied to the spectra of 5F-PB-22, AB-FUBINACA, AKB-48, caffeine, and procaine impregnated into paper and blank paper and measured and in the ATR-FTIR fingerprint region from 650 – 1800 cm^{-1}. Figure 6.23 shows the PC1, PC2 and PC3 score plots of these products impregnated into paper at 25 mg/mL. The ability of the classification model to detect different NPS and cutting agents impregnated into paper was tested with a set of five compounds and blank paper containing all spectra collected for sample at the three detected concentrations (15, 20 and 25 mg/mL). Only the highest concentrations had separate clustering and substance classification failed for both 15 and 20 mg/mL impregnated substances. For the highest concentration three products clustered separately including 5F-PB-22, AB-FUBINACA and caffeine, however, AKB 48 and procaine clustered with blank paper. The scree plot of the first principal component (PCs) described 77.37% of the data variation and three PCs described 97.92% of the data variation. When comparing PC scores of the NPS and cutting agents two compounds were misclassified due to clustering with blank paper and three (5F-PB-22, AB-FUBINACA and caffeine) were classified using PCA.

6.3.7. Transferability of ATR-FTIR spectral data between Bruker and Agilent spectrometers

6.3.7.1. Comparison between Agilent and Bruker FTIR spectrometers for NPS compounds

6.3.7.1.1. 5F-PB-22

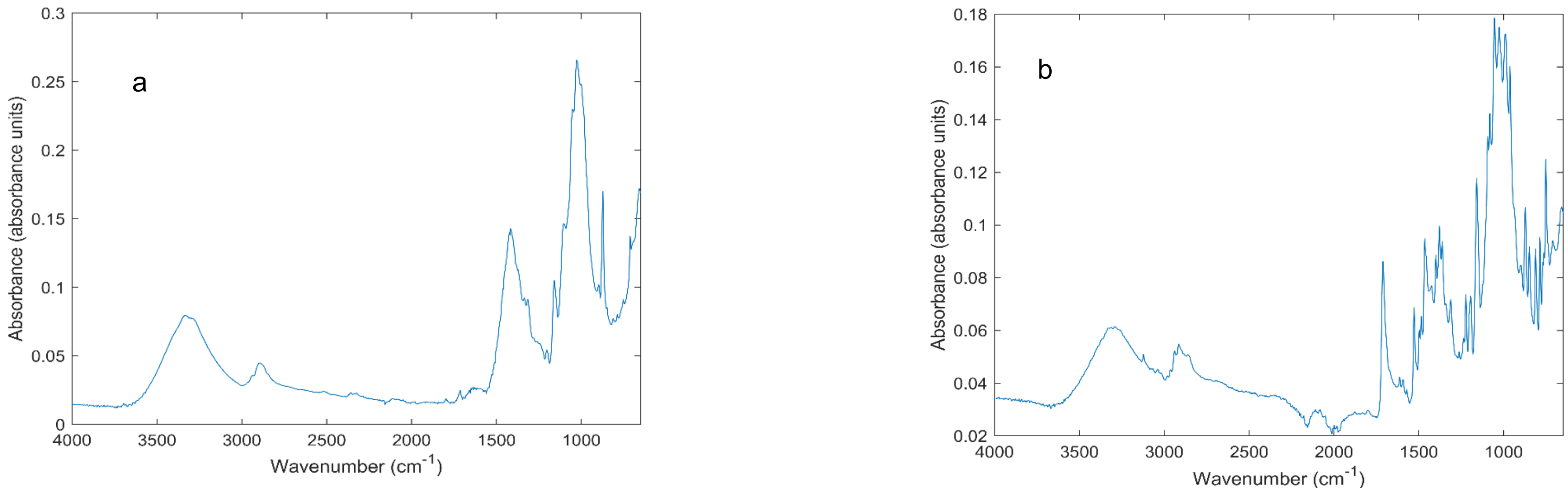


Figure 6.24 ATR-FTIR spectrum of 5F-PB-22 impregnated into paper measured using (a) spectrometer 1 and (b) spectrometer 2

Figure 6.24 is the FTIR spectrum of 5F-PB-22 impregnated into paper using spectrometer 1 and 2. A total of six spectral bands attributing to methylene rocking (C-H), aromatic ring out-of-plane bending (C-H), tertiary amine symmetrical stretching (C-N), symmetrical stretching of carboxylic acid (C=O), symmetrical and asymmetrical stretching of methyl (C-H) and symmetrical stretching of aliphatic primary amine (N-H) were observed. However, the spectrum from the Bruker FTIR spectrometer had more spectral bands with a higher absorbance attributing to 5F-PB-22 and not paper. Spectral shifts were observed for carboxylic acid stretching from 1711 cm^{-1} (Bruker) to 1715 cm^{-1} (Agilent), asymmetric stretching of methyl from 2914 cm^{-1} (Bruker) to 2915 cm^{-1} (Agilent) between the two instruments. The additional four spectral bands observed in the Bruker spectrum were not observed in the Agilent spectrum.

6.3.7.1.2. AB-FUBINACA

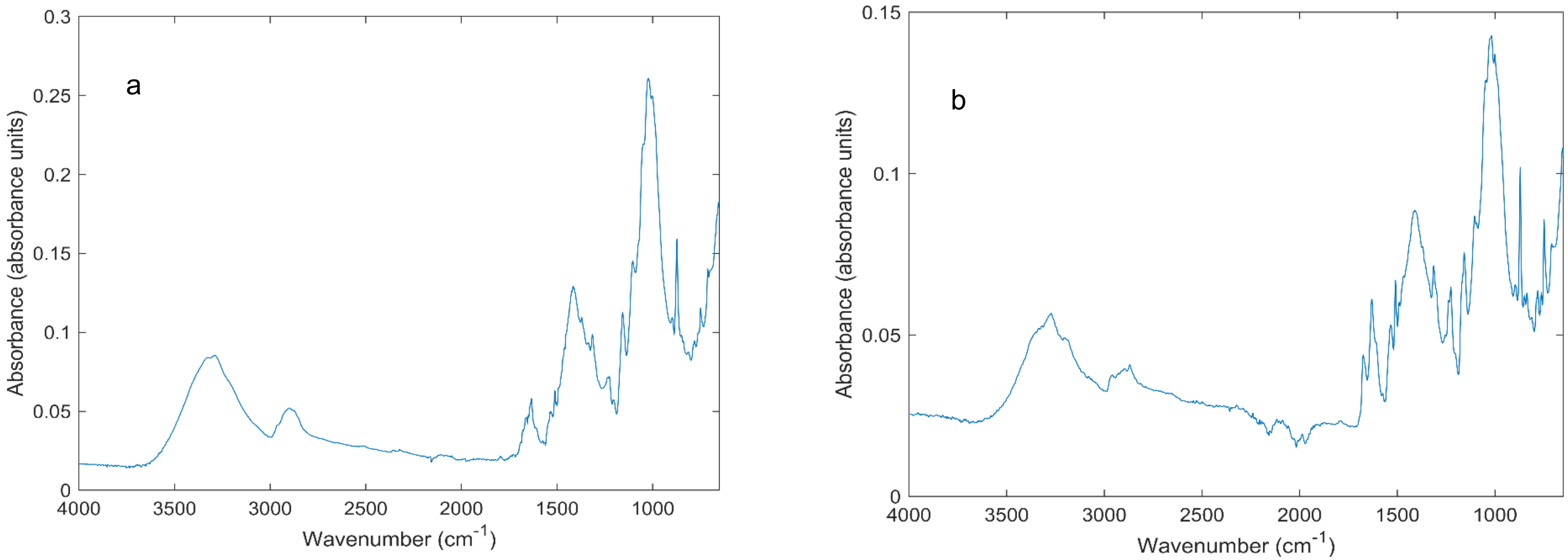


Figure 6.25 ATR-FTIR spectrum of AB-FUBINACA impregnated into paper measured using (a) spectrometer 1 and (b) spectrometer 2

Figure 6.25 shows the FTIR spectrum of AB-FUBINACA impregnated into paper using spectrometer 1 and spectrometer 2. A total of five spectral bands attributing to methylene rocking (C-H), aliphatic fluoro symmetrical stretching (C-F), symmetrical stretching of conjugated ketone (C=O), symmetrical stretching of methyl (C-H) and symmetrical stretching of aliphatic primary amine (N-H) were observed. Minor spectral shift were observed in the finger print region from 700 – 1800 cm^{-1} with methylene rocking shifting from 748 cm-1 (Bruker) to 749 cm^{-1} (Agilent), aliphatic fluoro group (C-F) shifted from 1226 cm^{-1} (Agilent) to 1227 cm^{-1} (Bruker) and the conjugated ketone (C=O) shifting from 1631 cm^{-1} (Bruker) to 1633 cm-1. However, major shifts were observed for symmetrical shifting of methyl from 2865 cm^{-1} (Bruker) to 2895 cm^{-1} (Agilent) and aliphatic primary amine stretching (N-H) from 3263 cm^{-1} (Bruker) to 3286 cm^{-1} (Agilent).

6.3.7.1.3. AKB-48

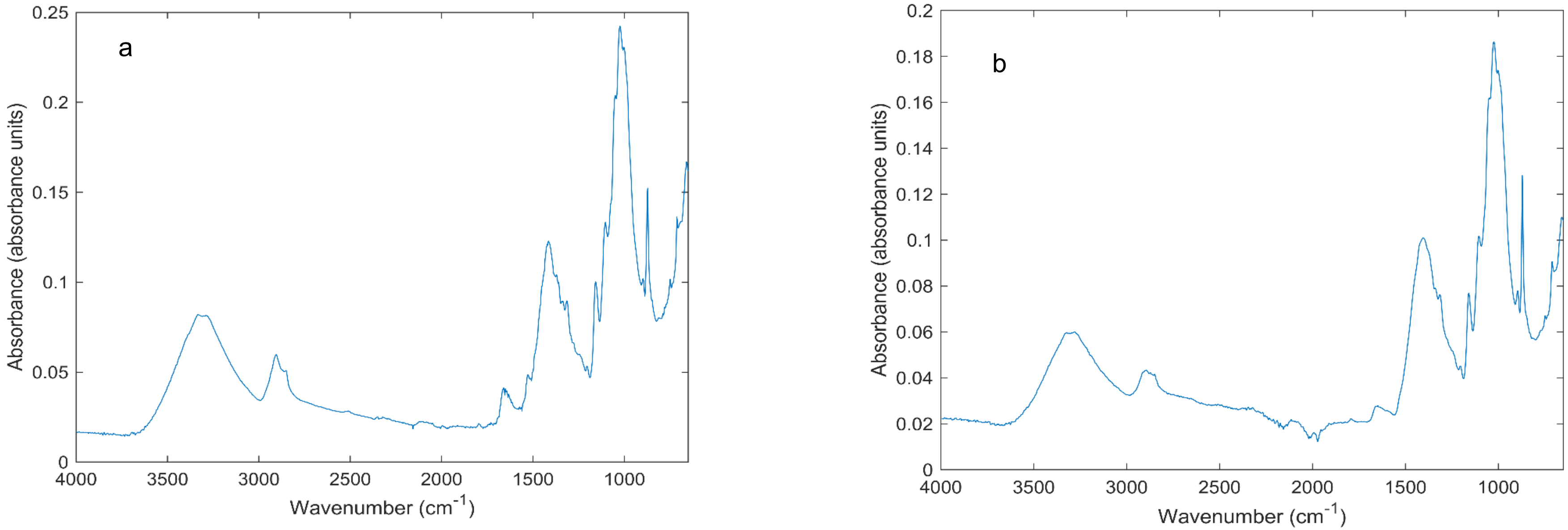


Figure 6.26 FTIR spectrum of AKB-48 impregnated into paper measured using (a) spectrometer 1 and (b) spectrometer 2

Figure 6.26 (a) is the FTIR spectrum of AKB-48 impregnated into paper using Agilent and (b) is using Bruker. A total of four spectral bands attributing to secondary amine bending (N-H), symmetrical stretching of a conjugated ketone (C=O), and methyl symmetric and asymmetric stretching (C-H) were observed. Minor spectral shifts were observed between the two instruments for the functional groups detected attributing to AKB-48. A spectral shift from 1662 cm^{-1} (Bruker) to 1663 cm^{-1} (Agilent) was observed for symmetrical stretching of a conjugated ketone (C=O) and the symmetrical and asymmetrical stretching of the methyl group shifted from 2863 cm^{-1} (Bruker) to 2854 cm^{-1} (Agilent) and 2908 cm^{-1} (Bruker) to 2906 cm^{-1} (Agilent), respectively. The spectral band observed at 1530 cm^{-1} on the Agilent FTIR spectrometer attributing to secondary amine bending (N-H) did not appear on the Bruker spectrometer.

6.3.7.2. Comparison between Agilent and Bruker FTIR spectrometers for cutting agent compounds

6.3.7.2.1. Caffeine

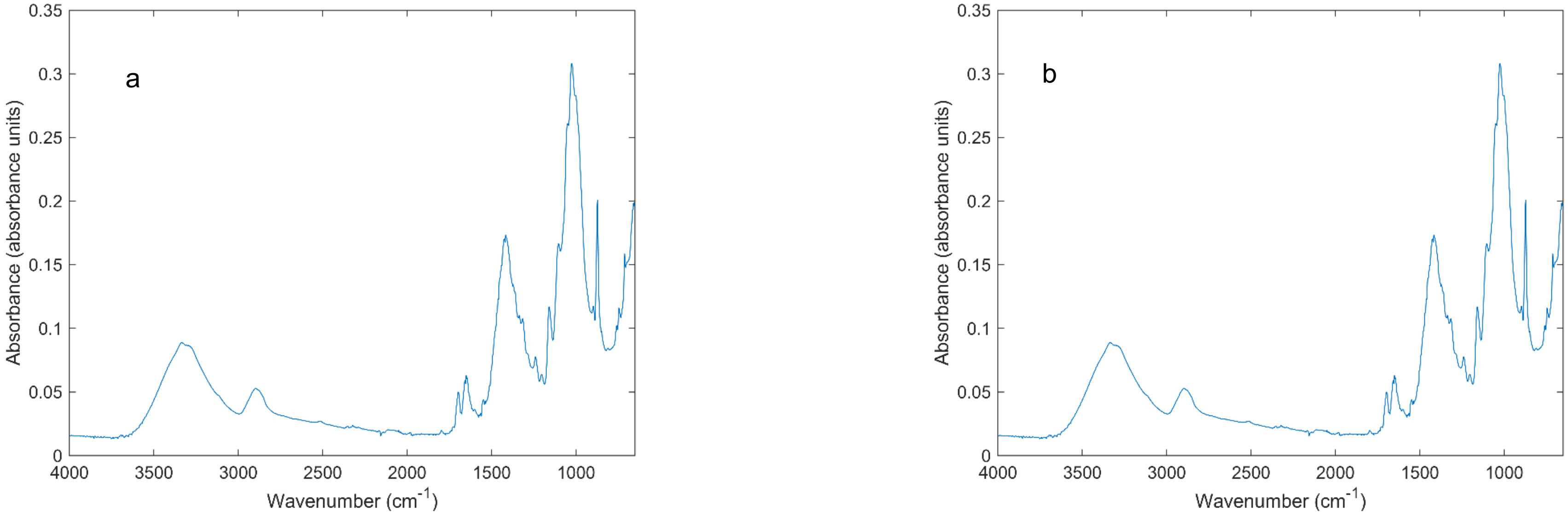


Figure 6.27 FTIR spectrum of caffeine impregnated into paper measured using (a) spectrometer 1 and (b) spectrometer 2

Figure 6.27 (a) is the FTIR spectrum of caffeine impregnated into paper using Agilent and (b) is using Bruker. A total of four spectral bands attributing to tertiary amine asymmetric stretching (C-N), symmetrical stretching of open-chain imino (C=N), symmetrical stretching of a carbonyl amide (C=O), and asymmetric stretching (N-H) were observed. Minor spectral shift were observed for all functional groups attributing to caffeine between the two spectrometer instruments and included a spectral shift from 1241 cm^{-1} (Bruker) to 1243 cm^{-1} (Agilent) for the tertiary amine, a shift from 1649 cm^{-1} (Bruker) to 1651 cm^{-1} (Agilent) for imino stretching, a shift from 1698 cm^{-1} (Bruker) to 1699 cm^{-1} (Agilent) for carbonyl amide stretching and a shift from 3340 cm^{-1} (Agilent) to 3344 cm^{-1} (Bruker) for asymmetric stretching of amide (N-H).

6.3.7.2.2. Procaine

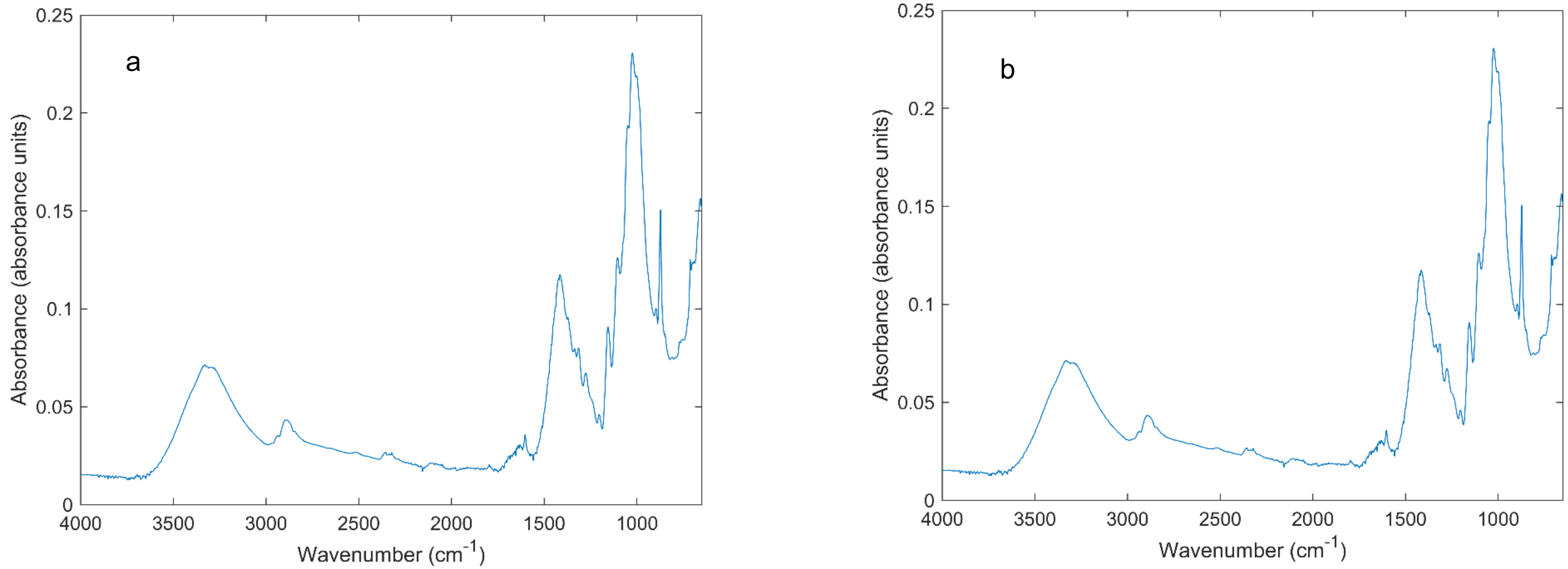


Figure 6.28 FTIR spectrum of procaine impregnated into paper measured using (a) spectrometer 1 and (b) spectrometer 2

Figure 6.28 (a) is the FTIR spectrum of procaine impregnated into paper using Agilent and (b) is using Bruker. A total of three spectral bands attributing to secondary alcohol symmetric stretching (N-H), symmetrical stretching of a carbonyl ester (C=O), and asymmetric stretching of methyl (C-H) were observed. Minor spectral shift was observed in the IR fingerprint region and included secondary alcohol shifting from 1277 cm^{-1} (Bruker) to 1278 cm^{-1} (Agilent) and carbonyl ester shifting from 1603 cm^{-1} (Bruker) to 1607 cm^{-1} (Agilent). A medium shift was observed for the symmetric stretching of aromatic amine from 2891 cm^{-1} (Bruker) to 2902 cm^{-1} (Agilent).

Table 6.4 Spectral shifts observed between Agilent and Bruker ATR-FTIR spectrometers of NPS and cutting agents impregnated into paper

Compound	Spectrometer 1			Spectrometer 2		
	Wavenumber (cm^{-1})	**Functional group**	**Absorbance**	**Wavenumber (cm^{-1})**	**Functional group**	**Absorbance**
5F-PB-22	752	C-H	0.125	753	C-H	0.091
	848	C-H	0.092	851	C-H	0.085
	1221	C-N	0.072	1228	C-N	0.054
	1711	C=O	0.086	1715	C=O	0.025
	2914	C-H	0.055	2915	C-H	0.040
	3122	N-H	0.051	3120	N-H	0.041
AB-FUBINACA	748	C-H	0.086	749	C-H	0.115
	1227	C-F	0.064	1226	C-F	0.072
	1631	C=O	0.061	1633	C=O	0.058
	2865	C-H	0.040	2895	C-H	0.052
	3263	N-H	0.055	3286	N-H	0.085
AKB 48	1535	N-H	0.030	1530	N-H	0.048
	1662	C=O	0.027	1662	C=O	0.040
	2863	C-H	0.041	2854	C-H	0.051
	2908	C-H	0.043	2906	C-H	0.060
Caffeine	1241	C-N	0.063	1243	C-N	0.076
	1649	C=N	0.057	1651	C=N	0.063
	1698	C=O	0.050	1699	C=O	0.049

	3344	N-H	0.067	3340	N-H	0.088
Procaine	1277 1603 2891	C-O C=O C-H	0.067 0.036 0.043	1278 1607 2902	C-O C=O C-H	0.069 0.035 0.045

6.4. Discussion

This is the first study to examine the use of ATR-FTIR spectroscopy for detecting and predicting NPS impregnated into paper. Research from Ford and Berg (2018) highlighted that NPS are now being smuggled into UK prisons and Ralphs (2016) reported that this trend has now been introduced into the homeless population. NPS pose a major public health threat to the wellbeing of homeless individuals and strategies are urgently required to detect NPS being impregnated into a variety of matrices.

Using qualitative interpretation of ATR-FTIR spectra to screen four NPS and four cutting agents impregnated into paper, we have provided the first analytical proof that NPS and cutting agents can be detected on paper using ATR-FTIR spectroscopy. A total of five compounds were detected on paper including three NPS and two cutting agents including all three SC (5F-PB-22, AB-FUBINACA & AKB-48) and caffeine and procaine. All three SC have been known to cause adverse effects and caffeine and procaine use are associated with cardiovascular and respiratory side effects (Harrison et al. 1963; Kovacs et al.1998; O'Connell et al. 2015; Cooper, 2016; McIlroy et al. 2016; Rook et al. 2016; Tait et al. 2016).

All substances that were detected using ATR-FTIR spectroscopy had a limit-of-detection (LOD) of 15 mg/mL. It should be noteworthy to mention that both 5F-PB-22 and AB-FUBINACA could be visually detected on paper as both crystallised onto the surface of the paper. Ford and Berg (2018) showed similar results when analysing prison mail suspected of containing NPS and reported that the paper had a 'waxy' texture and the compounds crystallised onto the papers' surface. These two cannabinoids both have poor solubility in polar liquids such as water and ethanol and so will deposit onto the papers surface rather than be carried into the bulk of the paper (Banister et al. 2015; Brandt 2017).

For AKB-48 and the synthetic benzodiazepine etizolam both had not crystallised onto the paper surface but rather had been carried into the bulk. This could explain why using ATR-FTIR spectroscopy could not detect etizolam as ATR analyses the surface of a sample and etizolam would have been carried into the bulk of the matrix. For AKB 48, only the functional groups attributing to the carboxamide linkage connecting the indazole moiety and adamantly group were detected (Gandhi et al. 2013; Veress and Nagy 2015). A reason for this could be due to the amine functional group (N-H) present in the carboxamide linkage bonding to the paper via hydrogen bonding after the solvent evaporated (Abiedalla et al. 2019). As AKB 48 was completely soluble in ethanol in concentrations up to 25 mg/mL the amine functional group could have bonded to the hydroxyl group in ethanol (OH) and been carried into the bulk of the matrix before being deposited near the surface of the paper after the solvent evaporated.

Out of the four cutting agents that were impregnated into paper and analysed using ATR-FTIR spectroscopy only caffeine and procaine were detectable in concentrations of 15 mg/mL and above. Caffeine and procaine could be visually detected and crystallised onto the papers surface, however, caffeine's crystallisation onto the surface was more profound and had a 'waxy' texture whereas procaine's did not. Benzocaine and lidocaine were not detectable impregnated into paper using ATR-FTIR spectroscopy and is likely due to the compounds being carried into the bulk of the matrix.

The PLSR models were established and assessed using chemometric indicators (RESEC, RMSEP, R_{cal}^2 and R_{pre}^2. Different models were used to predict the concentrations of the three detected SCB and two cutting agents and both calibration and prediction values were similar for all substances detected. This demonstrates that ATR-FTIR can be used for the determination of different concentrations of NPS and cutting agents impregnated into paper (Mevik and Cederkvist 2004). PLSR models have been developed by researchers to predict concentrations of solid drug mixtures and drug content in drinks but did not consider drugs impregnated into solid matrices (Hughes et al. 2013; Eliaerts et al. 2017; Materazzi et al. 2017).

The use of PCA to differentiate between different NPS and cutting agents proved successful but only with 5F-PB-22, AB FUBINACA and caffeine as these compounds crystallised onto the surface of the paper. These compounds had several spectral bands that were attributed to the impregnated substance and not paper, making it easier to differentiate between the compounds for PCA (Rodrigues et al. 2013; Marcelo et al. 2015). Similar work has used PCA to differentiate between abused substances impregnated into matrices but did not explain why PCA was successful for some substances and not others (Pereira et al. 2017; de Oliveira Magalhaes et al. 2019).

Typically, NPS that mimic stimulants such as amfetamine and cocaine would be taken orally in pill or powder form (EMCDDA, 2014). SC although available in powder form are normally sold sprayed or soaked onto herbal materials and smoked (Dresen et al. 2010; Uchiyama et al. 2010). However, as mentioned in the introduction SC are being sprayed or soaked into paper and smuggled into prisons decreasing the likelihood of the substances being detected. Ford and Berg (2018) presented analytical evidence that NPS and cutting agents are being smuggled into UK prisons via mail after the media and HMIP reported serious concern regarding the issue. Ralphs (2018) then reported an increasing issue with this type impregnation method with street dealers selling to the homeless population, either selling paper impregnated with NPS or cigarettes soaked in the NPS solution. The findings of NPS on paper raises serious safeguarding concerns for both incarcerated and homeless individuals. A further reason why dealers may be attracted to this method of concealing drugs is to avoid suspicion from law enforcement personnel when searching drug dealing suspects, preventing incarceration for the individual. A reason homeless individuals may be attracted to NPS use is the reduced risk of penalties under the current legislative framework.

6.4.1 Strengths and limitations

This research study involved the use of ATR-FTIR spectroscopy to detect NPS impregnated into paper. The results in this observational study showed that all three synthetic cannabinoids analysed could be detected on paper in concentrations of 15 mg/mL and above. Due to the limited quantity of the NPS available, it was not possible to included more concentrations to impregnate into paper. It was possible to visually detect the NPS on paper due to the substances crystallising onto the surface of the paper after the solvent evaporated. A limitation to this study was using the ATR accessory for the FTIR as this technique collects information on the surface of the sample. Although this accessory proved useful for all three synthetic cannabinoids and the two cutting agents it did not detect etizolam, benzocaine and lidocaine.

6.5. Conclusion

Overall, the use of ATR-FTIR spectroscopy has proven to be a successful technique for detecting some NPS impregnated into paper depending on the chemical structure and solubility in the solvent. The use of chemometrics to distinguish differences between different concentrations of NPS and cutting agent impregnated into paper proved successful for the compounds that crystallised onto the papers surface and for AKB 48. The three synthetic cannabinoids used in this study were detectable on paper and is due to crystallisation of the compound onto the surface of the paper or hydrogen bonding between a functional group present in the cannabinoid and the hydroxyl group in ethanol and depositing near the papers surface after evaporation. For the NPS and cutting agents that were not detectable impregnated into paper using ATR-FTIR spectroscopy was likely due to the substances being carried into the bulk of the matrix and ATR measures the surface of the sample. This urges the need to use diffuse reflectance for future work which penetrates deeper into the sample.

Chapter 7. Detectability of NPS impregnated into paper using Raman spectroscopy

7.1. Introduction

Raman spectroscopy underlies the interaction between the photons of light and the sample of interest through a phenomenon called scattering. Scattering is one of the phenomena that occur upon interaction of the photons with chemical species within the sample of interest. It is noteworthy to mention that other phenomena include absorption, reflection and transmission. In this respect Raman scattering is minute compared to other phenomena (Chalmers et al. 2012). The phenomena of Raman scattering is relatively new and was discovered in 1928 by Sir C.V. Raman who won the Nobel prize in 1930 for his discovery (Raman 1928). When the photon comes in contact with the sample the majority of the photons do undertake any exchange of energy before scattering. This latter phenomena is known as Rayleigh scattering. In Raman scattering, a small minority of the photons (1 in 1 million) exchange energy with the sample and either increases the or decreases the wavelength of light, which is detected and creates the unique spectrum. The exchange of energy between the photon and the sample is known as Raman scattering. Rayleigh scattering is 10^6 - 10^8 more frequent than Raman scattering.

The Raman scattering reveals molecular information from which structure and chemical information can be extracted to characterise a wide range of chemical compounds. The advantage of using Raman spectroscopy is that is non-destructive and requires little to no sample preparation with the ability to measure through glass, plastic and packaging (Chalmers et al. 2012; Smith and Dent 2019).

Raman spectroscopy has been previously applied to the analysis of drugs of abuse such as amfetamine, benzodiazepines, cannabinoids, cocaine and opiates, which includes different polymorphs and salts forms (Carter et al. 2000; Katainen et al. 2007; Ali et al. 2008; Hargreaves et al. 2008). Moreover, illicit drug residues impregnated into a variety of matrices have been studied and detected using Raman spectroscopy which enabled law enforcement personal and boarder control to analyse suspected materials of containing drug compounds without being in direct contact with the substance (Eliasson et al. 2008; Hargreaves et al. 2008; Ali et al. 2010).

Raman spectroscopy has been used for the detection and identification of NPS in forensic context but not extensively (Stewart et al. 2012; Mostowtt and McCord 2017; Deriu at al. 2019). Investigation of these substances by official methods of analysis has been usually performed by applying immunoassays, gas chromatography, capillary electrophoresis, liquid chromatography (Cheng et al. 2011; Karasek and Clements 2012;

Baker et al. 2014; Trana et al. 2020) or hyphenated-techniques. Nowadays it is becoming more important to develop rapid, non-destructive and reproducible methods to allow the “on-site analysis” of drugs including NPS.

Not only for drugs these techniques are needed but also for fast parcels, packages, mail, bottles, and other items that compounds can be concealed. Thus, the need to find sensitive and selective techniques for identifying concealed substances including drug mixtures and toxic substances without opening a suspected material is crucial. There is also growing concern regarding the concealment of drugs in a variety of matrices as it presents health hazard to law enforcement officers. Initially used by the drug cartels and criminal organisations to conceal drugs compounds in unsuspecting materials, impregnating drugs into textiles, fabrics and food products has been extensively documented (Eliasson et al. 2008; West and Went 2009; Ali et al. 2010). In face of these emerging challenges various researchers have developed methods to detect substances impregnated into matrices such as alcohol, textiles and food products. There is also growing concern regarding the concealment of drugs into matrices such alcohol, textiles and capsules. However, no study used spectroscopy for Raman spectroscopy for drugs on paper.

7.1.1 Aim

This research aimed to detect and interpret NPS products and cutting agents impregnated into paper at different concentrations using portable Raman spectroscopy. Information collected in the previous four studies informed the design of this research study. The specific objectives for this research study include:

1. Optimise the detection of paper, NPS and cutting agents using Raman spectroscopy with a 1064 nm laser source.
2. Interpret and identify functional groups present in NPS and cutting agents when impregnated into paper.
3. Determine if Raman spectroscopy can detect different concentrations of NPS and cutting agents.
4. Examine the use of chemometrics to differentiate different NPS and cutting agent concentrations.

7.2. Method

7.2.1 Study design

Samples of paper, NPS, cutting agents and solvents (same as the method presented in chapter 6) were used. The samples were measured either in raw form or after impregnation into paper. The four NPS and four cutting agents are the same compounds measured in chapter 6 and were chosen due to evidence presented by Ford and Berg (2018) and the Home Office (2018) reporting that NPS have been smuggled into UK prisons impregnated in paper since 2016. In addition, a respondent in chapter 2 (semi-structured questionnaire) reported they used Spice in prison that was impregnated into paper and as mentioned in chapter 4 the homeless population had started to use NPS impregnated into paper. The purpose of this research study was to develop and optimise the detection of NPS on different substrates of paper using Raman spectroscopy for the UK prison service. The initial step for conducting this experiment was to identify the most prevalent NPS compounds being smuggled into UK prisons. Ford and Berg (2018) confirmed six NPS compounds being smuggled into UK prisons on substrates of paper.

The four NPS included three synthetic cannabinoids (5F-PB-22, AB-FUBINACA and AKB-48) and one synthetic benzodiazepine (etizolam). The cutting agents consisted of four compounds and included benzocaine, caffeine, lidocaine and procaine. All cutting agents were purchased from Sigma Aldrich and were of analytical grade (purity ~99.9%). A total of five different densities of paper were used for this study (75 g/m^2, 80 g/m^2, 90 g/m^2, 100 g/m^2 and 120 g/m^2) and purchased from Navigator. Ethanol of analytical grade was purchased from Sigma Aldrich. All samples used in this study were manufactured in the UK. For the purpose of impregnation, only 80 g/m^2 was used as this is the most commonly used weight of paper. The chemical properties of the NPS and solvents used in this study are reported in (Chapter 6.2.1. Table 6.1 Chemical properties of the NPS and solvents used in the study).

7.2.2. Materials

Four NPS compounds of analytical grade (purity ~99.9%) including AB FUBINACA, AKB 48, etizolam and 5F-PB-22 were purchased from Sigma Aldrich. Four cutting agents of analytical grade including benzocaine, caffeine, lidocaine and procaine were purchased from Sigma Aldrich and used in this study. Ethanol of analytical grade (purity ~99.8%) were purchased from Sigma Aldrich. Five different densities of paper were purchased (75 g/m^2, 80 g/m^2, 90 g/m^2, 100 g/m^2 and 120 g/m^2) from Navigator. The chemical properties of the NPS and solvents used in this study are reported in (Chapter 6.2.1. - Table 6.2.1. Chemical properties of the NPS and solvents used in the study).

7.2.3. Instrumentation

Raman measurements were collected using handheld Rigaku FirstGuard 1064 nm Raman spectrometer (Figure 7.1). Each sample spectrum was collected over the wavenumber region 200 – 2000 cm^{-1}.

Figure 7.1 Handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.2.4. Procedure

Measurement of the NPS and cutting agent samples was done without sample treatment by direct contact with the sample. Paper samples were also measured without sample treatment. The rate of evaporation and impregnation duration had been previously determined (chapter 6.2.3) and is used in this chapter. This consists of 1 minute of soaking in a bath of ethanol and dissolved NPS or cutting agent and left to dry at ambient room temperature for 60 minutes. The four NPS compounds and four cutting agents were dissolved in ethanol in four different concentrations (10 mg/mL, 15 mg/mL, 20 mg/mL and 25 mg/mL) and impregnated onto five different densities of paper (75 g/m^2, 80 g/m^2, 90 g/m^2, 100 g/m^2 and 120 g/m^2) through soaking. Paper samples of each density were cut into 1 cm^2 segments and then soaked into each of the of the four NPS solutions for one minute per sample and left to dry at ambient room temperature and humidity for 30 minutes. Ten spectra were collected for each sample and each sample was the sum of 8 scans with 8 seconds exposure time and 490 mw laser power. A background measurement was performed prior to every Raman measurement.

7.2.5. Data analysis

All spectra were imported into Matlab 2020b for visualisation and interpretation. Data analysis comprised the use of two algorithms being PCA and PLSR that were used for the identification and quantification, respectively.

7.3. Results

7.3.1. Spectral analysis of paper using Raman spectroscopy

Spectral interpretation for blank paper (Figure 7.2) was conducted considering four regions. In the spectral range between 250 – 550 cm^{-1}, several closely spaced medium intensity bands were observed in the Raman spectrum and the predominant motions are skeletal bending modes involving C-C, C-O-C, O-C-C and O-C-O functional groups.

In the region between 550 – 950 cm^{-1} of the Raman spectra of paper, two weak bands widely spaced are observed. The two bands observed at 655 and 809 cm^{-1} are attributed to the out-of-plane bending of C-C-C, C-O-C, O-C-O and C-C-O. In the region between 950 – 1200 cm^{-1} one very strong band is observed at 1072 cm^{-1} and is attributed to the stretching of C-C and C-O functional groups. In the region between 1200 – 1600 cm^{-1} several closely spaced medium intensity bands are observed in the Raman spectrum and are attributed to C-C-H, O-C-H, C-O-H and H-C-H bending. Between 1430 – 1600 cm^{-1} the major spectral band observed is H-C-H bending; from 1430 – 1350 cm^{-1} is C-O-H bending; and from 1350 – 1200 cm^{-1} is H-C-C and H-C-O bending.

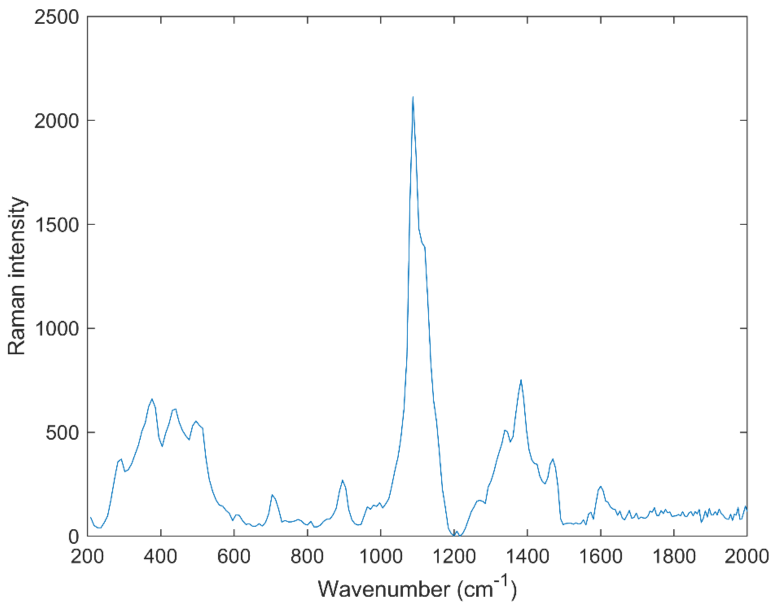


Figure 7.2 Raman spectrum of blank paper 80 g/m² measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.3.2. NPS spectral analysis interpretation using Raman spectroscopy

7.3.2.1. 5F-PB-22

The spectrum of 5F-PB-22 (Figure 7.3) had key spectral band features and was assigned C=O stretching at 1712 cm^{-1}, the indazole ring breathing at 1467, 1529, 1363 and 787 cm^{-1} and the quinoline ring at 497, 726, 1363 and 1565 cm^{-1}. The C-F band appears as a weak mode at 851 cm^{-1}.

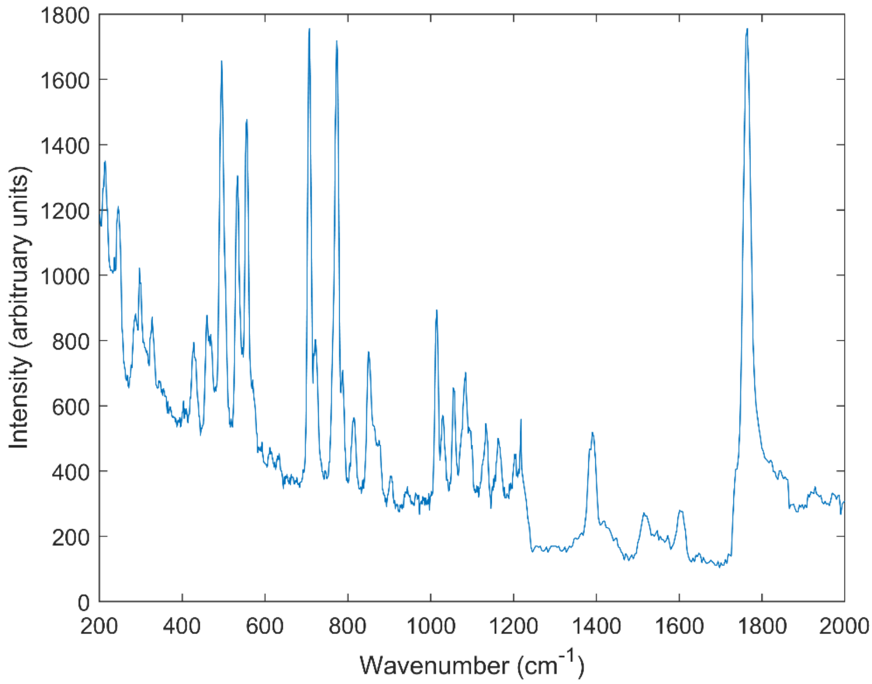


Figure 7.3 Raw Raman spectrum of 5F-PB-22 measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.3.2.2. AB-FUBINACA

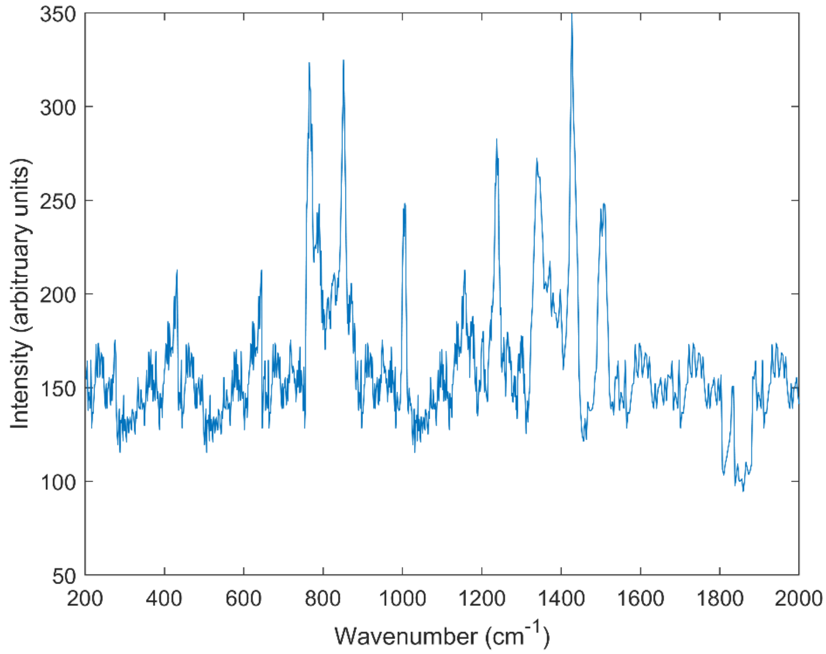


Figure 7.4 Raw Raman spectrum of AB-FUBINACA measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

In the spectrum of AB-FUBINACA (Figure 7.4) the vibrational mode at 770 cm^{-1} corresponds to stretching and bending vibrations of the 1st and 2nd C=O carbonyls of the amide and ester groups, respectively. The vibrational modes at 850 cm^{-1} and 1221 cm^{-1} are attributed to the C=O wagging, and the C-O stretching vibrations of the ester group only. The vibrational mode at 1090 cm^{-1} is associated with the combined N-H bend and the C-N stretch of the amide group along with the N–C and the 2nd C=O stretch of the amide group. The band at 1517 cm^{-1} is attributed to the asymmetrical in-plane stretching of C-N amide group.

7.3.2.3. AKB-48

The spectrum of AKB-48 (Figure 7.5) is dominated by three spectral bands observed at 790, 1342 and 1584 cm^{-1}. These spectral bands are attributed to symmetrical stretching of carbonyl (C=O), symmetrical in-plane stretching of tertiary amine (C-N), and symmetrical stretching of a conjugated ketone (C=O). Additional weaker spectral bands are observed at 1428, 1527 and 1730 cm^{-1} and attributed to asymmetrical in-plane stretching of aromatic amine (C-N), secondary amine wagging (N-H), and methylene rocking (C-H), respectively.

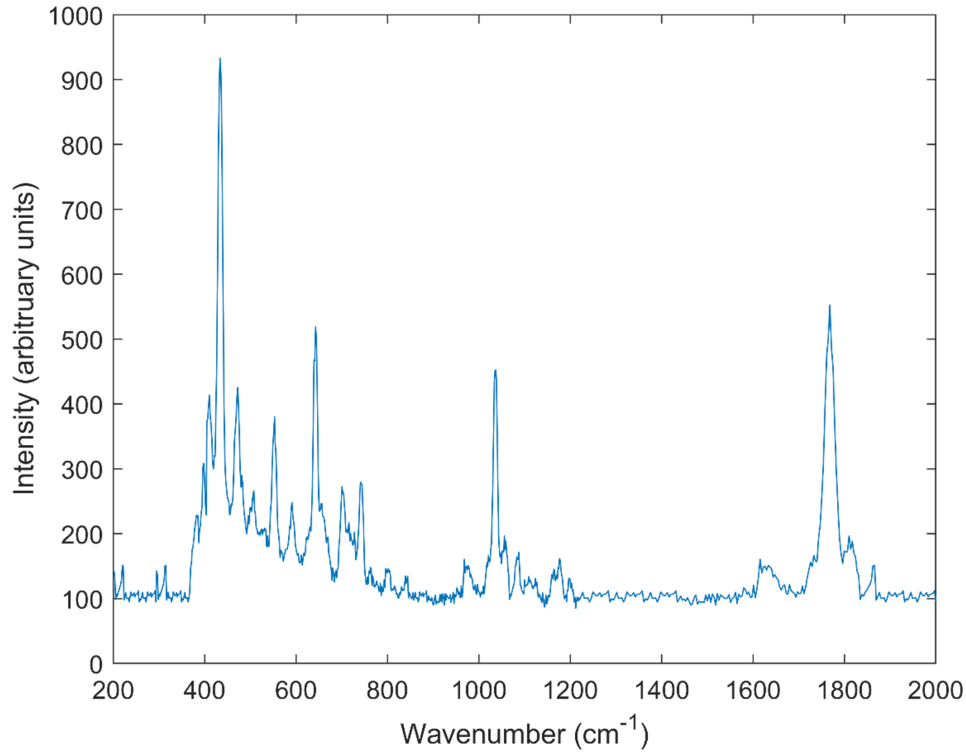


Figure 7.5 Raman spectrum of AKB-48 measured handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.3.2.4. Etizolam

The spectra for etizolam only has one dominant spectral band at 1496 cm^{-1} and is attributed to carbonyl amide asymmetrical stretching (C=N).

7.3.3 Cutting agent interpretation

7.3.3.1. Benzocaine

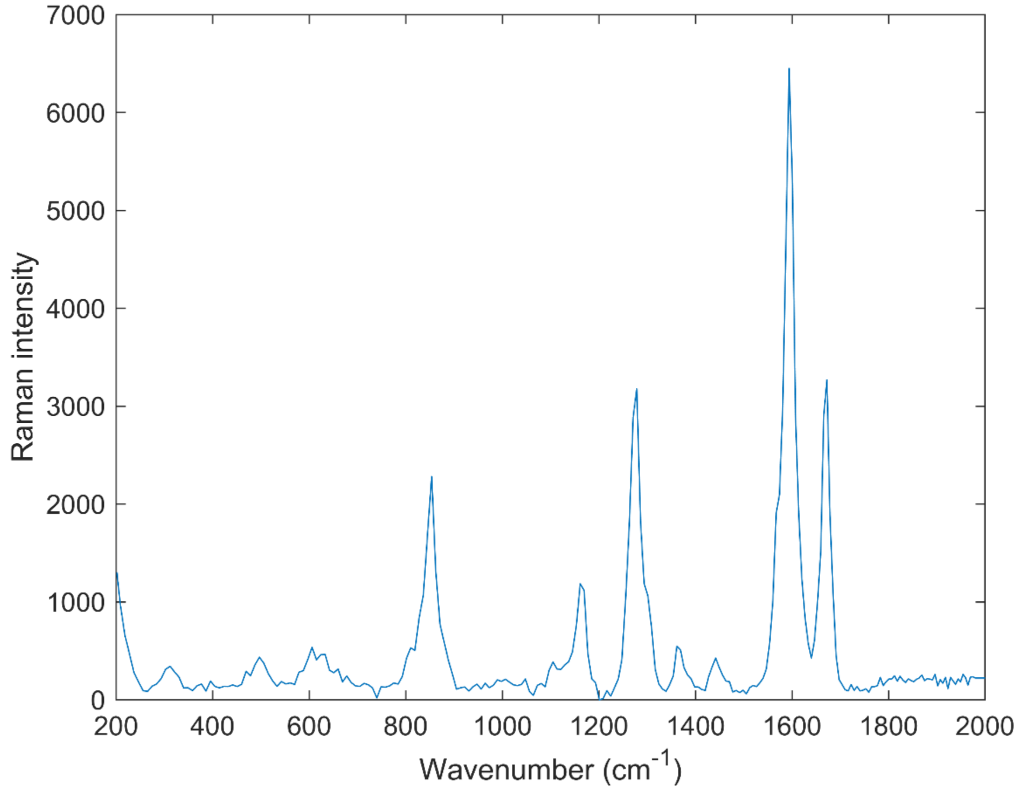


Figure 7.6 Raman spectrum of benzocaine measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

The Raman spectrum of benzocaine (Figure 7.6) had five key spectral bands and were observed at 807, 1186, 1238, 1597 and 1658 cm^{-1}. The medium sharp peak observed at 807 cm-1 is attributed to the in-plane bending of methylene (C-H), a weak sharp peak at 1186 cm^{-1} attributes to the symmetrical stretching of ether (C-O-C), a medium peak observed at 1238 cm^{-1} attributes to the skeletal vibrations of C-C, a strong peak observed at 1597 cm^{-1} attributes to the symmetrical stretching of alkyl ketone (C=O) and a medium peak at 1658 cm^{-1} attributes to amide scissoring (NH_2).

7.3.3.2. Caffeine

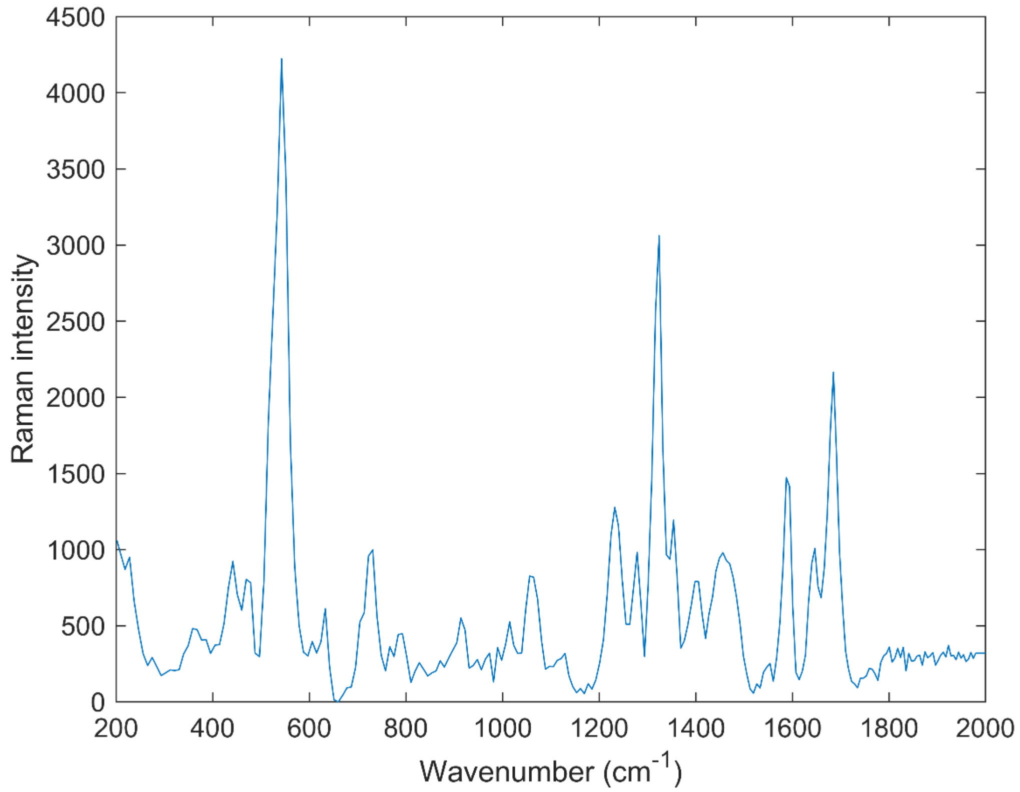


Figure 7.7 Raman spectrum of caffeine measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

The Raman spectrum of caffeine (Figure 7.7) shows main spectral bands observed at 442, 555, 744, 930, 1076, 1242, 1333, 1409, 1551 and 1698 cm^{-1}. The small spectral band located at 442 cm^{-1} is attributed to the stretching of CNO in the pyrimidine ring. Additional pyrimidine ring stretching is located at 555 cm^{-1} (strong band) and 744 cm^{-1} (medium band) and is attributed to CNC and OCN functional group.

7.3.3.3. Lidocaine

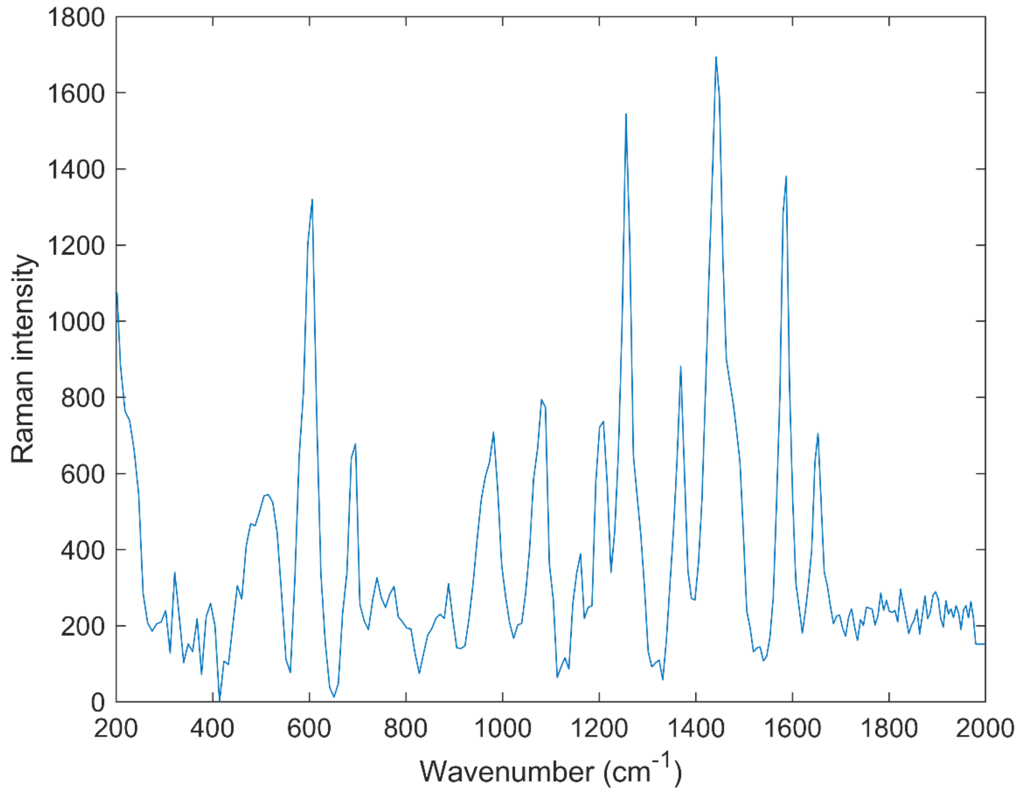


Figure 7.8 Raman spectrum of lidocaine measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

The main spectral bands for lidocaine are observed at 549, 603, 706, 1302, 1387, 1460, 1596 and 1667 cm^{-1}. The Raman spectrum of lidocaine (Figure 7.8) is also dominated by the CNC ring breathing at 1387 cm^{-1}, benzene ring stretching 1460 cm^{-1}, and amide modes at 603, 706, 1596 and 1667 cm^{-1}.

Table 7.1 Raman spectral information regarding NPS and cutting agents used in this study

Product number	Product name	Peak position	Peak intensity	Type of vibration	FTIR activity (strong, medium or weak), broad or narrow	Corresponding functional group	Potential constituent(s)
1	5F-PB-22	480	1637	Rocking	Weak and sharp	C-H	Methylene
		540	1493	chain vibration	Weak and sharp	C-C	Skeletal vibrations
		694	1782	Vibrations	Medium and sharp	C-C	Skeletal vibrations
		760	1711	Stretching	Strong and sharp	C-F	Fluoro
		1052	831	Symmetrical in-plane stretching	Medium and sharp	C-C	Skeletal vibrations
		1324	438	Asymmetrical in-plane stretching	Strong and sharp	C=O	Carboxylic acid
		1389	589	Stretching	Strong and sharp	C-N	Tertiary amine
		1411	417	chain vibration	Medium and sharp	C-C	Aromatic ring
		1546	241	chain vibration	Strong and sharp	C-C	Skeletal vibrations
		1589	245	chain vibration	Medium and sharp	C=O	Alkyl ketone
		1703	1767	Stretching	Strong and sharp	C-O	Primary alcohol
2	AB-FUBINACA	770	326	Rocking	Strong and sharp	C-H	Methylene
		821	330	Symmetrical in-plane stretching	Medium and sharp	N-N	Aromatic nitro compound
		1277	275	Asymmetrical in-plane stretching	Weak and sharp	C-O	Carbonyl amide
		1356	268	Stretching	Medium and sharp	C-N	Amide
		1405	349	Asymmetrical in-plane stretching	Medium and sharp	N-H	Secondary amine
		1511	289	Asymmetrical in-plane stretching	Medium and sharp	C-N	Secondary amine
		1659	179	Wagging	Medium and broad	N-H	Aliphatic primary amine
3	AKB-48	276	831	Rocking	Strong and sharp	C-H	Methylene
		405	438	Vibrations	Medium and sharp	C-C	Skeletal vibrations
		781	589	Breathing	Medium and sharp	C-H	Aromatic ring
		1340	330	Vibrations	Strong and sharp	C-C	Skeletal vibrations

		1381	275	Symmetrical in-plane stretching	Weak and sharp	C-N	Tertiary amine
		1428	589	Asymmetrical in-plane stretching	Medium and sharp	C-N	Aromatic secondary amine
		1527	417	Wagging	Medium and sharp	N-H	Secondary amine
		1574	241	Symmetrical stretching	Weak and sharp	C=O	Conjugated ketone
		1730	245	Stretching	Weak and sharp	C-H	Methylene
4	Etizolam	437	208	Breathing	Weak and sharp	C-H	Aromatic ring
		642	251	Stretching	Weak and sharp	C-Cl	Aliphatic chloro compound
		1032	267	Vibrations	Weak and sharp	C-C	Skeletal vibrations
		1495	671	Stretching	Strong and sharp	C=N	Carbonyl amide
5	Benzocaine	445	1109	Vibrations	weak and sharp	C-C	Aliphatic chain
		478	1036	Wagging	weak and sharp	NH_2	Primary amine
		586	4128	Wagging	strong and sharp	NH_2	Primary amine
		1076	895	Symmetrical stretching	weak and sharp	C-O-C	Ether
		1238	1398	Vibrations	Medium and sharp	C-C	Skeletal vibrations
		1378	3862	In-plane deformation	strong and sharp	O-C=O	Carboxylate salt
		1501	1490	In-plane twist	Weak and broad	CH_2	Methyl
		1589	1789	Breathing	Medium and sharp	C-C	Aromatic hetero ring
		1606	1375	Scissoring	weak and sharp	NH_2	Amide
		1701	2097	Stretching	Medium and sharp	C=O	Alkyl ketone
6	Caffeine	574	4309	Deformation	strong and sharp	C-N	Pyrimidine ring
		1120	870	Asymmetrical bending	weak and sharp	C-C	Skeletal vibrations
		1209	1225	Symmetrical stretching	Medium and sharp	C-N	Secondary amine
		1307	3068	Stretching	strong and sharp	C-C	Indazole ring
		1399	1190	Symmetrical bending	Medium and sharp	CH_2	Methyl
		1438	1004	Vibrations	medium and broad	C-C	Aromatic ring
		1580	1476	Symmetrical stretching	Medium and sharp	C-N	Amine

		1630	1156	Out-of-phase stretching	Medium and sharp	C-O	Carbonyl amide
		1679	2205	In-phase stretching	strong and sharp	C-O	Carbonyl amide
7	Lidocaine	549	589	Wagging	medium and broad	NH_2	Primary amine
		603	1306	Stretching	strong and sharp	C-N	Amide
		1302	1524	In-plane twist	strong and sharp	CH_2	Methyl
		1387	835	Stretching	Medium and sharp	C-N	Tertiary amine
		1460	1689	Breathing	strong and sharp	C-C	Aromatic ring
		1578	1378	Stretching	strong and sharp	C=O	Alkyl ketone
		1667	734	Scissoring	strong and sharp	NH_2	Aliphatic secondary amine
8	Procaine	542	509	Torsion	medium and sharp	C-C	Skeletal vibrations
		607	796	Wagging	medium and broad	N-H	Primary amine
		850	2065	bending	strong and sharp	C-H	Methylene
		1209	1252	Rocking	Medium and sharp	CH_3	Methyl
		1311	3357	Stretching	strong and sharp	C-N	Tertiary amine
		1386	481	Stretching	weak and sharp	C-O	Secondary alcohol
		1429	317	Breathing	weak and sharp	C-C	Aromatic ring
		1597	6753	Stretching	strong and sharp	C=O	Carbonyl ester
		1674	3871	Scissoring	Medium and sharp	N-H	Aromatic amine

5F-PB-22: Quinolin-8-yl 1-(5-fluoropentyl-)-1H-indole-3-carboxylate, AB-FUBINACA: N-[(1S)-1-(aminocarbonyl)-2-methylpropyl]-1-[(4-fluorophenyl)methyl]-1H-indazole-3-carboxamide, AKB-48: N-(1-adamantyl)-1-pentyl-1H-indazole-3-carboxamide.

7.3.3.4. Procaine

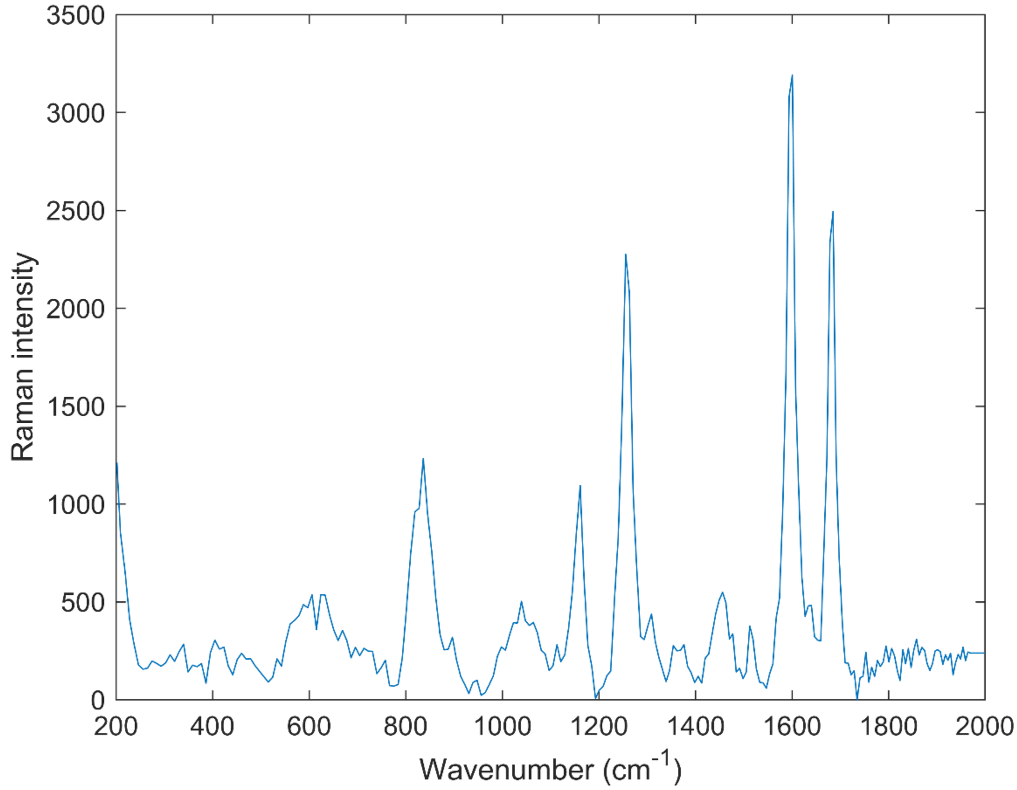


Figure 7.9 Raman spectrum of procaine measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

A total of six spectral bands were observed for procaine measured with Rigaku Raman spectrometer equip with a 1064 nm laser (Figure 7.9). The spectral bands were observed at 607, 850, 1209, 1311, 1597 and 1674 cm^{-1}, attributing to benzene ring deformation (C-C), methyl wagging (C-H), methyl in-plane bending (C-H), tertiary amine symmetrical stretching (C-N), aromatic ring breathing (C-C) and carbonyl ester asymmetrical stretching (C=O).

7.3.4. Spectral interpretation of Synthetic cannabinoids impregnated into paper

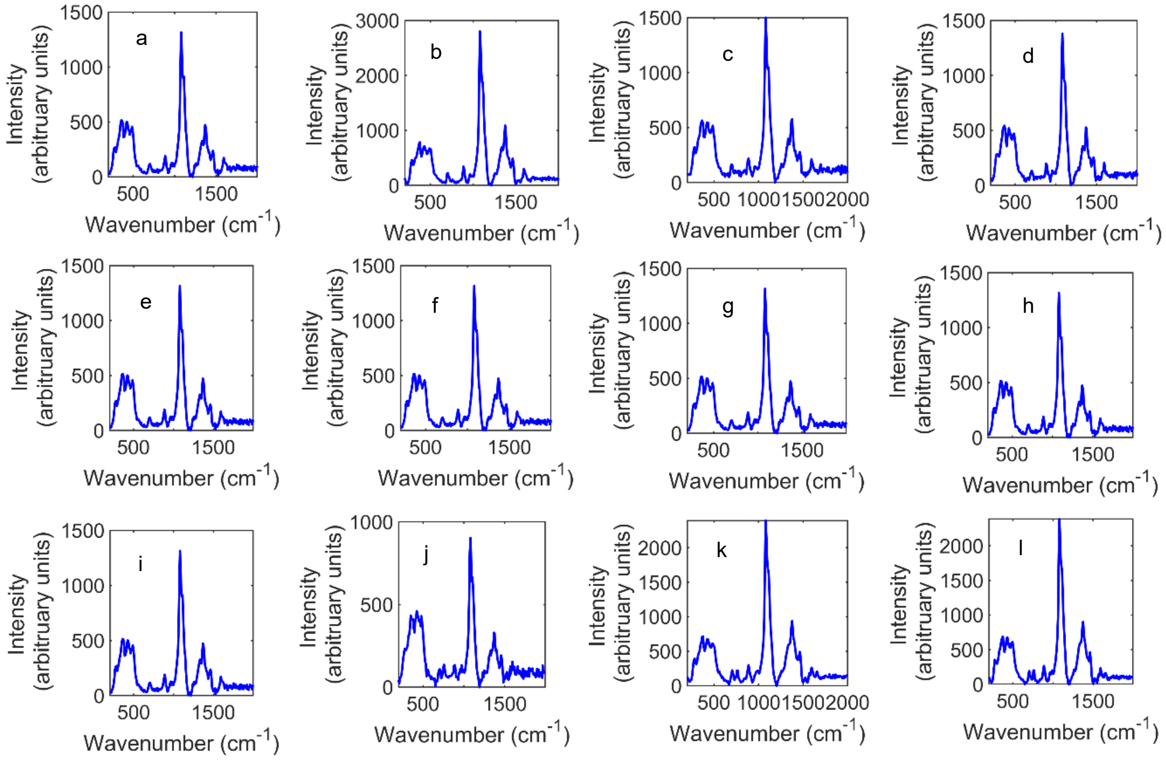


Figure 7.10 Raw Raman spectra of 5F-PB-22 impregnated into paper at (a)10 mg/mL (b) 15 mg/mL (c) 20 mg/mL (d)25 mg/mL, AB-FUBINACA impregnated into paper at (e)10 mg/mL (f) 15 mg/mL (g) 20 mg/mL (h) 25 mg/mL and AKB-48 impregnated into paper at (i) 10 mg/mL (j) 15 mg/mL (k) 20 mg/mL (l) 25 mg/mL measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.3.4.1. 5F-PB-22

Surprisingly, the synthetic cannabinoid 5F-PB-22 was not detectable using Raman spectroscopy equip with a 1064 nm laser source when impregnated into paper in concentrations of between 10 - 25 mg/mL. This was not the case when using ATR-FTIR spectroscopy as discussed in Chapter 6.4.1. where the compound were detectable in concentrations of 10 mg/mL and above.

7.3.4.2. AB FUBINACA

The synthetic cannabinoid AB-FUBINACA was not detectable using Raman spectroscopy equip with a 1064 nm laser when impregnated into paper in concentrations between 10 – 25 mg/mL. The spectral interpretation revealed that functional groups with strong Raman absorption 770, 1004, 1225 and 1405 cm^{-1} attributing to methylene rocking (C-H), C-C asymmetric bending, amide symmetrical stretching (C-N) and secondary amine bending (N-H) were not detectable using Raman spectroscopy. It is possible that the strong absorption band at 1004 cm^{-1} was masked by strong absorption peak attributing to C-O stretching in paper.

7.3.4.3. AKB-48

The synthetic cannabinoid AKB-48 impregnated into paper was detected in concentrations of 20 mg/mL and above using Raman spectroscopy equip with a 1064 nm laser source. A total of three peaks attributing to only two functional groups were present in paper impregnated with AKB-48 and included carboxylic acid (C=O) and amine (N-H) functional groups. A weak sharp peak at 650 cm^{-1} and a medium sharp peak at 1680 cm^{-1} attributes to primary amine functional group at the carboxamide linkage. A medium sharp peak at 1650 cm^{-1} attributes to the stretching of carboxylic (C=O) functional group. The same spectral peaks in the carboxamide linkage were observed when using ATR-FTIR spectroscopy as mentioned in Chapter 6.4.3.

7.3.4.3.1. Area of interest for AKB-48

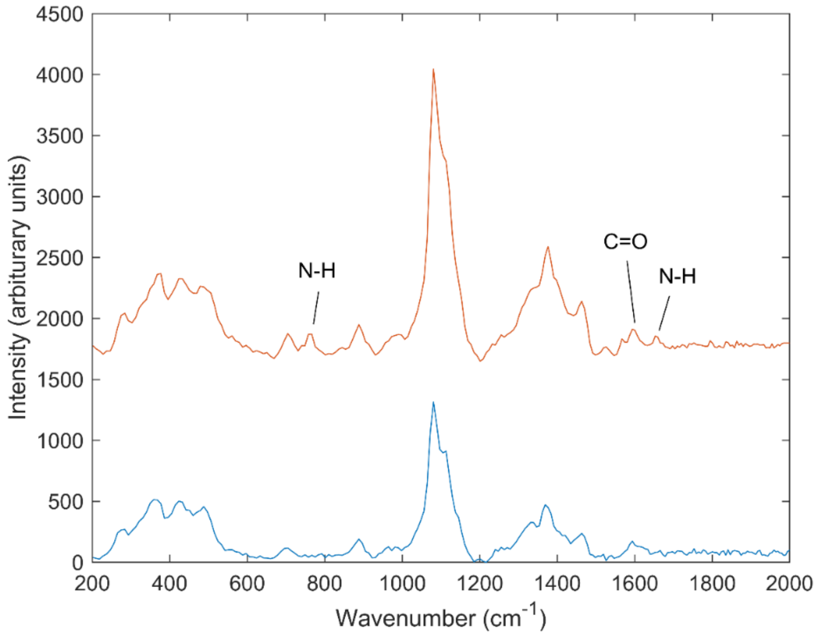


Figure 7.11 Raman stacked spectra of blank paper (blue) and AKB-48 impregnated into paper at 25 mg/mL concentration measured in the wavenumber region 200 - 2000 cm^{-1} using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

Spectral bands attributing to functional groups present in AKB-48 and not paper were observed at 650, 1650 and 1680 cm^{-1} (Figure 7.11). The peaks at 650 and 1680 cm^{-1} are attributed to N-H bending and N-H stretching of the secondary amine at the carboxamide linkage connecting the adamantyl group and indazole moiety. The peak observed at 1650 cm^{-1} is attributed to carbonyl stretching at the carboxamide linkage attached to the secondary amine. A clear pattern has shown that the carboxamide linkage connecting the adamantly group and indazole moiety can be used to interpret paper impregnated with AKB-48 when using Raman spectroscopy equip with a 1064 nm laser source and ATR-FTIR spectroscopy.

7.3.4.4. Etizolam

The synthetic benzodiazepine etizolam was not detectable using Raman spectroscopy when impregnated into paper in concentrations between 10 to 25 mg/mL. The spectral interpretation revealed that functional groups for etizolam especially the fluoro functional group (C-Fl) was not detected using ATR-FTIR spectroscopy. A reason for this is that etizolam was carried into the bulk of the paper or evaporated with the solvent.

7.3.5. PLSR of AKB-48

AKB-48 was the only NPS derivative detected impregnated into paper using Raman spectroscopy and so, a PLSR model was developed only for AKB-48 (Figure 7.12). The model validity was characterised with RMSEC, RMSEP, R_{cal}^2 and R_{pre}^2 with VIP-selecting variables under 10 factors had the best performance. The calibration model for AKB-48 showed with RMSEC and R_{cal}^2 values of 0.7515% and 0.9819, respectively. The prediction model showed similar values to the calibration model with RMSEP and R_{pre}^2 values of 0.8120% and 0.9752, respectively. The random pattern for the residual plot and high R^2 values indicate a good PLSR model performance.

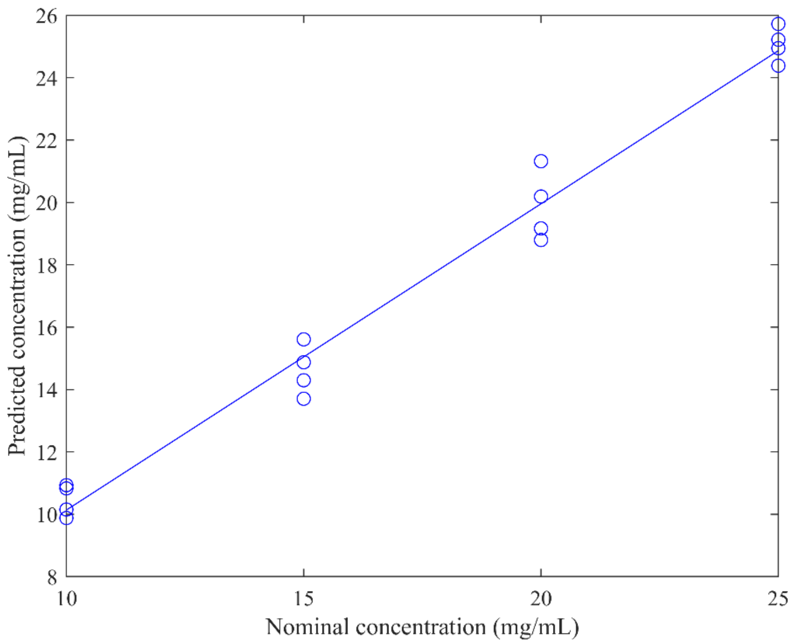


Figure 7.12 PLSR calibration model of AKB-48 impregnated into paper.

7.3.6. Spectral interpretation of cutting agents impregnated into paper

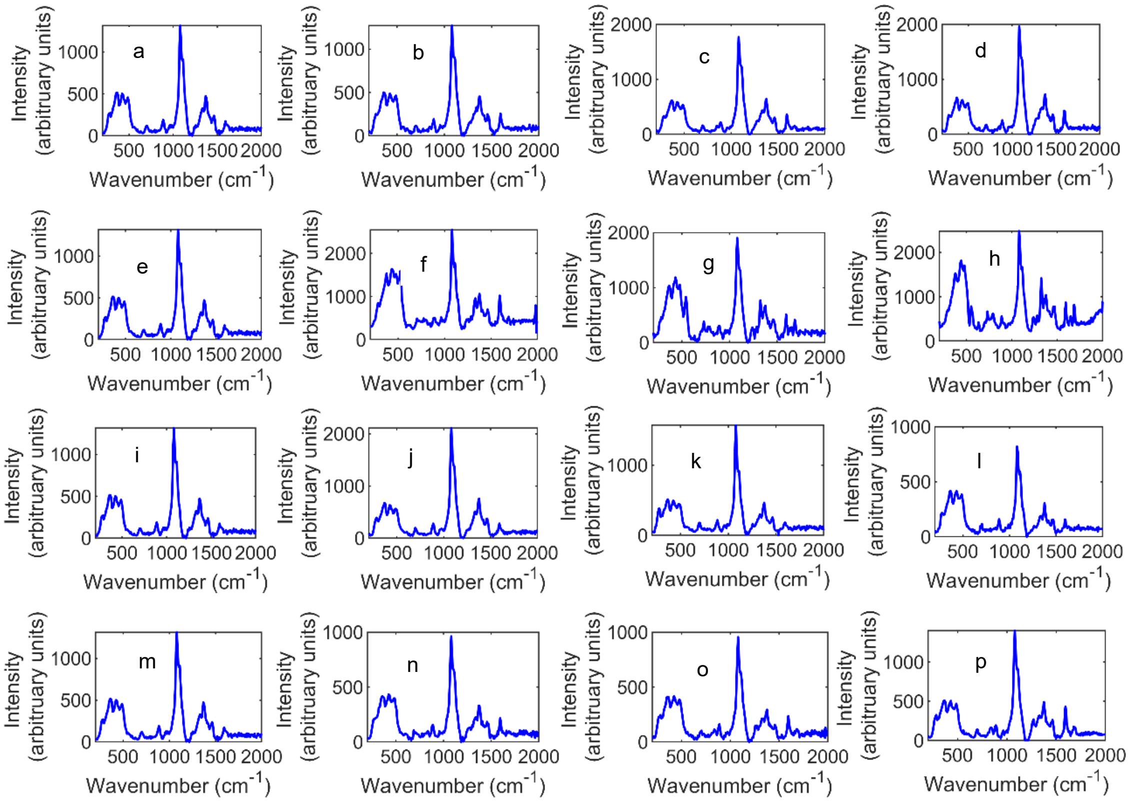


Figure 7.13 Raw Raman spectra of benzocaine impregnated in paper at (a) 10, (b) 15, (c) 20 and (d) 25 mg/mL, caffeine impregnated into paper at (e) 10, (f) 15, (g) 20 and (h) 25 mg/mL, lidocaine (i) 10, (j) 15, (k) 20 and (l) 25 mg/mL and procaine impregnated into paper at (m) 10, (n) 15, (o) 20 and (p) 25 mg/mL measured using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

7.3.6.1. Benzocaine

Benzocaine was not detectable using Raman spectroscopy equip with a 1064nm laser source when impregnated into paper in concentrations between 10 - 25 mg/mL. Benzocaine was not detected on paper using ATR-FTIR spectroscopy as well and is likely to being carried into the bulk of the paper.

7.3.6.2. Caffeine

Caffeine impregnated into paper was detected in concentrations of 15 mg/mL and above. The Raman spectrum showed various characteristic peaks attributing to caffeine and not paper. At 15 mg/mL functional groups attributing to caffeine are observed at 790, 1312 and 1597 cm^{-1} attributing to C-C (790 and 1312 cm^{-1}) and out-of-phase stretching of C-O (1597 cm^{-1}) functional groups. At 20 mg/mL three more spectral bands are observed attributing to pyrimidine ring deformation (C-N) at 550 cm^{-1}, secondary amine symmetrical stretching (C-N) and in-phase stretching of carbonyl amide (C-O). The final concentration of 25 mg/mL did not include more spectral bands but the intensity of caffeine bands increased.

7.3.6.2.1. Area of interest for caffeine

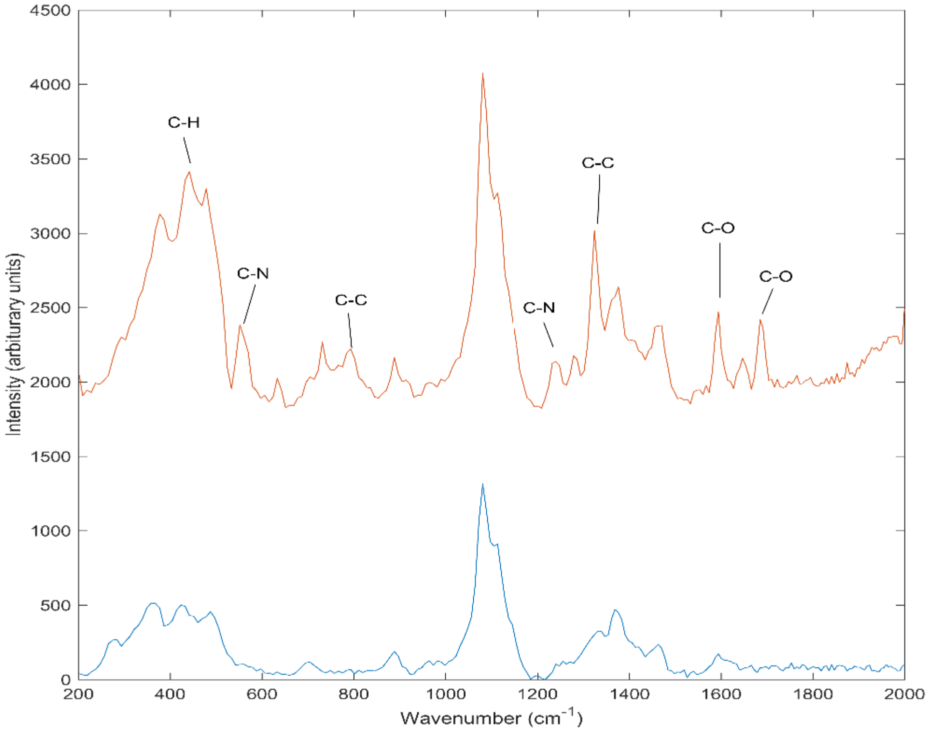


Figure 7.14 Raman stacked spectra of blank paper (blue) and caffeine impregnated into paper at 25 mg/mL concentration measured in the wavenumber region 200 -2000 cm^{-1} using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

The most prominent peaks attributing to caffeine (Figure 7.14) and not paper were in the wavenumber region between 200 to 2000 cm^{-1}. Interesting features concern the caffeine bands at 450, 515, 790, 1207, 1312, 1597 and 1680 cm^{-1} and are assigned to methylene rocking (C-H), pyrimidine ring deformation (C-N), skeletal vibrations (C-C), symmetrical stretching of a secondary amine (C-N), indazole ring symmetrical stretching (C-C) and out-of-phase (C-O) and in-phase stretching of carbonyl amide (C-O), respectively.

7.3.6.3. Lidocaine

Lidocaine was not detectable using Raman spectroscopy equip with a 1064 nm laser source when impregnated into paper in concentrations between 10 - 25 mg/mL. Lidocaine was not detectable when using either Raman or ATR-FTIR spectroscopy as discussed in Chapter 6.4.1. and is likely due to being carried into the bulk of the paper or evaporated with the solvent.

7.3.6.4. Procaine

Procaine impregnated into paper was detected in concentrations of 20 mg/mL and above using Raman spectroscopy equip with a 1064 nm laser source. A total of four spectral bands attributing to four functional groups were present in paper impregnated with procaine and included methylene (C-H), carbonyl ester (C=O), and tertiary (C-N) and aromatic amine (N-H) functional groups.

7.3.5.6.1. Area of interest for procaine

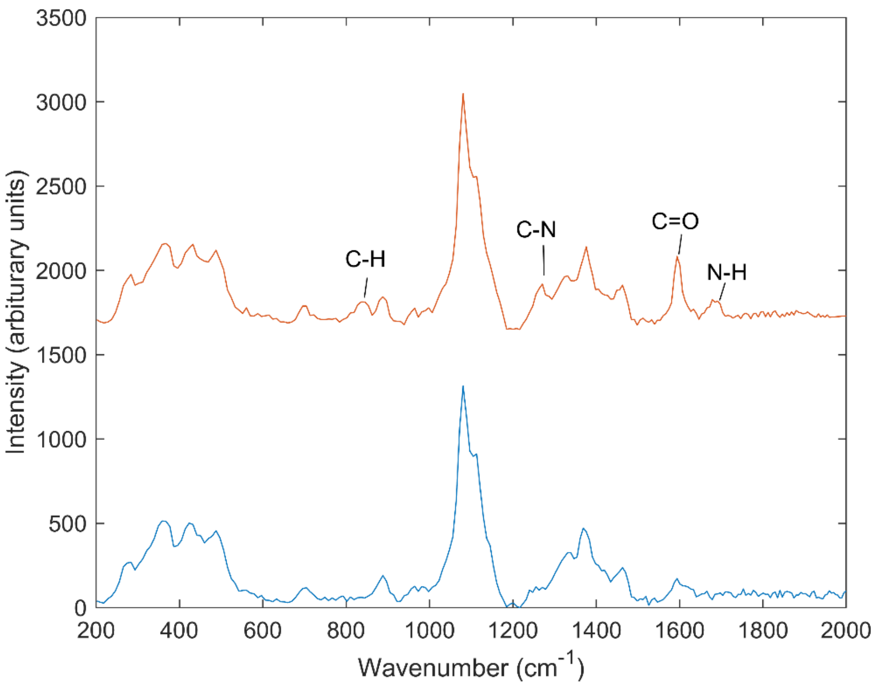


Figure 7.15 Raman stacked spectra of blank paper (blue) and procaine impregnated into paper at 25 mg/mL concentration measured in the wavenumber region 200 -2000 cm^{-1} using handheld Rigaku FT-Raman spectrometer equipped with 1064 nm laser wavelength

Figure 7.15 shows the spectrum for blank paper and procaine impregnated into paper in the wavenumber region of 200 – 2000 cm^{-1}. Four characteristic peaks are observed that are attributed to procaine and not paper. A weak sharp peak at 850 cm^{-1} attributes to methylene in-plane bending. A medium sharp peak at 1311 cm^{-1} attributes to the asymmetrical stretching tertiary amine and a weak sharp peak at 1674 cm^{-1} attribute to aromatic amine scissoring (N-H). A strong sharp peak at 1597 cm^{-1} attributes to the symmetrical stretching of a carbonyl ester (C=O).

7.3.7. PLSR of caffeine and procaine

For the two cutting agent compounds that were detected impregnated into paper using Raman spectroscopy, PLSR models were developed to quantify caffeine and procaine concentrations. The model validity was characterised with RMSEC, RMSEP, R_{cal}^2 and R_{pre}^2 with VIP-selecting variables under 10 factors had the best performance. These results demonstrated that the PLSR models for the aforementioned cutting agents had good performance. For the caffeine calibration model (Figure 7.16) dataset it showed a RMSEC and R_{cal}^2 of 1.1601% and 0.917. The RMSEP and R_{pre}^2 were very similar to the calibration set being 1.609% and 0.905.

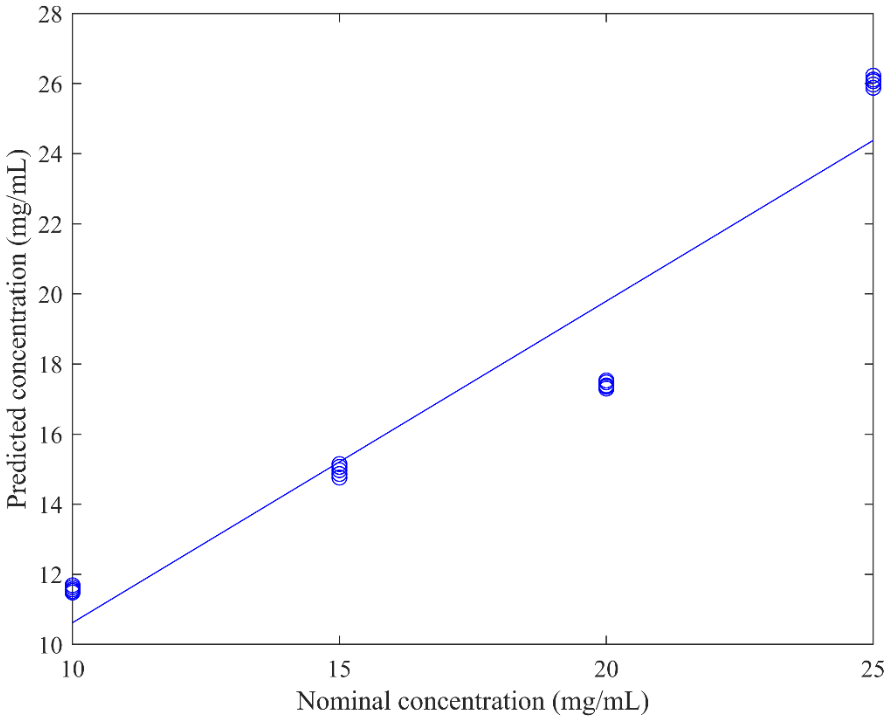


Figure 7.16 PLSR calibration model of caffeine impregnated into paper

The best performance of PLSR for cutting agents used was procaine (Figure 7.17). The RMSEC and R_{cal}^2 of the calibration set were 0.4498 % and 0.9935, respectively. The RMSEP and R_{pre}^2 was 0.5872% and 0.9895 with a random pattern for the residual plot, indicating a good PLSR model performance.

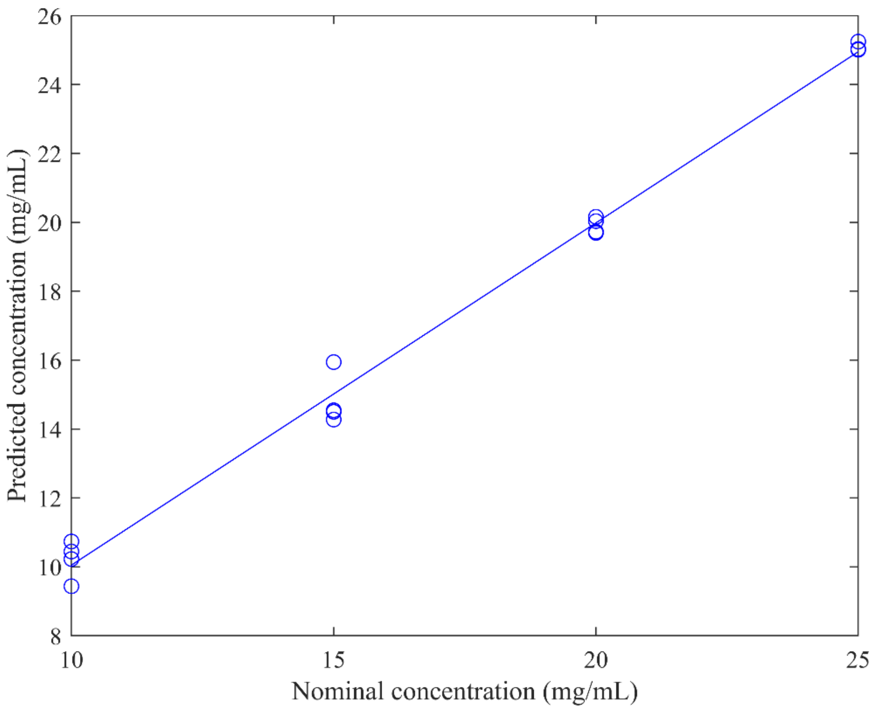


Figure 7.17   PLSR calibration model of procaine impregnated into paper

7.3.8. PCA of detected NPS and cutting agents

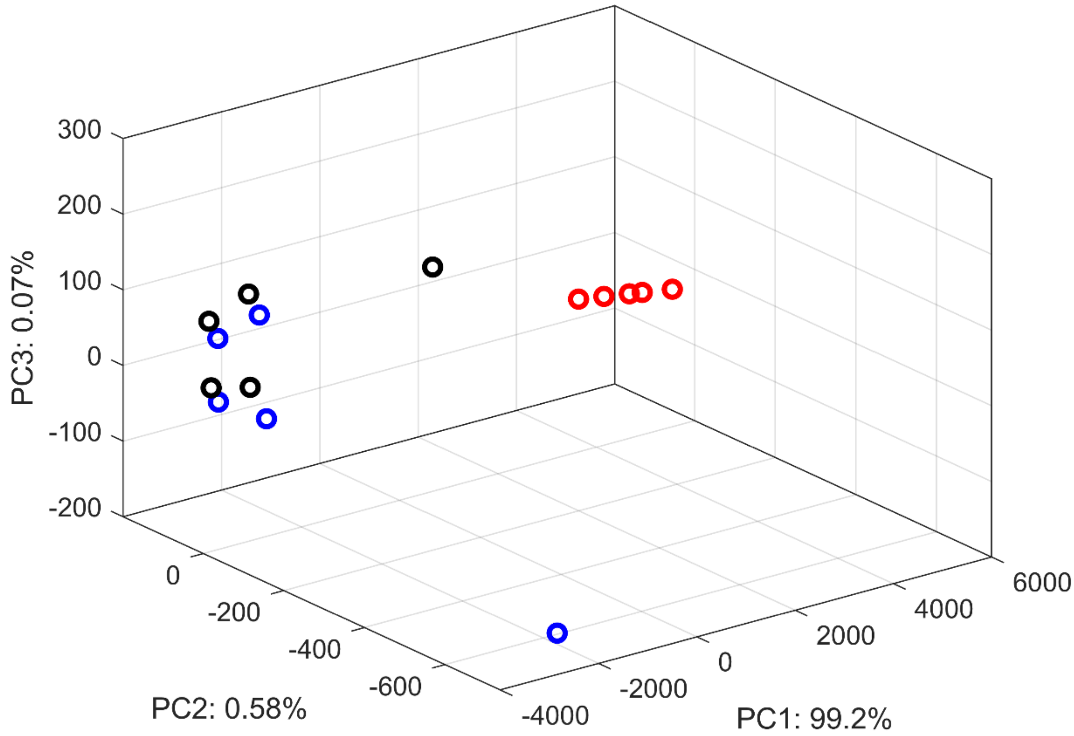


Figure 7.18 PC scores of AKB-48 (blue), procaine (black), caffeine (red), and blank paper (yellow) plotted on a three dimension PC plot

PCA was then applied to the spectra of AKB-48, caffeine, and procaine impregnated into paper and blank paper and measured and in the Raman spectral region between 600 – 2000 cm^{-1}. Figure 7.18 shows the PC1, PC2 and PC3 score plots of these products impregnated into paper at 25 mg/mL. The ability of the classification model to detect different NPS and cutting agents impregnated into paper was tested with a set of three compounds and blank paper containing all spectra collected for sample at the three detected concentrations (15, 20 and 25 mg/mL). Only the highest concentration is shown due to poor separate clustering and high PC1 loading score. The scree plot of the first principal component (PCs) described 77.37% of the data variation and three PCs described 97.92% of the data variation.

7.4. Discussion

This is the first study to examine the use of Raman spectroscopy for detecting NPS impregnated into paper. As mentioned in Chapter 6 research conducted by Ford and Berg (2018) highlighted the initial smuggling of NPS on paper to later be confirmed as a method being used by the homeless population (Ralphs 2016). This has created an urgency in developing portable spectroscopic methods to detect NPS and cutting agents impregnated into textile matrices such as paper. Using both qualitative and quantitative interpretation of Raman spectroscopic data to screen four NPS and four cutting agents we have provided analytical proof that NPS and cutting agents can be detected impregnated into paper. A total of three compounds: one NPS and two cutting agents, were detected on paper using Raman spectroscopy equip with a 1064 nm laser source.

The SCRA, AKB-48 and cutting agent procaine were both detected in concentrations of 20mg/mL and above, whereas caffeine was detected in concentrations of 15mg/mL and above. Surprisingly, 5F-PB-22 and AB-FUBINACA had crystalised onto the surface of the paper but were not detectable using Raman spectroscopy equip with a 1064nm laser source. A reason for this could be due to the use of a 1064nm wavelength laser which is predominantly used to reduce background fluorescence in organic samples, but at considerable sacrifice to signal strength (Smith and Dent 2005; Chalmers et al. 2012). Interference from background fluorescence is a common challenge in Raman spectroscopic analysis and the use of near-Infrared (NIR) excitation is often chosen as a method of reducing fluorescence (McCreery 2000). This also could explain why the paper samples had such a strong signal as paper is composed of plant material (cellulose) and is classified through the interpretation of lignin's (Braz et al. 2013). Similar research conducted West and Went (2009) evaluated the use of Raman spectroscopy in the detection of drugs of abuse on textile fibres after recovery with adhesive lifters. Although, detection of the abused drugs was confirmed by the technique at a lower wavelength using a (632.8 nm) helium-neon laser it was more difficult to identify textiles due to the biological nature (Creasey et al. 2017). Additionally, the drugs were extracted using adhesive tape and then measured without the matrix, which is why a helium-neon laser was chosen.

Functional groups attributing to the carboxamide linkage present in AKB 48 were detected using Raman spectroscopy and ATR-FTIR spectroscopy (Chapter 6). The detected spectral bands attributing to NPS or cutting agents consisted of amine, carbonyl and methyl functional groups, functional groups that dominate biological samples. This elaborates the use of different wavelength lasers for sample identification in complex samples. For this chosen study it was necessary to use a higher wavelength laser source due to the biological nature of the paper and reduction of background fluorescence.

The PLSR models proved successful in predicting the concentrations of AKB-48, caffeine and procaine, however, the use of PCA to distinguish different NPS or cutting agents proved difficult in this research study. The inherent weakness of using PCA to differentiate between AKB-48, caffeine and procaine was likely due to the low number of spectral points in the Raman spectrum, being between 231 – 240 datapoints. In comparison to portable ATR-FTIR spectroscopy used in Chapter 6 which had a total of 1798 spectral datapoints. Comrey and Lee recommended a sample size of 300 for adequate and accurate PCA but did not report the recommended ratio of subjects to items. Larger samples sets tend to minimise the probabilities of error, maximise the accuracy of the data, and increase the generalisability of the results (Shaukat et al. 2016). Using guidelines set by Nunnally (1978) for an item to subject number of 10:1 ratio or a minimum of 400 subjects to assess the suitability of using PCA, it was determined that a total of 20 subjects per model with a minimum of 231 datapoints (items) per spectrum equalled a ratio above 10:1. However, both the sample size and ratios are essential and ignoring either one can have the same result: errors of interference (Osborne and Costello 2004). Failure to have a representative sample of sufficient size results in unstable loadings, random and non-replicable fundings (Cliff 1970; MacCallum et al. 1999).

7.4.1. Limitations

This research study used Raman spectroscopy equip with a 1064 nm laser source to detect NPS and cutting agents impregnated into paper. The results showed that only AKB-48, caffeine and procaine were detected impregnated into paper using Raman spectroscopy in concentrations of 15 mg/mL and above. A limitation to this study was just using the 1064 nm laser source and not 532 nm and 785 nm in addition as some NPS are better analysed using either 532 nm or 785 nm laser sources. A limited quantity of NPS available made including more concentrations not possible. Moreover, the limited number of spectral points in the Raman spectrum made PCA analysis difficult to differentiate between concentrations due to a limited number of spectral points.

7.5. Conclusion

In summary, the use of Raman spectroscopy equip with a 1064nm laser source has proven to be a successful technique in detecting NPS and cutting agent compounds impregnated into paper. The use of chemometric proved difficult in differentiating between different concentrations of impregnated NPS or cutting agents due to a limited number of spectral data points per spectrum. The three compounds that were detectable on paper is due to crystallisation of the compound onto the surface of the paper or hydrogen bonding between a functional group present in the cannabinoid and the hydroxyl group in ethanol and depositing near the papers surface after evaporation.

Additional discussions will take place in Chapter 8, which discusses the results collected in each chapter. These findings will be of interest to Law enforcement personal and Industry organisations who specialise in spectroscopy and create spectral libraries for compound identification. The methodology of impregnating NPS and cutting agents into paper may serve as a useful guide for scientists who develop libraries with impregnated compounds in a variety of matrices.

Chapter 8: Discussion

Using a mixed-methods approach to determine the prevalence, motivations and effects of NPS among the homeless population has provided an insight into NPS profiles and day-to-day lives. Chapters 1 and 2 introduced the thesis and the methodological approach used. Chapters 3, 4 and 5 presented data that provided information regarding the prevalence of NPS among the homeless, their motivations behind consumption, and the effects associated with NPS. Chapters 6 and 7 present IR and Raman spectroscopic data on NPS impregnated into paper. This penultimate chapter reiterates the key contributions of the thesis and summarises the overarching findings and narrative that has been developed. After summarising the main findings, the chapter reflects on the research journey and the benefits of using a mixed-methods research design, and the associated limitations.

Prevalence and profile of homeless NPS users

This thesis investigated NPS consumption among the homeless population. Given the lack of evidence-based literature on the emergence of NPS among the homeless population, a systematic review would provide reliable information about NPS consumption among the homeless population. Due to national and international control and regulation of NPS the use of these compounds shifted from the general to the homeless population with the media highlighting high levels of public intoxication. After analysing drug use trends among the homeless population, it became apparent that the use of NPS among the homeless has been reported in literature since 2017. The use of traditional drug substances had been prevalent among the homeless population, but the rapid emergence of NPS among this population raised significant concern. Policy makers and governmental officials did suggest that banning NPS would lead to the drugs being sold on the black market becoming more prevalent among vulnerable street populations such as the homeless (Home Office 2018). However, soon after the introduction of the PSA in 2016 media articles were published reporting homeless individuals were using SCRAs in city centres such as Manchester, London and Birmingham (Ralphs et al. 2020). The systematic review showed that since 2017, SCRAs were reported in more than 50% of the evaluated publications with a mean prevalence of 66.87%. The rapid emergence of SCRAs among the homeless population did see additional NPS consumed such as hallucinogens and benzodiazepines but were reported less frequently. The systematic review captured the emergence of NPS the prevalence over different countries. Yet, it provided limited knowledge on the underlying mechanisms associated with NPS use.

The use of a range of different NPS (e.g., Spice, mephedrone, NBOMe, China white etc.) was not associated with the homeless population as found in the review but instead focuses on SCRAs. Additionally, the evaluated publications in the review did not consider the profile of homeless NPS users and so major information was missing in regards to their knowledge and experiences. Hence, a semi-structure questionnaire was developed to investigate the knowledge and experiences of NPS among users from the homeless population. The findings from the questionnaire showed that 68.4% of the homeless population had used NPS, to which Spice, the SCRAs, was the most popular derivative. The prevalence reported in the semi-structured questionnaire was similar to that of the prevalence reported in the systematic review and in previous research conducted in the UK.

The homeless population did also use stimulant NPS derivatives such as mephedrone, China white and silly walk but were not desired like SCRAs. The use of SCRAs in the homeless population has been reported in literature and media publications but little information is available regarding stimulant NPS among the homeless. The findings in the questionnaire did show that NPS stimulants were consumed in doses between 0.05 – 0.25 grams and effects that were present within 30 minutes after ingestion, similar to traditional stimulant drugs, such as cocaine. Information regarding the profile of SCRAs among homeless users again, is limited in literature but typically report SCRAs as a herbal preparation consumed via the smoking route. What this thesis further investigated was the dose, onset of action and duration of effects associated with SCRAs use. It was found that SCRAs were normally consumed in doses above one gram, effects that were present within five minutes after ingestion lasting between 2 – 3 hours. This thesis highlighted that SCRAs are used in a very similar way to traditional cannabis whereby smoking herbal materials results in a fast onset of action.

For male and female homeless NPS users, no significant differences were observed but it was shown that longer periods of homelessness increased the likelihood of using NPS. Longer periods of homelessness have been shown to increase the use of substance use, typically to escape from the realities of homelessness/street life. Although longer periods of homelessness increase NPS consumption, individuals who lived on the streets were less likely to use NPS than individuals residing in sheltered living, such as hostels or emergency accommodation.

Motivations

The motivations behind NPS consumption for the homeless population were similar to the reasons behind traditional drug use being escapism and pain relief. Initially, the homeless would start using NPS due to their potency, cheap price and ability to pass drug-screening but continued use resulted in self-treatment of physical and psychological conditions. Spice, the SCRAs, would be used daily by homeless individuals to treat symptoms of physical pain encountered whilst homeless including sciatica, arthritis and prolapsed disks in the spice. The use of traditional opioid drugs such as heroin have been reportedly used by the homeless to treat physical pain encountered whilst homeless. However, self-treatment of physical pain through substance use is associated with addiction and has been argued that the pain is associated with withdrawal symptoms (Macleod et al. 2016). It could be argued that homeless individuals who use NPS to escape from the realities of homelessness increase their use when experiencing physical and psychological issues with homelessness. Gray, Ralphs and Williams (2020) reported that use of SCRAs were very similar to traditional drug use namely to escape from the realties of street life and provide relief from the physical conditions of a street-based lifestyle. What this thesis did highlight that homeless individuals were more likely to consume SCRAs in sheltered accommodation (e.g., hostels) than unsheltered (e.g., streets). This may suggest that the use of SCRAs starts in sheltered accommodation and leads to living in unsheltered accommodation if use continues. Thus, escaping the realities of street life and providing relief from physical and psychological issues could be the result from longer durations of homelessness and NPS use.

This thesis did report that individuals who were chronically homeless (more than three years homeless) were more likely to consume SCRAs than intermittent and acute homeless individuals. The findings from this thesis therefore, contribute to the literature by highlighting SCRAs consumption is increased by living in sheltered accommodation and longer durations of homelessness. While the implementation of disciplinary mechanisms in homeless accommodation can be detrimental to the wellbeing of homeless individuals, hostels have been seriously affected from prolific substance use, injecting drug use, noise levels and poor sleep condition. However, as reported earlier where one of the reasons the homeless started using NPS was due to their ability to pass drug screening and could suggest why they changed from traditional drugs to NPS/SCRAs. While there is evidence SCRAs are consumed in sheltered accommodation, the literature has generally not reflected on this issue and more surveillance in hostels needs to be done to reduce the desire of SCRAs.

However, Chapter 5 highlighted the high prevalence of SCRAs being used in public settings from the homeless population in areas such as Manchester, Doncaster, and Bristol. The public were seriously affected when coming into contact with homeless under the influence of SCRAs leaving some individuals scared. This in turn suggests that the homeless will use SCRAs in a variety of locations regardless of their surroundings.

Effects associated with NPS consumption among the homeless population

Effects associated with NPS consumption in this thesis is divided into three main areas: desired effects from NPS consumption, adverse events associated with NPS consumption and, the effects on society and service providers from the homeless population consuming NPS.

Chapter 4 showed the effects desired by homeless NPS users. The homeless population did primarily desire to consume NPS for self-treatment purposes but enjoyed a range of different factors from NPS consumption. For Spice the SCRAs, individuals desired the relaxing and calming effects associated with their use similar to natural cannabis. However, Spice users would also desire out-of-body experiences which is an effect typically associated with dissociative compounds such as ketamine. NPS Stimulant derivatives such as mephedrone would produce stimulation effects that were desired from homeless individuals.

The adverse events associated with NPS consumption as mentioned in Chapters 3, 4 and 5 affected the majority of homeless NPS users. In Chapter 3, the adverse events associated with SCRAs consumption included physical and psychological issues due to the potency and unknown chemical composition. The consumption of Spice resulted in serious health consequences increasing the likelihood and duration of hospitalisation. Additionally, psychological problems such as depression, psychosis, paranoia and anxiety were linked with SCRAs consumption. Chapter 4, however, further investigated the adverse events associated with Spice consumption and showed that specific SCRAs doses induced different adverse events. This is an important for literature as no information to date has reported specific SCRAs doses induce specific adverse events. Moreover, tolerance, addiction and withdrawal have been linked to SCRAs consumption (Macleod et al. 2016; Gray et al. 2021). Chapter 4 in this thesis highlights that higher doses of SCRA induce loss of motor control and lower doses induced cardiovascular adverse event. Continued Spice use increased both mental and physical health issues and higher SCRAs doses also lead to an increased likelihood of receiving medical treatment following hospitalisation. Moreover, females were more likely to receive medical treatment following hospitalisation than males and therefore, the findings from this Chapter contribute to the literature by highlighting higher SCRAs dose induce nervous system adverse events and lower doses induce cardiovascular, which affects more females than males. Chapter 5 also highlights that increased Spice use increase the risk of hospitalisation.

Chapter 5 focuses on how NPS consumption among the homeless population has affected the public and service provided to the homeless. In the US and Canada, the consumption of SCRAs is reportedly lower than that of the UK but instead have a serious issue with synthetic opioid derivative such as fentanyl. Fentanyl has been blamed for causing higher levels of homelessness that leads to higher levels of public intoxication, increased hospitalisation and increased crime. The public blamed the lack of resources provided from the government on the increase of fentanyl consumption among the homeless population. It was discussed that the government ignored the issues with homelessness and fentanyl use by decriminalising the possession of fentanyl through Prop 47. The negative attitude towards the government was shown in Chapter 5 highlighted how ignoring the issues associated with homelessness and fentanyl consumption increased the burden on homeless accommodation and emergency services. The consumption of Spice was consumed predominantly in the UK in areas such as Manchester, London and Doncaster. Again, like fentanyl Spice consumption among the homeless population was blamed on the government for failing to reduce consumption. Twitter users held the negative attitude towards the government blaming them for the increase in crime and hospitalisation resulting from Spice use. By failing to reduce Spice consumption among the homeless, high levels of SCRAs prevalence and public intoxication has put a serous burden on health services, a similar reaction to the consumption of fentanyl by the homeless population. This has highlighted how the high prevalence of SCRAs and public intoxication of the two NPS have increased crime and the burden on health services leads to increased hospitalisation with issues affecting the nervous and cardiovascular systems.

<u>Chemical confirmatory testing of NPS</u>

One of the primary issues encountered in the aforementioned chapters was confirming the NPS derivative consumed by the homeless as no chemical confirmatory tests were conducted. Usually, suspicious material such as powders and herbal material are confiscated when found by law enforcement and tested in forensic laboratories confirming the drug present. Concealing NPS has migrated to less suspicious materials such as paper and cigarettes potentially avoiding confiscation from law enforcement as reported in literature and in the semi-structured questionnaire. It was reported in Chapter 4, the semi-structured questionnaire that Spice was first consumed in the prison yard on paper to avoid suspicion from prison guards. This method of concealment has now been reported in the homeless population (Lloyd et al. 2018) and is why Chapters 6 and 7 employs portable IR and Raman spectroscopy to detect NPS and predict their concentrations impregnated into paper. Information available in literature on the detection of NPS impregnated into paper is limited but has either used destructive techniques such as HLPC (Ford and Berg 2018) or IR spectroscopy to identify NPS in blotters (derivatives of LSD). Therefore, the final two chapters of this thesis used IR and Raman spectroscopy in detection of NPS impregnated into paper. The purpose is for on-spot detection for law enforcement when suspicious paper materials are found on homeless individuals.

The results from IR spectroscopy showed that all three SCRAs were detectable impregnated into paper in concentrations above 15 mg/mL. It was found that 5F-PB-22 and AB-FUBINACA crystalised onto the papers surface and had the appearance that a compound had been impregnated into the paper. However, AKB-48 did not crystalise onto the papers surface but instead was carried into the bulk of the paper matrices. Instead, for AKB-48 the carboxamide linkage was detected using ATR-FTIR spectroscopy suggesting that the carboxamide linkage in the AKB-48 molecule hydrogens bonds to the papers in-surface, enabling ATR-FTIR spectroscopy to detect the SCRA. This can also explain why etizolam was not detected as no available hydrogen bonding between etizolam and the paper, and instead etizolam was either carried into the bulk of the paper (not detected using a surface technique such as ATR) or evaporated with the solvent when it was left to dry at ambient room temperature. The same effect was seen with Raman, where the carboxamide linkage of the AKB-48 molecule was detected due to the hydrogen bonding to the inside of the papers surface. The carboxamide linkage was attributed to AKB-48 as paper does not contain this functional group and is specific to AKB-48. However, the three additional NPS were not detected using Raman spectroscopy. A likely reason for the poor detectability of the NPS impregnated into paper was the use of the 1064 nm laser which operates using a longer wavelength (less energy) leading to less Raman scattering. The 1064 nm laser is best for detection of biological/organic samples and where paper is an organic matrix it would have the predominant Raman scattering effect, leading some NPS not being detected.

Predicting the concentrations of the detected compounds impregnated into paper was proven successful for all detectable compounds on both ATR-FTIR and Raman spectroscopy. This highlights the use of spectroscopy namely ATR-FTIR spectroscopy in the detection and prediction of NPS impregnated into paper. This chemical confirmatory research within this thesis highlights the use of portable spectroscopy for on-spot detection to be used by law enforcement.

Reflections on taking a mixed-methods approach

Initially, the proposed methodology involved conducting in-depth interviews with homeless NPS users to gain an understanding of their addiction to the substances. However, due to the COVID-19 pandemic, interviews with the homeless could not go forward and it became apparent that additional chapters were required to answer the research question. Furthermore, if in-depth interviews could have been conducted i would have had to wait for more than 12 months to conduct interviews.

Using a mixed-methods approach overcame this challenge as the duration of the COVID-19 pandemic was longer than initially expected. This point was strongly reinforced when I conducted the systematic review and thematic analysis of Twitter data. Because I had captured the emergence of NPS among the homeless population through evaluating the literature and captured the attitudes and opinions of the public regarding NPS consumption among the homeless population.

The findings of this thesis cannot be generalised to all homeless NPS users in the UK. It may have been beneficial to have a larger number of participants in the semi-structured questionnaire, although as discussed, recruitment was difficult due to the nature of the questions asked and no incentive offered. Additionally, the sample mostly consisted of males. This is not unusual as many research studies report more males are homeless than females.

Although interviews could not be conducted, it may have been beneficial to speak to a number of service providers to contrast their different views and opinions regarding homelessness and NPS consumption. It may have also been beneficial to analyse confiscated NPS samples from homeless individuals to examine the compounds present in their NPS samples. Although this would have confirmed the NPS they were using, developing spectroscopic libraries was deemed a necessary step before analysing confiscated samples.

Strengths and novelty of this PhD

The original contribution to knowledge of this PhD thesis emerges from the adoption of investigating the profile of NPS among the homeless population using a mixed-methods approach. This distinguishes it from other studies which have used qualitative or quantitative approaches, and not a combination of both. This approach allowed for a focus on the profile of homeless NPS users whilst providing experimental techniques to confirm the NPS present.

A strength of this thesis has been a wide range of study design and perspectives to the consumption of NPS among the homeless population. The systematic review highlighted the emergence of NPS among the homeless population since 2017 (Chapter 3). The semi-structured questionnaire (Chapter 4) investigated the NPS profiles of the UK homeless population proving information about dose specific adverse events. Additionally, thematic analysis of Twitter data (Chapter 5) allowed for the voices of the pubic and homeless service providers to emerge as this information is normally not evaluated.

The time frame for which this thesis was undertaken represented an additional strength. The research began in September 2018 and the time frame included the emergence of NPS among the homeless population, which occurred after the PSA May 2016. The data collected took place after the introduction of the PSA and the analysis yielded important research questions that could be useful in assessing the impact of the PSA.

The chemical confirmatory testing, is, to the best of the researchers knowledge, the first to use this approach to help confirm the NPS present/reported from homeless individuals as this information could not be confirmed in Chapters 3, 4 and 5. It provided an interesting extension to the more traditional qualitative and quantitative approaches.

Chapter 9: Conclusions

9.1. Introduction

The previous study chapters in this research were undertaken to determine the profile of NPS of among users from the homeless population. This area of research was chosen due to the lack of comprehensive studies that considered a mixed-method approach to understand drugs among the homeless. During the course of this PhD it had been established that previous research had captured prevalence and NPS derivatives used but this research was limited to few prospective and/or retrospective studies. Hence, no systematic review captured the emergence of NPS among the homeless population.

Research question 1:

In order to achieve the first objective, a systematic review was conducted to investigate substance use trends among the homeless population in an attempt to capture the emergence of NPS among the homeless population. This enabled the researcher to determine the emergence of NPS among the homeless population, the prevalence and most popular derivative used. At the systematic review stage, the researcher also discovered that confirming the NPS derivative reportedly used was impossible without chemical confirmatory testing. The trends in substance use among the homeless population revealed that since 2017, researchers had started to publish studies reporting NPS consumption among homeless individuals, namely SCRAs. Alcohol was the most prevalent substance prior to 2017 and SCRAs became more prevalent afterwards. SCRAs were easy to acquire for homeless individuals in sheltered settings and were obtained at no or low price. However, they were linked to long term adverse events such as paranoia , anxiety and PTSD.

Research question 2:

A key advantage of using the systematic review was to capture the emergence of NPS among the homeless population. However, several gaps regarding the knowledge and experiences of NPS among the homeless were established and further addressed in Chapter 4. The use of questionnaires has been a popular tool in the social sciences to investigate specific populations. The second objective was addressed by conducting a semi-structured questionnaire in the UK. The findings of the questionnaire revealed that the homeless population had consumed the SCRAs, Spice in high doses to self-treat physical and psychological pain. It was also found that longer durations of homelessness increased the risk of NPS consumption that led to the participants using SCRAs for escapism purposes. These findings also revealed profile of adverse events associated with NPS consumption. Participants who consumed lower doses of SCRAs would experience cardiovascular adverse events being blood pressure and heart rate. Whereas, larger doses (above one gram) of SCRAs caused severe nervous system adverse events that would result in an inability to move, known as loss of motor control. When experiencing nervous system adverse events participants were almost twice as likely to receive medical treatment following hospitalisation. This was likely due to paranoia as few participants reported recovering in hospital from their adverse events. A detailed discussion can be found in Chapter 4.4. Identifying these associated issues with NPS consumption among the homeless population led the author to explore the perceptions of the public through thematically analysing Twitter data, which is discussed in Chapter 5.

<u>Research question 3:</u>

Completion of the first two objectives provided a good foundation to address the third objective and this was discussed in Chapter 5. Chapter 5 developed an exploratory framework to understand the perceptions of the public regarding NPS and homelessness. The findings from this study showed the demographic regions that were affected by NPS and homelessness which revealed that SCRAs were predominantly consumed in the UK, whereas, NSO were consumed in the US and Canada. The public perceived the government as not dealing with the use of NPS among the homeless population creating a negative stigma towards service providers. The public were concerned with the levels of SCRAs used in public places causing visible public intoxication, and in some cases leading to hospitalisation. NSOs on the other hand, the public criticised the service providers for not improving rehabilitation programs, policing tactics, and housing support. Additionally, easy access to NSOs was reported to have increase levels of homelessness which led to higher levels of public intoxications. After conducting the first two study chapters and exploring the perceptions of the public on Twitter, the results collected showed that confirming the NPS derivative was not possible and new concealment method such as impregnating into paper were becoming more popular.

<u>Research questions 4 and 5:</u>

Therefore, Chapters 6 and 7 aimed to chemically profile NPS in paper matrices and detect and predict the purity of NPS compounds impregnated into paper. After highlighting that the homeless are starting to consume NPS impregnated into paper, the final two chapters were conducted to provide on-spot detection for law enforcement for suspected paper matrices. The results collected from Chapter 6 showed that ATR-FTIR spectroscopy could detect all three SCRAs impregnated into paper, but not the synthetic benzodiazepine, etizolam. All three SCRAs were detected in concentrations of 15 mg/mL and above. PLSR proved successful in predicting the purity of both NPS and cutting agents (caffeine and procaine). Raman spectroscopy, could only detect the SCRA AKB-48 impregnated into paper as well as caffeine and procaine. This is due to AKB-48's carboxamide linkage hydrogen bonding to the inside of the papers surface allowing ATR-FTIR and Raman spectroscopy to detect AKB-48. The Raman PLSR models proved more successful in detecting the purity of AKB-48, caffeine, and procaine than ATR-FTIR; however, this is due to the low number of spectral points of the Raman (240) spectrometer in comparison to the ATR-FTIR (1768) spectrometer.

Implications of thesis results

Following on from the previous conclusions, this PhD thesis has made the following contributions:

This study contributed to the literature regarding the prevalence of NPS among users from the homeless population. Despite research being conducted into the prevalence of NPS among the homeless population all studies researched the problem in specific locations and not countrywide. This research found that since the emergence of NPS in 2017 the prevalence of NPS among the homeless population ranged between 66 – 68.4% in the systematic review (Chapter 3) and semi-structured questionnaire (Chapter 4). This study contributed to a more generalisable NPS prevalence statistic for the homeless population by analysing homeless populations from multiple geographical areas.

The second contribution of this thesis, to the profile of NPS among users from the homeless population was identifying the dose, onset of action and durations of effects for specific NPS classes. In previous research studies, the durations of effects have been discussed; however, there is no literature to the authors knowledge that identifies dose and onset of action attributed to specific NPS among users from the homeless population. For example, questions can be asked regarding the SCRAs dose taken and how long does it take to take effect? This study found that the homeless consumed SCRAs doses in the range of 0.05 – 4 grams, but a majority consumed in doses above one gram (Chapter 4.3.). The larger doses of SCRAs were consumed to self-treat psychological or physical pain and provide an escape from the realities of homelessness. Through this study the author found that the duration of homelessness and location of sleep could impact NPS consumption. It was found that longer durations of homelessness increased the likelihood of NPS consumption. Additionally, homeless individuals living in sheltered accommodation were more likely to consume NPS than homeless individuals rough sleeping.

Third, this thesis reflected the publics perception on the homeless using NPS. Previous research had not considered the perception of the public but instead focused on gaining the perspectives of service providers. Twitter users tweeting about SCRAs were concerned about the high prevalence of the SCRAs Spice, being used by the UK homeless population in public places. This in turn led to an increased rate of crime and hospitalisation among the homeless that created a negative stigma towards the government suggesting they had failed, and the issue is overlooked. Novel synthetic opioids (NSOs) on the other hand, were confined to the US and Canada but presented different issues. The largest discussions on Twitter about NSOs was focused on how the service providers had failed to reduce consumption and decriminalising possession. High levels of NSO abuse and public intoxication were discussed to cause/increase levels of homelessness in both the US and Canada. Although the government only received negative stigma from the public regarding the homeless populations use of NPS, the public showed support towards the homeless SCRAs users in the UK and NSO users in the US and Canada.

The fourth contribution of this thesis were established by using Fourier transform infrared and Raman spectroscopy to detect and predict NPS impregnated into paper matrices. Both techniques could identify, characterise and quantify NPS and impurities in paper matrices. Being portable and non-destructive they are beneficial for law enforcement, border control and fast parcel services encountering NPS during their work.

Limitations

During the course of conducting the research in this thesis several limitations were encountered. First and foremost was the COVID-19 global pandemic, which consequently led to in-depth interviews with homeless participants being cancelled.

The continuous national and international lockdowns changed the research process for this PhD and instead of the in-depth interviews, thematic analysis of Twitter data were conducted. Additionally, sample size limitations were encountered in the semi-structured questionnaire. Despite contacting and disseminating the questionnaire to multiple charities questionnaire completion among the homeless population regarding NPS use has proven difficult. Immense efforts were made prior to and during dissemination but the ability to reach the homeless was difficult due to the vulnerability and ability to contact the population. The specific NPS compounds they were using could not be confirmed as not chemical confirmatory testing were done. The tweets gathered from Twitter were only collected in the English language and this affected the generalisability of the findings of non-English speaking countries. Some of the sub-themes had a low number of tweets assigned to them but the quality of the sub-themes were good. Further limitations were met in the spectroscopic chapters relating to chemical substance number and experiments conducted. The cost of the NPS standards prevented the purchase of more than four NPS derivatives and impurities. Due to lockdown, access to laboratories were limited and that affected the number of experiments.

Strengths

By combining social and scientific research this thesis used multiple approaches in order to address an important problem in the UK and worldwide being NPS and homelessness. Previous studies have used one route to approach the problem by either using social or scientific, but not both. For this thesis the systematic review provided evidence-based knowledge on the emergence of NPS among the homeless population since 2017. The qualitative content explored in-depth insight to the perceptions of the public, which had not been previously fully understood. The use of handheld portable spectroscopic instruments proved successful in detecting NPS and cutting agents on a small scale. The methods could be adopted to other contexts and for other samples (e.g. airports, law enforcement, customs, hospitals and nightclubs), especially in cases of a pandemic or social restrictions.

Further research

Keeping in mind this thesis used a mixed-methods approach to determine the profile of NPS among users from the homeless population, this is a relevant and time consuming study and proposes recommendations for further research.

First, conducting the questionnaire in different locations and languages would provide more generalisable NPS consumption prevalence among the homeless population and not country/language specific. Additionally, thematic analysing Twitter data in different languages would collect information from individuals who were not included in the study.

Second, although this research aimed to use qualitative interviews due to the COVID-19 pandemic they could not be conducted. Therefore, future research should interview chronic NPS users from the homeless population to gain an in-depth understanding of their day-to-day lives.

Third, apply spectroscopic methods to larger sample size and use surface-enhanced Raman (SERS) and surface enhance infrared absorption spectroscopy (SEIRA). In order to improve the sensitivity of detection of NPS.

Finally, by using diffuse instead or ATR and different Raman lasers more chemical information could be revealed from analysing NPS impregnated into matrices. A limitation to the Raman study was the use of the 1064 nm laser which is best at analysing biological compounds but operates at a longer wavelength and lower energy. Additionally, the use of diffuse would reveal chemical information deeper than the surface, a limitation of using ATR.

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Appendix

Appendix I: Semi-structured questionnaire

Questionnaire regarding of knowledge and experiences of NPS among the homeless population:

Part I – Demography

1. What is your age range? ☐ 18-24 ☐ 25-29 ☐ 30-34 ☐ 35-39 ☐ 40-49 ☐ 50-59 ☐ 60-64

2. What is your biological sex? ☐ Male ☐ Female ☐ Prefer not to say

3. What is your ethnic background? ☐ White ☐ Asian ☐ Black ☐ Mixed, please specify

4. What is your sexual orientation?

5. Since when have you been homeless?

6.If you had a job before you were homeless, what was it and for how long did you work?

7. Where do you usually sleep? ☐ Streets ☐ Someone's house ☐ Sofa Surfing ☐ Hostel ☐ Emergency accommodation ☐ Other, Please Specify:-

8. Do you have any contact with your family? If yes, answer 8 and 9; if no go to Part II.
☐ Yes ☐ No

9. If yes, where do they live?

10. If you have any contact with your family, how often?

Part II - NPS use

11. Have you ever voluntarily taken legal highs? (voluntarily means by choice and not under any pressure.
☐ No (If no, please go to part III) ☐ Yes, if yes:-

12. What legal highs have you taken? Please specify:-

13. What amount of the drug is taken? Please specify:-

14. How does the drug come? ☐ Herbal ☐Pill/Tablet ☐ Powder ☐ Other, please specify

15. How long does it take for the drug to take effect? ☐ 1 minute or less ☐ 5 minutes ☐ 10 minutes ☐ 30 minutes ☐ 1 hour ☐ Other, Please specify

16. How long do the effects last? ☐ 1 hour or less ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 hours ☐ 6 hours or more

17. How often do you take the drug(s)? ☐ Daily ☐ 4-6 days a week ☐ 2-3 days a week ☐ 1 day a week ☐ 1 day a month ☐ Once a year

18. How do you take the drug? ☐ Injecting ☐ Oral ☐ Smoking ☐ Snorting ☐ Other, please specify

19. Where do you get the legal highs from?

20. Did you purchase the ‘legal highs’ before or after May 2016? ☐ Before ☐ After

21. How much do you buy when purchasing legal highs? ☐ 0-0.25 grams ☐ 0.25-0.5 grams ☐ 0.5-1.0 grams ☐ 1-2 grams ☐ 2-3 grams ☐ 4+ grams

22. How much is paid for the amount recieved? ☐ £5 for 0.5 grams ☐ £5 for 1 gram ☐ £10 for 0.5 gram ☐ £10 for 1 gram ☐ £20 for 0.5 gram ☐ £20 for 1 gram ☐ Other, please specify

Part III – Motivation for use

23. If you take legal highs, what is the main reason for using them?

24. Do you take legal highs in addition to other recreational drugs (heroine, cannabis, cocaine, crack) and alcohol? ☐ No ☐ Yes, please specify:-

25. If you had replaced traditional drugs and alcohol uses by legal highs, what was the reason for the change?

26. Did the ban on ‘legal highs’ in 2016 impact your consumption? ☐ Yes ☐ No

27. If you have stopped taking legal highs, what was the reason for you stopping?

Part IV – Desired Effects

28. What positive effects (if any) do you experience from the use of legal highs? ☐ Calming/Relaxation ☐ Anti-anxiety ☐ Fully Aware/Alertness ☐ Hallucinations ☐ Out of body experience ☐ Other, please specify:-

29. What do you enjoy about taking legal highs?

30. Do you use legal highs to relieve pain or other unwanted feelings? ☐ No ☐ Yes, please specify:-

Part V – Adverse Effects

31. Have you seen any negative effects associated with using legal highs? ☐ No ☐ Yes, please specify what were these effects?

32. How long did the negative effects continue?
☐ 1 hour or less ☐ 2 hours ☐ 3 hours ☐ 4 hours ☐ 5 hours ☐ 6 hours or more

33. Did you require medical treatment following these effects?
☐ Hospitalisation ☐ Non-hospitalised medical treatment ☐ No

34. If hospitalised, how long for?

35. Did you see a doctor or a nurse? ☐ Doctor ☐ Nurse ☐

36. If you consume 'legal highs' is it to treat any of the following? ☐ Anxiety ☐ Bipolar disorder ☐ Depression ☐ Suicidal thoughts ☐ schizophrenia ☐ Other, Please specify

37. Has your NPS use impacted your life in any of the following areas:-☐ Financial

	issues e.g. debt ☐ Relationships ☐ Physical Health ☐Preventing Recovery ☐ Anti-social Behaviour ☐ Mental Health ☐ Criminal activity/ Offending 38. In your opinion, how widespread is the use of legal highs? [ ] 39. Are you receiving any support for drug use? ☐ No ☐ Yes, please specify where below [ ] 40. If you are not receiving any support, would you like to? ☐No ☐ Yes 41. If you are not and would like to receive support for NPS use; would you know where to seek help and advice to do so? ☐No ☐ Yes 42. do you have any other comments that you like to communicate? [ ]

Consent form:

Participant Agreement Form

Full title: Knowledge and experiences of legal highs among users from the homeless population.

Name, position and contact details of researcher: Tilak Ginige, Senior Lecturer at Bournemouth University, tginige@bournemouth.ac.uk

Please tick appropriate boxes	***Yes***	***No***
Taking Part:		
I have read and understood the Project Participant Information Sheet.	☐	☐
I confirm that I have had the opportunity to ask questions.	☐	☐
I understand that my participation is voluntary.	☐	☐
I understand that I am free to withdraw up to the point where the questionnaire is submitted.	☐	☐
Should I wish not to answer any particular question(s), I am free to decline.	☐	☐
I agree to take part in the project.	☐	☐
Use of the information I provide for this project only:	☐	☐
I understand my personal details are not requested and the questionnaire is completely anonymous.	☐	☐
I understand that my words may be quoted in publications, reports, webpages and other research outputs.	☐	☐
Use of the information I provide beyond this project:	☐	☐
I understand that the anonymised information given in this questionnaire may be used by the researcher team to support other research projects in the future, including future publications, reports or presentations.	☐	☐

Number of Participant	Date	Signature

Name of researcher	Date	Signature

This form should be signed and dated by all parties after the participant receives a copy of the participant information sheet and any other written information provided by the participants. A copy of the signed and dated participant agreement form should be kept with the projects main documents which must be kept in a secure location.

Appendix B: Tweets extracted from Twitter.

Table B1. Locations of homeless using fentanyl

Country	Area	Quotation	TN
Canada	British Columbia	Clean! Clean all the dirty needles in the park and clean up the over doses in Vancouver B.C. FOCUS! Homelessness is out of control. Fentanyl and Meth riddles the downtown core.	1
		The problem in Vancouver and now some in Victoria etc, is the f****g Fentanyl. The homelessness is an issue because of Vancouver and Victoria becoming hot real estate markets. The two issues are not necessarily mutually exclusive. Though housing issues affect non drug users too	2
		This is wonderful news! However, more need to happen to tackle the homelessness and Fentanyl crisis which is a direct result of homes in Vancouver and Toronto becoming a piggy bank rather than a place where people live:	3
		We should protest homelessness, corruption, high house prices & rent, Fentanyl & other drug dealing gangs, money laundering, immigration skyrocketing without building new affordable supply, no PBR being built and COV's incompetence in Vancouver like this. #VanRE #moneylaundering	4
		rampant homelessness, Oppenheimer, an affordability crisis, the DTES, empty homes, empty retail, and fentanyl, is not awesome. #vancouverisawful	5

		CCP-compromised ex-Vancouver mayor G**** juice company is ‘Happy’ to help Ms. E*** in Africa who grows Moringa for his juice, but he could give two f**** about the homeless, mentally ill Canadians living on the streets of Van. No profit there.	6
		The good news: according to Vancouver's annual homeless count, the number of homeless dropped for the first time since 2015, going from 2,223 to 2,095. The bad news: count was done at the beginning of March, right before #COVID19, so the numbers don't reflect current reality.	7
		to stop being heavily ironic for just a moment: me with two kids and $900/mo (no CERB for me!) is LUCK. i am one of the LUCKY ONES. i have a home in a rural town, the only place i can afford to live i can't access medical specialists in Vancouver, though, cos travel costs.	8
		Same-old, same-old. M says he's fine. He was attended by paramedics (and maybe #Vancouver Coastal Health - I'm taking latter w/ grain of salt) after his #fentanyl #overdose last wk. I'm told tho, #naloxone was given by one of my #homeless peers before ambulance arrived.	9

		Vancouver has a massive Fentanyl/Heroin homeless problem. They are dying in the streets everyday. Income inequality is bad. Sweden had a GRENADE & RAPE problem. Toronto has 8 parks with homeless encampments, people shooting up and smoking crack on Queen E... Shall I go on?	10
		You left out the health of those addicted to substances that are contributing to homelessness. 1500+ overdose fentanyl deaths in BC in a year and that many grieving families. Isn't it time SOMEONE, presumably healthcare offered to treat these people as if they were sick?? FAIL!	11
		175 people dead In June by overdose in BC alone. This is a calamity and the real health emergency we are facing in this country. #addiction #safesupply #supervisedconsumptionsites #harmreduction #homelessness #MentalHealthMatters #opioidcrisis #fent #fentanyl	12
		Recently in Kamloops a toddler found a baggy of suspected #fentanyl in a park. Now I know it could be unrelated to homelessness, but unless someone will inspect every inch prior to other people using the park, then no. Invest in proper housing and mental health support.	13

		May and June numbers of actual overdose deaths for BC were nearly 400. The New York area must be just devastated. British Columbia has started safe supply & putting the homeless in hotel rooms. The gov. is learning that the only way to end fentanyl is to provide real heroin.	14
	Old Strathcona	Organisers behind this homeless camp in Old Strathcona hope to draw attention to the city's housing issues by bringing them #right out into the open	1
		Strathcona Park took over for Oppenheimer Park for the winter, dealing with the homeless and fentanyl crisis. Transfer from homeless shelters to housing is more common. Shelter lifers can become real (free food)	2
	Ontario	This story. What is the matter with Ottawa, so many years into a homeless and fentanyl crisis, that we do not look after those who put their lives on the line, to look after us?	1
		This is wonderful news! However, more need to happen to tackle the homelessness and Fentanyl crisis which is a direct result of homes in Vancouver and Toronto becoming a piggy bank rather than a place where people live:	2
		Toronto has 8 parks with homeless encampments, people shooting up and smoking crack on Queen E... Shall I go on?	3

		“The seized drugs included 283 grams of #fentanyl , an opioid that’s up to 100 times more powerful than heroin and has been linked to many fatal overdoses in Southwestern Ontario in recent years.” #cdnpoli	4
US	Baltimore	Baltimore City Keep Playing With Your Life and Your Freedom Dealing With Our Democratic Party. The Homelessness Abandon Houses Issues. The Poor School System and Opioid and Fentanyl Overdose. The High Crime and Homicide Rates. Do Our Local Leaders Really Want Change To Our City	1
		Look around Baltimore inner city communities. Homelessness, Abandoned Houses, The opioid and fentanyl epidemic. Your Crime and Homicide Rate. ACLU isn’t the privacy of our inner city lives being violated. What about to protect and service in our inner city communities.	2
		I was born and raised in Baltimore City. I grew up in the poorest communities. Our goal is helping to turn our inner city around. I’m not a politician or local leader. I fight against homelessness, the opioid and fentanyl epidemic. Our goal rehabbing houses for low income people	3

	California	There's a reason why K**** only got 2% of the vote campaigning for president. Her political history is strewn with power hungry grabs and scandals. She made possession of fentanyl/meth/heroin a misdemeanour in California and now there's historic homelessness.	1
		The problem is that G**** and K**** made possession of fentanyl/meth/heroin a misdemeanour in California (Prop47). This is why there's record homelessness, theft and overdoses. The policy doesn't effect rich elites.	2
		California also has historic level homelessness after K**** H**** passed her Prop47. She made possession of fentanyl/meth/heroin a misdemeanour. Now property crimes and overdoses are common. Quite the leftist elite policy that doesn't effect the rich, but all others.	3
		American liberals don't care about drug charges any longer. In California, K**** H**** made possession of fentanyl/meth/heroin a misdemeanour. Now they have historic homelessness and overdoses.	4

		The first installation of our new #ZeroWaste stations went in on the corner of Government and Humboldt today. In the coming months they'll spread across downtown, urban villages and parks to reduce waste going to landfill by improving composting and recycling options	5
		California, all that will be left is elite liberals and the poor. The middle class is leaving. Prop47 making possession of fentanyl/meth/heroin a #misdemeanor..now nobody goes to jail-they go back to their homeless encampments.	6
		California isn't all bad. For example, when the rolling power outages reach my town, I will still be able to read by the light of the hellfire until a homeless person kills me.	7
		Progressivism 101, it always hurts the one Progressives say they want to protect: "Uber & Lyft Set to 'Suspend' Operations in CA; Senior Citizens, Working Poor, and Chronically Ill Will Be Hit Hardest"	8
		This is terrifying for Portland residents, who are pawns in a ridiculous political chess game. Same goes for: - California - New York - COVID - Homeless problem - Fentanyl crisis - Police	9

		shootings Basically everything is being weaponized, and everybody loses.	
		Los Angeles? Where drug addicts, homeless and criminals rule the streets? And deaths from fentanyl have doubled?	10
		our anti-public safety agenda is a detriment to California! Meth, heroin, cocaine, fentanyl a misdemeanour! Unsheltered homeless the highest in the country! Prop. 47, Prop. 57 and Prop. 64 to open the door for CA's ruin! Hell on Earth on H**** watch!	11
		Well, actually the governor of California and LA mayors are Democrats. So, strictly speaking B**** America. Most so-called “homeless” on West Coast are drug addicts, heroin, fentanyl etc as seen graphically in Seattle.	12
		here are images of him as well. he is also homeless as he brags about doing fentanyl and being rich. he lives in Bakersfield, Ca btw!	13
		Ya, oh no. Think of LA & San Francisco's homeless pops. This appears to be what's happening. I think California and maybe Oregon and Washington are already the only states where you can still find black tar Could be wrong but that's what I've heard for a while now. #fentanyl	14

		other than roaring homeless cases, defunded police, and a fentanyl problem. commie-fornia is beautiful	15
		What about protecting law abiding citizens and cleaning up the homeless encampment on Octavia and Oak that have taken over the area. And they're in violation of California law by having fentanyl within 1000 feet of a school!! #DoYourJob	16
		What ever happened to the wars in the Middle East, illegal immigration, Israel, the border wall, Fentanyl and drug smuggling, sex trafficking, homeless encampments in California, North Korea, and Maxine Waters?	17
		How does Mayor E*** G****** explain his failed leadership on Los Angeles' homelessness crisis?	18
		Teenager found drugs and died of overdose when volunteering to help at homeless camp B**** M****, 18, was found dead at a homeless camp in Echo Park, Los Angeles, after using cocaine laced with opioid epidemic drug Fentanyl while helping at the camp	19
		Ya, oh no. Think of LA & San Francisco's homeless pops. This appears to be what's happening. I think California and maybe Oregon and Washington are already the only states where you can still find black tar Could be wrong but that's what I've heard for a while now. #fentanyl	20

		You forgot without DRUGS heroin in the police departments CRACK COCAINE in the poor #SouthCentral Los Angeles and many other cities say Chicago…?? FENTANYL in Hollywood streets #Homeless getting it for one dollar a kick	21
		A landmark legal decision ordering all homeless removed from under & near LA freeways and put into housing beginning next Friday. Where will they go? City leaders are scrambling. Residents rejoicing	22
		Hi Baby T****, You wanna see the #WalkingDead? Come see our tent cities of Homeless & Fentanyl junkies in #DTLA #Hollywood & #NOHO. We're 100% democrat run it's a mess. Count your blessing you can afford to live in HB and thank your neighbours for voting logically. #wakeup	23
		You forgot without DRUGS heroin in the police departments CRACK COCAINE in the poor #SouthCentral Los Angeles and many other cities say Chicago…?? FENTANYL in Hollywood streets #Homeless getting it for one dollar a kick	24
		Was just out in #Hollywood, it's gotten worse. WE are going to have a generation of children that think #homeless encampments and packs of FENTANYL Junkies are totally normal.	25

		As a San Franciscan I will say it’s nice to take a break from the common narratives: exorbitant taxes, homelessness, fentanyl epidemic, fleeing residents & businesses, and Economic shutdown. It’s so much easier to just say there’s an apocalyptic vibe here. Take it or leave it.	26
		In my addiction, heroin and crack were my go to drugs. But when I hit the streets of #SanFrancisco, I used meth, klonopin, fentanyl, alcohol and ketamine too. I didn't care so long as I was high. This is #what we are dealing with. #Drugaddiction complicates #homelessness.	27
		The corner of Golden Gate and Hyde is the largest open-air drug market in San Francisco. The northwest corner is controlled by Honduran street gangs. The southwest corner is controlled by black dealers. Everything is for sale: heroin, fentanyl, meth, crack, klonopin, weed	28
		I recall H**** M*****, when she came to SF and did her research for the article she wrote on homelessness in SF, she spent $8 to buy some fentanyl, just to prove what was going on.	29
		Guy straight nodded out on Heroin/Fentanyl on the this morning. No judgement here. I used to do the same thing. It's just sad that he's stuck in the ongoing tragedy of homelessness and drug addiction. There's a way out. It's called #recovery. #SanFrancisco	30

		48 people experiencing homelessness in San Francisco died between March 30 and May 24. That's up from 14 during the same time period in 2019. Public health officials say the deaths are more likely due to overdoses from fentanyl and indirect impacts from the coronavirus pandemic.	31
		Seriously bold reporting here. 130 needles handed out in a few hours to E**** without a single mention of treatment. So much for needle "exchange" Not a single hotel was designated for sober people or for those trying to kick their habits. SF is funding a lot of drug use...	32
		The greater majority of San Francisco's locals don't approve of tents. Not because they hate homeless. But because they use fentanyl and shoot up in front of our businesses and homes. But the minority of unhoused addicts get all of the finance and attention. Harm reduction. Etc.	33
		Question the self-described experts, though, and you're dismissed as a rube, even as their grand experiment—the giant petri dish of San Francisco—is evidence that they've failed."	34
		San Francisco, we don't have a homeless+poverty problem, we have a fentanyl crisis with complete legality for drug dealers problem. Stop acting "woke" and wake up to #VoteThemOut.	35

		SF gov & leaders are directly responsible for the deaths of hundreds. I'm sickened by the virtue signalling around "harm reduction". I'm infuriated by the victim mentality that we can't do more. We can. We must. We *need* mandatory drug rehabilitation.	36
		So you give the homeless free hotel rooms plus you give them drugs and drug paraphernalia meth Fentanyl heroin what the hell are the city of San Francisco leaders thinking of these drugs is what destroyed these people's lives	37
		Absolutely staggering numbers released today: Overdoses in San Francisco increased from 259 in 2018 to *441* in 2019. Of the 441 overdoses, 54% involved fentanyl. 2020 is expected to be worse.	38
		We are in crisis. This is one of addiction. Local advocates estimate 85% of our homeless population is severely addicted to Fentanyl, Meth, Heroin & Alcohol. Treatment is not going to be free and SF cannot afford to care for all those who arrive. We need funding.	39
		So true. Go to the Tenderloin in ultra-progressive San Francisco and see how the homeless drug addicts are being helped by being given tents and a steady supply of fentanyl, or, if they're lucky, free hotel rooms.	40

		These are "harm reduction" kits for SF's homeless housed in hotels. It is my understanding that they include brillo to make a screen for your pipe, foil strips, and 'tooters' (straws) for smoking Fentanyl. 9 ppl have overdosed & died so far. TBD how many overdoses reversed.	41
		BS covid isn't dangerous to street people. Many homeless shelters have 70% infection rates but zero deaths - because they usually are younger and thinner. Now meth and fentanyl (which have killed double the number of people in sf than covid) are dangerous.	42
		So San Francisco contracted to put homeless people into free motel rooms, with free needles, booze,cigarettes, meth and pot pipes, foil for smoking fentanyl & Narcan (you know-in case someone Shock! Overdosed!) isn't it wonderful how Dems value human life?! Sick, corrupt...evil?	43
		Dear K****, What would you do with all the Fentanyl dealers in San Francisco - that are killing our at risk homeless folks and others?	44

		People are really leaving San Francisco: 'The 2020 San Francisco exodus is real, and historic, report shows	45
		Advocates say the percentage of homeless struggling with addiction varies between 24-41%. Based on my lived experience being homeless in SF, 8+ out of every 10 unhoused residents I met were struggling with drug addiction. Mostly Heroin, Fentanyl and Meth.	46
		given hotels and access to fentanyl to the unhoused bums and junkies. There are more bums and junkies dead from this move than from Covid in SF. It is the SFBOS "final solution" for the homeless...fentanyl chambers/gas chambers are the free hotel rooms	47
		They play this game in San Francisco. Dilapidated & packed jail wasn't replaced in 2015. Now Meth/Fentanyl dealers are caught and released. Addiction, drug psychosis & OD deaths among the homeless skyrocketing in the name of "harm reduction"	48
		Hotels are a waste of money and time. The virus has had a minor effect on the homeless population. Hard drugs like heroin, meth and fentanyl have killed more people in SF than covid. Stop the hotel agenda.	49

		Ya, oh no. Think of LA & San Francisco's homeless pops. This appears to be what's happening. I think California and maybe Oregon and Washington are already the only states where you can still find black tar Could be wrong but that's what I've heard for a while now. #fentanyl	50
		Is exploitation of the most vulnerable as a means of supporting yourself sound OK to you? That's what's happening in #SanFrancisco at the street level. Large groups of organised drug dealers are exploiting the homeless population by selling Fentanyl, Heroin, Meth and Crack.	51
		If Fentanyl, Meth, Crack and Heroin were not so easily available on the streets 24/7 some of the 48 homeless that died since March might still be alive. Why does this logic appear to be in the minority in San Francisco?	52
		I drove around the SF today, Filthy as ever, 100's homeless everywhere. Now living in front of shuttered businesses in tents. Open air drug markets operating as usual on Sixth and the loin with the usual Honduran heroin fentanyl crack dealers quite conspicuous. What a joke	53
		I work in the Tenderloin in SF helping homeless Vets get housed. 2 years ago I was a homeless heroin addict and I witnessed 3 OD deaths in 6 months. Today, I walk or drive by at least 1 OD per	54

		day. It's the Fentanyl. We must get it off the street. Narcan can't save them all.	
		Drone footage shows San Francisco's first sanctioned temporary tent encampment for the homeless. The camp provides a safe sleeping area in a fenced-off space near City Hall with designated spots for tents to help with social distancing	55
	Chicago	You forgot without DRUGS heroin in the police departments CRACK COCAINE in the poor #SouthCentral Los Angeles and many other cities say Chicago…?? FENTANYL in Hollywood streets #Homeless getting it for one dollar a kick	1
	Dallas	I just realized that Jul 26 2018 I was in Dallas and at roughly 5:30pm I stopped to slip a $20 into the shirt pocket of a sleeping homeless guy on a bench. Only he was dead. Heroin/Fentanyl. What a day that was.	1
	Oregon	Ya, oh no. Think of LA & San Francisco's homeless pops. This appears to be what's happening. I think California and maybe Oregon and Washington are already the only states where you can still find black tar Could be wrong but that's what I've heard for a while now. #fentanyl	1

		This is terrifying for Portland residents, who are pawns in a ridiculous political chess game. Same goes for: - California - New York - COVID - Homeless problem - Fentanyl crisis - Police shootings Basically everything is being weaponized, and everybody loses.	2
	New york	I started homeless and addicted to fentanyl in Philly, NYC, DC & Baltimore. Now I am clean and prepared. Took a while. It's a process.	1
		This is terrifying for Portland residents, who are pawns in a ridiculous political chess game. Same goes for: - California - New York - COVID - Homeless problem - Fentanyl crisis - Police shootings Basically everything is being weaponized, and everybody loses.	2
	Washington	I started homeless and addicted to fentanyl in Philly, NYC, DC & Baltimore. Now I am clean and prepared. Took a while. It's a process.	1
	Nashville	Used To Be Homeless On The South Side Of Nashville At The Age Of 21. Never pan handled tho. Used to work a hard labor temp service job for 12 hours a day for $60 for food. Be Grateful For What You have. I am blessed to have a roof over my head once again let alone game.	1

	Florida	Bipolar disorder is real, and it can be devastating. My homeless brother once told me he needed my help to run for the Minnesota Governors office. He's dead now, the Proud Boys in Florida sold him Fentanyl laced meth	1
	Seattle	My mom & I were homeless by the pier in Seattle for 2 years where we scrounged to eat trash food and maintain our area without being bothered. I was abused and sexually assaulted. While being a cop I overdosed on fentanyl through an airborne exposure and had 2 children die on me	1
		Check out the YouTube documentary "Seattle is Dying." Yes, there are mentally ill and working homeless, but for the most part its a drug crisis. I lived there until recently. Meth, fentanyl, heroin.	2
		Well, actually the governor of California and LA mayors are Democrats. So, strictly speaking B**** America. Most so-called “homeless” on West Coast are drug addicts, heroin, fentanyl etc as seen graphically in Seattle.	3

Table 3. Quotations of the economic issues associated with fentanyl consumption

Sub-theme	TN	Quotation
Fentanyl causes homelessness	1	Chinese $$ aka money laundering, whilst flooding the territory with CCP fentanyl creating homelessness
	2	but fentanyl and other opiates kill people every day, cause homelessness, and drain hospital resources
	3	making use of most dangerous addictive drugs like Heroin, Meth, Cocaine and Fentanyl a misdemeanour! G*** G**** who is running against J**** L**** was co-author! Homelessness exploded by 40%!
	4	You left out the health of those addicted to substances that are contributing to homelessness. 1500+ overdose fentanyl deaths in BC in a year
	5	How come no one talks about the huge epidemic with meth, heroine and fentanyl. Fixing that problem would help a lot of things in this country like homelessness for one!!
	6	The problem is that G*** and K**** made possession of fentanyl/meth/heroin a misdemeanour in California

	(Prop47). This is why there's record homelessness, theft and overdoses
7	My money is on fentanyl and meth as cause of homelessness.... institutional racism comes in last
8	We are programmed to think the homeless crisis is about humanitarianism and housing. It's not. It's a fentanyl crisis being enabled by 1) City leaders and the for profit service providers who make millions 2) drug dealers who act with impunity. 3) And us - Compassion Zombies.
9	In the US cheap meth and fentanyl are causing a homeless crisis much like this and decriminalisation has made it much worse
10	So "cheap" meth and fentanyl are causing homeless crisis..
11	Hug and release as usual. When will you realize if you stop the Meth, heroine, and fentanyl THEN YOU STOP THE HOMELESS EPIDEMIC!!!

	12	I was able to maintain my government job while popping pills, but I couldn't function when I turned to Heroin/Fentanyl and became homeless within a year. This isn't meant to stigmatise, but to point out the progression of drug addiction. #recovery brought it all back.
Fentanyl more desirable than housing	13	Baltimore City Keep Playing With Your Life and Your Freedom Dealing With Our Democratic Party. The Homelessness Abandon Houses Issues.
	14	Never mind the fact it’s just wholly inappropriate in the middle of a smoky sky, global pandemic, homelessness and fentanyl overdose crisis.
	15	poor air quality Moth Armageddon Fentanyl + homelessness Housing affordability crisis Crumbling economy

16	Homelessness is out of control. Fentanyl and Meth riddles the downtown core.
17	Every country on earth has homelessness.. T**** should be directing policies to address our housing shortages.. government backed loans for housing could help
18	There were 1 or 2 tents on this same street 2 years ago. What has happened since then? It's not just COVID19. The tents were already stacking up before March.
19	Yep, our last point in time count showed 30% increase in homelessness. Affordability, skyrocketing rents & displacement were largely to blame. Also yes, an increase in fentanyl.
20	Also endless homeless encampments
21	other than roaring homeless cases, defunded police, and a fentanyl problem
22	rampant homelessness, Oppenheimer, an affordability crisis, the DTES, empty homes, empty retail, and fentanyl, is not

	awesome. #vancouverisawful
23	Look around Baltimore inner city communities. Homelessness, Abandoned Houses, The opioid and fentanyl epidemic. Your Crime and Homicide Rate. ACLU isn’t the privacy of our inner city lives being violated. What about to protect and service in our inner city communities.
24	Los Angeles? Where drug addicts, homeless and criminals rule the streets? And deaths from fentanyl have doubled ?
25	Those people don't want jobs and they don't want to be off the streets. All I want is there meth and fentanyl.
26	80% of our homeless are addicts and would choose heroin/fentanyl/meth over housing
27	They have already... you just don't notice it because it is in a fine deadly continuous stream! GMO's Planned Parenthood, geo-engineering, the opioid and fentanyl overdoses, suicides,

		70% one pay check away from homelessness, Walmart & Amazon destroying small business...etc!
	28	so i am able to afford shelter but not treatment. unlike homeless people, i can access cheap pain medication that doesn't have to come in a needle, and doesn't have fentanyl mixed in. other people are a lot less lucky than me. if rent goes up, i might be joining them.
Lack of resources provided from the government causes homeless to use fentanyl	29	rampant homelessness, Oppenheimer, an affordability crisis, the DTES, empty homes, empty retail, and fentanyl, is not awesome.
	30	short term gain by the greedy who allowed expensive, rampant condo for Chinese $$ aka money laundering, whilst flooding the territory with CCP fentanyl creating homelessness, addictions, despair of locals. Deal with the issue: corruption and greed otherwise, decay and crime

	31	Um, “sleeping”? Everybody knows that is a huge heroin and fentanyl parking lot and the homeless camped out in tents sell drugs so the guy obviously nodded out and set his car on fire. This is one of the reasons I’m moving out of this shithole
	32	My stepson overdosed and died in July on Fentanyl PRESCRIBED BY THE VA in quantities enough to kill 100 people. That's just one problem. The homelessness and lack of services is overwhelming to our heroes
	33	The good news: according to Vancouver's annual homeless count, the number of homeless dropped for the first time since 2015, going from 2,223 to 2,095. The bad news: count was done at the beginning of March, right before #COVID19, so the numbers don't reflect current reality.

Fentanyl declared real health emergency	1	Homeless, Faeces, people nodding out from Heroin/Fentanyl. I'm bummed
	2	The faecal and heroin, fentanyl lined streets of this once pristine locale is a sight to behold, with it's massive homeless pop, panhandlers & criminals.
	3	This is a calamity and the real health emergency we are facing in this country. #addiction #safesupply #supervisedconsumptionsites #harmreduction #homelessness #MentalHealthMatters #opioidcrisis #fent #fentanyl
	4	Initially there was a lot of concern that COVID19 was going to sweep thru the homeless population. But it never happened. So, ironically, what ended up happening is we isolated a bunch of drug addicts and about 22 of them killed themselves with Fentanyl.
	5	Homeless drug addicts need a supply of safe fentanyl. The deaths

	happen because the potency varies too much. Have pharmacists or chemists dilute and divide the drugs
6	Okay, and how many fentanyl related deaths in the homeless population in that time
7	A man who has been struggling with homelessness for some time used fentanyl last week to ensure a + screen (been stable on bupe for months), still turned away from treatment. Today desperately wants to try again, but has conjunctivitis and no urgent care will see him
8	The catalyst for him seeking treatment was homelessness. This is the man I've been tweeting about for over a month. The same man who was stable on bupe and chose to inject fentanyl in order to have a pos. drug screen to get a bed in the hopes his housing

	issue would be addressed.
9	You forgot without DRUGS heroin in the police departments CRACK #COCAINE in the poor #SouthCentral Los Angeles and many other cities say Chicago…?? FENTANYL in Hollywood streets #Homeless getting it for one dollar a kick
10	They're in the midst of three simultaneous crises -- homelessness, fentanyl-overdose deaths and COVID. Tomorrow, city is supposed to be announcing special measures to contain the spread in DTES #COVID19Vancouver #vanpoli
1	As a San Franciscan I will say it's nice to take a break from the common narratives: exorbitant taxes, homelessness, fentanyl epidemic, fleeing residents & businesses, and Economic

	shutdown. It’s so much easier to just say there’s an apocalyptic vibe here. Take it or leave it.
2	People are really leaving San Francisco: 'The 2020 San Francisco exodus is real, and historic, report shows
3	The problem in Vancouver and now some in Victoria etc, is the f*cking Fentanyl.
4	We are in crisis. This is one of addiction. Local advocates estimate 85% of our homeless population is severely addicted to Fentanyl, Meth, Heroin & Alcohol. Treatment is not going to be free and SF cannot afford to care for all those who arrive. We need funding.
1	If he means take back Canada from China, I'm for that. China, and our corrupt politicians enabling them, right up to the PMO, is the cause of many of our problems today including fentanyl,

	homelessness, stratospheric housing, unaffordable education.
2	Many of the homeless have been marginalised and left homeless by the inflow of illicit money from China, over decades making livable rents impossible and who've been dying en masse from street drugs laced with fentanyl ALSO coming from China.
3	B******? If you're so smart then why is Seattle one of the cities hit hardest? Why don't you keep your backyard clear of Heroin, Fentanyl, and homelessness. The longer this goes the more you benefit, Mr. Vaccine! #B******IsNotOurSavior #HeStartedThis
1	Everybody knows that is a huge heroin and fentanyl parking lot and the homeless camped out in tents sell drugs so the guy obviously nodded out and set his car on fire.

	2	The province has had to intervene. City Hall hosted a violent fentanyl gang on their doorstep.

Table 5. Quotations of the social issues associated with fentanyl

Sub-theme	TN	Quotation
Fentanyl consumed in public areas	1	#ANTIFA is homeless kids paid with #Meth and #Fentanyl from COVID/Border shutdown related overstocks. #Riots, #Looting and #Fireworks are #ANTIFAKids high AF on free drugs. If they talk... no more drugs
	2	But when I hit the streets of #SanFrancisco, I used meth, klonopin, fentanyl, alcohol and ketamine too. I didn't care so long as I was high. This is what we are dealing with. #Drugaddiction complicates #homelessness.
	3	Only slept for 2 hours last night and dreamed that a homeless man overdosed from fentanyl in my house, then a big group of people assembled (including B**** S*****) for the funeral of a sheriff instead of the homeless man and they all hugged me without masks, so happy Tuesday?!
	4	You’re addicted to fentanyl, homeless, and fighting everyday to stay alive, yet you still think you’re better than a Black woman who graduated with a diploma AND a degree. A black woman who is working this kind of job because she cares about people like you. Shit is crazy.

5	Recently in Kamloops a toddler found a baggy of suspected fentanyl in a park.
6	Don't smoke a homeless man's weed... long story short last night I did and I immediately knew that it wasn't just weed. Woke up this morning and got the rest of what I had tested and it was laced with Fentanyl. Shit knocked me unconscious. I'm such a fkn idiot.
7	If you give homeless people money, they'll just buy drugs with it" actually i give them edibles *and* money. they usually use the money to buy a coffee so they can have restroom privileges. and the weed makes it less likely they're gonna get fucked over by fentanyl
8	Fentanyl is one of the safest drugs known to man. All you need is a microgram scale with ~1 ug linearity. How would you precisely measure the amount of marijuana you pour rig, B****?
9	What about protecting law abiding citizens and cleaning up the homeless encampment on Octavia and Oak that have taken over the area. And they're in

	violation of California law by having fentanyl within 1000 feet of a school!! #DoYourJob
10	Teenager found drugs and died of overdose when volunteering to help at homeless camp B**** M****, 18, was found dead at a homeless camp in Echo Park, Los Angeles, after using cocaine laced with opioid epidemic drug Fentanyl while helping at the camp
11	We are in crisis. This is one of addiction. Local advocates estimate 85% of our homeless population is severely addicted to Fentanyl, Meth, Heroin & Alcohol. Treatment is not going to be free and SF cannot afford to care for all those who arrive. We need funding.
12	Well, actually the governor of California and LA mayors are Democrats. So, strictly speaking B***** America. Most so-called "homeless" on West Coast are drug addicts, heroin, fentanyl etc as seen graphically in Seattle.
13	Advocates say the percentage of homeless struggling with addiction varies between 24-41%. Based on my lived experience being homeless in SF, 8+ out of every 10

	unhoused residents I met were struggling with drug addiction. Mostly Heroin, Fentanyl and Meth.
14	he is also homeless as he brags about doing fentanyl
15	Guy straight nodded out on Heroin/Fentanyl on the this morning. No judgement here. I used to do the same thing. It's just sad that he's stuck in the ongoing tragedy of homelessness and drug addiction. There's a way out. It's called #recovery. #SanFrancisco
16	safe injection" sites shut down and fentanyl supply get cut off..
17	I recall H***** M*****, when she came to SF and did her research for the article she wrote on homelessness in SF, she spent $8 to buy some fentanyl, just to prove what was going on.
18	W*** A****** was 23, homeless and addicted to heroin, then fentanyl.
19	The gov. is learning that the only way to end fentanyl is to provide real heroin.
20	Bipolar disorder is real, and it can be devastating. My homeless brother once told me he needed my help to run for the Minnesota Governors office.

	He's dead now, the Proud Boys in Florida sold him Fentanyl laced meth
21	One supplier said he'd break the bags down and lace one for each dealer with fentanyl.
22	Teenager found drugs and died of overdose when volunteering to help at homeless camp B***** M****, 18, was found dead at a homeless camp in Echo Park, Los Angeles, after using cocaine laced with opioid epidemic drug Fentanyl while helping at the camp
23	Fentanyl and Carfentanil are deadly drugs and they are easily found.
1	Boston's homeless swear by the stuff and #COVID19 bounces off them like hail on a tin roof.
2	I guess we should all start prophylaxis with meth, fentanyl, and liquor wrapped in brown paper bags. Boston's homeless swear by the stuff and #COVID19 bounces off them like hail on a tin roof.
3	BS covid isn’t dangerous to street people. Many homeless shelters have 70% infection rates but zero deaths - because they usually are younger and thinner. Now meth and

	fentanyl (which have killed double the number of people in sf than covid) are dangerous.
4	Misinformed media needs to catch up now. Well, that is, considering fentanyl is purportedly an evil chemical that is absorbed through the skin of your hands and is part of a conspiracy to lure kids into the realm of homelessness and addiction according to them.
5	Once again you are looking at one side of the spectrum. Some of these stories are painting a picture of homeless people with the issue. 87% of fentanyl overdoses happen indoors. In that number there are 40 hrs week working ppl. But other variables are supply amounts and quality.
6	I hear that Wyoming and Montana,Maine,Idaho are very nice this time of year. No rolling blackouts,few(er) instances of senseless random violence, minimal homeless camps drenched in urine and fentanyl.. You can also bring your own burn barrel. Good times

	7	The greater majority of San Francisco's locals don't approve of tents. Not because they hate homeless. But because they use fentanyl and shoot up in front of our businesses and homes. But the minority of unhoused addicts get all of the finance and attention. Harm reduction. Etc.
Fentanyl causes increased mortality rate	1	The homeless and drug addicted populations are growing. Overdoses at all time highs.
	2	It is my understanding that they include brillo to make a screen for your pipe, foil strips, and 'tooters' (straws) for smoking Fentanyl. 9 ppl have overdosed & died so far. TBD how many overdoses reversed.
	3	Homeless V6A2T2, the epicenter of the Fentanyl Overdose crisis; the pharmacies, housing support endowment, First Nations, Coast/Inner Salish people, Inuit, Yukon and Cree who have lived and died in the DTES, V6A2T2, illicit / pharma intensive / Narcan frontline WAR on drug users.
	4	Now there's historic homeless populations and overdoses.

5	Same-old, same-old. M says he's fine. He was attended by paramedics (and maybe #Vancouver Coastal Health - I'm taking latter w/ grain of salt) after his #fentanyl #overdose last wk. I'm told tho, #naloxone was given by one of my #homeless peers before ambulance arrived.
6	the homeless are being used as human guinea pigs
7	When I was on the street, dealers would have me sample new batches of Heroin all the time. Free. And I was happy too. I didn't care. I was an addict. There were free drugs to be had.
8	Drug cartels are widely producing fentanyl and the homeless are being used as guinea pigs
9	they're using the homeless as human guinea pigs to test the drugs
10	Agreed, dude. And that's pretty ironic too, because I have ore than a couple of friends who are homeless crack and fentanyl addicts who look WAAAAAAY worse than pics I see of Vietnam soldiers in the field. They seem to die of OD's or murder fairly often as well.

11	seen as homeless by many, as Zombies from the way fentanyl and meth affect physical coordination.
1	we have a terrible homeless problem in our downtown core. Fentanyl is rampant and sadly we wear the badge of OD capital of North America. More than 1100 dead in 1yr
2	left thousands of people homeless in the vacancy crisis, and allowed a fentanyl crisis to kill people because you don't approve of them.
3	1500+ overdose fentanyl deaths in BC in a year and that many grieving families
4	175 people dead In June by overdose in BC alone. This is a calamity and the real health emergency we are facing in this country.
5	48 people experiencing homelessness in San Francisco died between March 30 and May 24. That’s up from 14 during the same time period in 2019. Public health officials say the deaths are more likely due to overdoses from fentanyl and indirect impacts from the coronavirus pandemic
6	and the fentanyl is killing people everyday. Stay healthy!

7	The concern really should be all the young people, not famous music "leaders," who have been losing their life to heroin and fentanyl, one the other day among homeless I deliver meals to.
8	All I know is 441 American homeless humans died from overdose last year. And those numbers will be toppled this year.
9	Absolutely staggering numbers released today: Overdoses in San Francisco increased from 259 in 2018 to *441* in 2019. Of the 441 overdoses, 54% involved fentanyl. 2020 is expected to be worse.
10	The supervisors have been directing their attention away from the drug crisis and towards a made belief in covid and the homeless. Meanwhile more people have died of heroin, meth and fentanyl then covid, guns and cars combined by double...
11	Los Angeles? Where drug addicts, homeless and criminals rule the streets? And deaths from fentanyl have doubled ?

12	what ended up happening is we isolated a bunch of drug addicts and about 22 of them killed themselves with Fentanyl.
13	given hotels and access to fentanyl to the unhoused bums and junkies. There are more bums and junkies dead from this move than from Covid in SF. It is the SFBOS "final solution" for the homeless...fentanyl chambers/gas chambers are the free hotel rooms
14	May and June numbers of actual overdose deaths for BC were nearly 400. The New York area must be just devastated.
15	The 3 deaths I personally witnessed when homeless were all from Fentanyl overdose. 2 from smoking it and 1 from shooting it up.
16	suddenly there are junkies living in your park. Your nephew just died of a fentanyl overdose.
17	The virus has had a minor effect on the homeless population. Hard drugs like heroin, meth and fentanyl have killed more people in SF than covid
18	When I was homeless, I woke up next to dead people from Fentanyl OD. Twice. And

	watched a 3rd die as EMT'S gave CPR for 35 minutes. Fentanyl=death.
19	If Fentanyl, Meth, Crack and Heroin were not so easily available on the streets 24/7 some of the 48 homeless that died since March might still be alive. Why does this logic appear to be in the minority in San Francisco?
20	Three homeless people die every day on our streets - why? Fentanyl and meth. Use your head. Have a nice night.
21	DEATHS HAVE SOARED AMONGST HOMELESS FROM FENTANYL NOT CORONAVIRUS AND YOU ARE DOING NOTHING ABOUT IT!!! YOU HAVE BLOOD ON YOUR HANDS!!!
22	I work in the Tenderloin in SF helping homeless Vets get housed. 2 years ago I was a homeless heroin addict and I witnessed 3 OD deaths in 6 months. Today, I walk or drive by at least 1 OD per day. It's the Fentanyl. We must get it off the street. Narcan can't save them all.

23	My stepson overdosed and died in July on Fentanyl PRESCRIBED BY THE VA in quantities enough to kill 100 people.
24	Addict goes back to college to work with addicts, mental health, homelessness ect. Moves to DTES from on to work and after my mental health spiralling and the fentanyl death of my partner...
25	homelessness, fentanyl-overdose deaths
26	The homeless are doing fentanyl and dying of overdoses in the hotel rooms.
27	As someone that used Opioids/Fentanyl/Heroin and witnessed 3 overdose deaths and many more that escaped death on the streets when I was homeless, I feel you.
28	homeless are being used as human guinea pigs to test the drug's potency, which has left many dead.
29	Narcos are experimenting and testing fentanyl doses on the homeless, which has resulted in 20 overdose deaths.
30	I just realized that Jul 26 2018 I was in Dallas and at roughly 5:30pm I stopped to slip a

		$20 into the shirt pocket of a sleeping homeless guy on a bench. Only he was dead. Heroin/Fentanyl. What a day that was.
	31	Idk man killing and abusing puppies in the name of a criminal who did fentanyl seems pretty bad to me.
	32	Teenager found drugs and died of overdose when volunteering to help at homeless camp B**** M****, 18, was found dead at a homeless camp in Echo Park, Los Angeles, after using cocaine laced with opioid epidemic drug Fentanyl while helping at the camp
	33	i watch my friends succumb to homelessness and death due to drug addiction
	34	Homeless addicts given hotel rooms during Covid-19 are offered the complete range of drug paraphernalia. Boxes of needles, glass pipes for meth and crack, and Fentanyl supplies are laid out in the lobbies like a breakfast buffet. Fatal overdoses, not surprisingly, have spiked.
	35	Homeless drug addicts need a supply of safe fentanyl. The deaths happen because the

		potency varies too much. Have pharmacists or chemists dilute and divide the drugs
Increased crime due to fentanyl consumption	1	Everybody knows that is a huge heroin and fentanyl parking lot and the homeless camped out in tents sell drugs so the guy obviously nodded out and set his car on fire
	2	Not hating but isnt burning down small businesses and lighting homeless people's belongings on fire terrorism?? Idk man killing and abusing puppies in the name of a criminal who did fentanyl seems pretty bad to me.
	3	Every time I win a case (and I’ve never lost), i celebrate with my clients by taking them to watch homeless people fight over a bag of fentanyl
	4	My mom & I were homeless by the pier in Seattle for 2 years where we scrounged to eat trash food and maintain our area without being bothered. I was abused and sexually assaulted.
	5	The homeless are super aggressive with peaceful citizens. Called 911 on a few of them as they were screaming at people demanding money and blocking sidewalk right of way. Maybe the price of fentanyl going up, I don't know

6	, the #homeless congregate in open-air drug markets; dealers wear gloves and masks and sell heroin, fentanyl, and meth in broad daylight. Residents describe the environment as apocalyptic, with encampments, trash, and drugs in every corner
7	The impact of the new policy has been dramatic. In the Tenderloin ... neighbourhoods, the homeless congregate in open-air drug markets; dealers ... sell heroin, fentanyl, and methamphetamine in broad daylight
8	the homeless congregate in open-air drug markets; dealers wear gloves and masks and sell heroin, fentanyl, and methamfetamine in broad daylight.
9	The corner of Golden Gate and Hyde is the largest open-air drug market in San Francisco. The northwest corner is controlled by Honduran street gangs. The southwest corner is controlled by black dealers. Everything is for sale: heroin, fentanyl, meth, crack, klonopin, weed

10	They're trading the homeless fentanyl and meth and whatever else in return for what they're doing.
11	They abuse drugs because they are homeless. Many communities here have been displaced and we're not doing much about it. I've openly seen people selling fentanyl on the streets DAILY and cops just stand around and smile lol
12	Homeless living in tents on the sidewalk, dealers on every corner. One supplier said he'd break the bags down and lace one for each dealer with fentanyl.
13	Is exploitation of the most vulnerable as a means of supporting yourself sound OK to you? That's what's happening in #SanFrancisco at the street level. Large groups of organised drug dealers are exploiting the homeless population by selling Fentanyl, Heroin, Meth and Crack.
14	Containment, cheap fentanyl and an abundance of fentanyl dealers is the quickest way and is attempting to reduce the homeless population.

	15	Clean! Clean all the dirty needles in the park and clean up the over doses in Vancouver B.C. FOCUS!
	16	LMAO there isnt going to be anybody downtown except the criminals and thugs trafficking fentanyl while pretending to be homeless people? Businesses and the people who support them will be long gone!!
	17	We had gutter punk homeless kids telling everyone they were in charge and then coming to the medical tent asking me for fentanyl.
	18	The problem is that G*** and K**** made possession of fentanyl/meth/heroin a misdemeanour in California (Prop47). This is why there's record homelessness, theft and overdoses
	19	She made possession of fentanyl/meth/heroin a misdemeanour. Now property crimes and overdoses are common.

Table 7. Quotations regarding the services provided to homeless fentanyl users

Sub-theme	TN	Quotation
Public support shown towards reducing fentanyl consumption	1	Strathcona Park took over for Oppenheimer Park for the winter, dealing with the homeless and fentanyl crisis. Transfer from homeless shelters to housing is more common. Shelter lifers can become real (free food)
	2	From my perspective, "try smoking or snorting it instead" as harm reduction advocates promote, carries little weight with me. Promote #recovery
	3	I want to acknowledge those fighting covid and/or the fentanyl crisis for a living. Often working double or triple shifts, working on the frontlines of mental illness, addiction and homelessness.
	4	Our goal is helping to turn our inner city around. I'm not a politician or local leader. I fight against homelessness, the opioid and fentanyl epidemic. Our goal rehabbing houses for low income people

5	We should outlaw Meth & Fentanyl & arrest dealers. We should work with ICE on this as a huge % are here illegally. We should develop a strategy about the tents and give cops tools to help people out of homelessness.
6	I started homeless and addicted to fentanyl in Philly, NYC, DC & Baltimore. Now I am clean and prepared. Took a while. It's a process.
7	Guy straight nodded out on Heroin/Fentanyl on the this morning. No judgement here. I used to do the same thing.
8	once I saw a homeless man selling a shirt that said fuck fentanyl and I wish I bought it
1	For a truly authentic homeless experience they need heroin, booze and fentanyl.
2	Imagine after eating fish and eggs, or pizza with beer! with that beard! Makes me want to vomit! And you swear you look manly with that beard but you look like a homeless person on fentanyl with oxycodone... worthless... beer and beard... they rhymed Lmao

	3	Amazing that fentanyl is a permissible drug to the leftists that deliver them needles and drug delivery facilities with a smile on their face. Lefty population control eugenicists looked at K***** and said "Hold my beer." Internment camps, homeless camps where humanity dies.
	4	And I guess white lives don't matter when one commits suicide or OD's on fentanyl. Nor do they seem to matter when they're homeless after fighting in pointless wars either
Government ignore issues on homelessness	1	Democrats only address things that gain political advantage. Media ditto. Homelessness, child trafficking, fentanyl and opium addiction, are completely ignored. I wish I could say Republicans do better, but they don't.
	2	We should protest homelessness, corruption, high house prices & rent, Fentanyl
	3	It's quite brazen and overwhelming All the fentanyl, homelessness, law enforcement/judicial paralysis second order effects from

	globalization the finest win cooperation
4	on this subject if you defund public safety to make pocket change in a town full of unsecured storm drains and homeless fentanyl addicts you deserve the guillotine
5	How will the bc liberals fake bc money that was stolen by your party, or bc hydro, or better yet, how they DIDNT help the homeless and turned their backs on gangs and fentanyl.
6	This story. What is the matter with Ottawa, so many years into a homeless and fentanyl crisis, that we do not look after those who put their lives on the line, to look after us?
7	Also endless homeless encampments, fentanyl being handed out by the government and corruption at every level
8	Cutting demand for Fentanyl is not easy. The homeless and drug addicted populations are growing.

9	Start in your own party. Former MLA J*** T****** privileged son is a fentanyl trafficker & pedo. G**** C***** a drunk driver... and lest we not forget C***** C*****... Quick cycle: fentanyl trafficking, money laundering, real estate, evictions, homeless, fentanyl.
10	Do you heart bleeds for homeless American kids. Riots and looting. You love fentanyl China . You need illegals in a pandemic with deadly diseases
11	San Francisco, we don’t have a homeless+poverty problem, we have a fentanyl crisis with complete legality for drug dealers problem. Stop acting “woke” and wake up to #VoteThemOut.
12	who are pawns in a ridiculous political chess game. Same goes for: - California - New York - COVID - Homeless problem - Fentanyl crisis - Police shootings Basically everything is being weaponized, and everybody loses
13	Check out the YouTube documentary "Seattle is Dying." Yes, there are mentally ill

	and working homeless, but for the most part its a drug crisis. I lived there until recently. Meth, fentanyl, heroin.
14	Dear K*****, What would you do with all the Fentanyl dealers in San Francisco - that are killing our at risk homeless folks and others?
15	historically high rates of fentanyl poisoning, and now homeless people who have no shelter are very discouraging and have made me rethink my support
16	Vancouver has a massive Fentanyl/Heroin homeless problem. They are dying in the streets everyday. Income inequality is bad.
17	So what again did you do for housing, the homeless, and the fentanyl crisis again Todd? I remember when your government attacked critics of your "housing policy" as being racist. Please sit down, Todd! #bcpoli
18	Hi Baby T****, You wanna see the #WalkingDead? Come see our tent cities of Homeless & Fentanyl junkies in #DTLA #Hollywood & #NOHO. We're 100% democrat run it's a mess. Count your blessing you can afford to

	live in HB and thank your neighbours for voting logically. #wakeup
19	still dealing with Covid 19 and housing homeless youth, today I snapped back to deal with the realities of Fentanyl use among our young people, and their building rage. It's a firestorm, folks.
20	And they both created a massive fentanyl problem and rabid and angry homeless #poulation, not to mention selling us out to every fucking shitty developer who promised Cushy jobs for them once they left government
21	What about protecting law abiding citizens and cleaning up the homeless encampment on Octavia and Oak that have taken over the area. And they're in violation of California law by having fentanyl within 1000 feet of a school!! #DoYourJob
22	DEATHS HAVE SOARED AMONGST HOMELESS FROM FENTANYL NOT CORONAVIRUS AND YOU ARE DOING NOTHING ABOUT IT!!!

		YOU HAVE BLOOD ON YOUR HANDS!!!
	23	Was just out in #Hollywood, it's gotten worse. WE are going to have a generation of children that think #homeless encampments and packs of FENTANYL Junkies are totally normal.
Government failed in reducing fentanyl	24	How does Mayor E*** G******* explain his failed leadership on Los Angeles' homelessness crisis?
	25	endless homeless encampments, fentanyl being handed out by the government and corruption at every level
	26	Do you heart bleeds for homeless American kids. Riots and looting. You love fentanyl China . You need illegals in a pandemic with deadly diseases
	27	And of course a lot of homeless here from other states that are cold, we have the best weather. But I agree that the people in charge don't care about the homeless. There's homeless vets For crying out loud and that's also a national problem

28	We should protest homelessness, corruption, high house prices & rent, Fentanyl & other drug dealing gangs, money laundering, immigration skyrocketing without building new affordable supply, no PBR being built and GOV's incompetence in Vancouver like this. #VanRE #moneylaundering
29	Ive been say this for months. The supervisors have been directing their attention away from the drug crisis and towards a made belief in covid and the homeless. Meanwhile more people have died of heroin, meth and fentanyl then covid, guns and cars combined by double...
30	How come no one talks about the huge epidemic with meth, heroine and fentanyl. Fixing that problem would help a lot of things in this country like homelessness for one!!
31	However, more need to happen to tackle the homelessness and Fentanyl crisis which is a direct result of homes in Vancouver and Toronto becoming a piggy bank rather than a place where people live:

	32	It’s pretty messed up when the #Conservative party is even tangentially tied to drugs this deadly considering how they treat those with addictions and homeless not to mention pushing harsh sentencing...
	33	Recently in Kamloops a toddler found a baggy of suspected fentanyl in a park. Now I know it could be unrelated to homelessness, but unless someone will inspect every inch prior to other people using the park, then no. Invest in proper housing and mental health support.
Government allow homeless to use fentanyl	1	So you give the homeless free hotel rooms plus you give them drugs and drug paraphernalia meth Fentanyl heroin what the hell are the city of San Francisco leaders thinking of these drugs is what destroyed these people's lives
	2	So true. Go to the Tenderloin in ultra-progressive San Francisco and see how the homeless drug addicts are being helped by being given tents and a steady supply of fentanyl, or, if they're lucky, free hotel rooms.

3	So San Francisco contracted to put homeless people into free motel rooms, with free needles, booze,cigarettes, meth and pot pipes, foil for smoking fentanyl & Narcan (you know-in case someone Shock! Overdosed!) isn’t it wonderful how Dems value human life?! Sick, corrupt...evil?
4	So great, you’ve banned “Popcorn” Tobacco products. Also pretty amazing you’re allowing local governments to supply the homeless Fentanyl and other hard drugs while shelter during Covid and I can’t have a burger in a restaurant. What are u doing next?
5	given hotels and access to fentanyl to the unhoused bums and junkies. There are more bums and junkies dead from this move than from Covid in SF. It is the SFBOS “final solution” for the homeless...fentanyl chambers/gas chambers are the free hotel rooms
6	170 ventilators will not be enough for the thousands of homeless and Honduran

	fentanyl dealers you left in SF while "mayor". China loves you cutie pie.
7	whilst flooding the territory with CCP fentanyl creating homelessness
8	left thousands of people homeless in the vacancy crisis, and allowed a fentanyl crisis to kill people because you don't approve of them.
1	He is! S**** also sponsored Prop. 47 making use of most dangerous addictive drugs like Heroin, Meth, Cocaine and Fentanyl a misdemeanor! G***** G***** who is running against J**** L**** was co-author! Homelessness exploded by 40%!
2	There's a reason why K***** only got 2% of the vote campaigning for president. Her political history is strewn with power hungry grabs and scandals. She made possession of fentanyl/meth/heroin a misdemeanour in California and now there's historic homelessness.
3	The problem is that G**** and K***** made possession of fentanyl/meth/heroin a misdemeanour in California (Prop47). This is why there's record

	homelessness, theft and overdoses.
4	California also has historic level homelessness after K***** H**** passed her Prop47. She made possession of fentanyl/meth/heroin a misdemeanour. Now property crimes and overdoses are common. Quite the leftist elite policy that doesn’t effect the rich, but all others.
5	American liberals don’t care about drug charges any longer. In California, K***** H**** made possession of fentanyl/meth/heroin a misdemeanour. Now they have historic homelessness and overdoses.
6	Affordable housing” turns into projects. Get rid of prop47 and the historic homelessness numbers will drop. K**** H**** making possession of fentanyl/meth/heroin a misdemeanour has been a tragic failure.
7	We should outlaw Meth & Fentanyl
8	P**** signed a law into order making hard drugs throughout the state, i.e fentanyl, cocaine, etc...4grams and under a misdemeanour. One gets 4

	shots at this until it becomes a DUI. We pay for mental/drug therapies. Homeless get what?
9	California, all that will be left is elite liberals and the poor. The middle class is leaving. Prop47 making possession of fentanyl/meth/heroin a misdemeanour now nobody goes to jail-they go back to their homeless encampments.
10	our anti-public safety agenda is a detriment to California! Meth, heroin, cocaine, fentanyl a misdemeanour! Unsheltered homeless the highest in the country! Prop. 47, Prop. 57 and Prop. 64 to open the door for CA's ruin! Hell on Earth on H**** watch!
11	Stay away from the homeless areas that K**** H**** created with Prop47. She made possession of fentanyl/meth/heroin a misdemeanour. Now there's historic homeless populations and overdoses.
12	When will K**** H**** failed Prop47 come up? She made possession of fentanyl/meth/heroin a misdemeanour and now nobody does jail

		time..instead they go back to their homeless encampments.
	13	High rent, changes in the law (Prop 47) and the proliferation of drugs available on the street. Especially Meth and Fentanyl. When I was homeless 8 of 10 homeless people I met where struggling with addiction. Including myself.
Fentanyl use on the rise	14	Fentanyl abuse is on the rise. Opioid abuse is still a thing. Educational disparities. Human rights violations in China. Healthcare for the elderly, disabled, and children. Homelessness.
	15	Affordability, skyrocketing rents & displacement were largely to blame. Also yes, an increase in fentanyl.
	16	I fight against homelessness, the opioid and fentanyl epidemic.
	17	Talking Peace With The Most Violent Offender In The Epidemic Fentanyl - Do you see the homeless running from the emotional and mental violence
	18	The city is in the business of growing its user base -- fentanyl user base, that is. It needs your money to offer more luxury hotel rooms, booze and

		pot to the nation's entire homeless population. There is no end to it. The more free stuff you offer, the bigger the problem gets.
	19	Rural parts of this country can't stop smoking meth and injecting Fentanyl but we don't blame Republicans
	20	Homeless people go where there is $$$. Then again, I live in the South and the homeless problem in rural America is real. So much heroin and fentanyl; you poor bastards... If this is what you call making America great again, thanks but no thank
	21	Most the fentanyl is gone and my homeless are in hotels
Rehabilitation programs have failed	1	just quit fentanyl n heroin after nearly a year and smoked meth a few times i got lots of homeless and junkie homies but ill still laugh at crackheads doin wild shit bc its funny lmao id say its funnier tbh since u can relate
	2	Sending all of the good energy out to my patient from earlier today, a homeless trans woman, who overdosed on fentanyl. She was given Narcan

	and brought back from near death
3	Isn’t it time SOMEONE, presumably healthcare offered to treat these people as if they were sick?? FAIL!
4	A man who has been struggling with homelessness for some time used fentanyl last week to ensure a + screen (been stable on bupe for months), still turned away from treatment. Today desperately wants to try again, but has conjunctivitis and no urgent care will see him
5	Seriously bold reporting here. 130 needles handed out in a few hours to E**** without a single mention of treatment. So much for needle "exchange" Not a single hotel was designated for sober people or for those trying to kick their habits. SF is funding a lot of drug use
6	Wouldn't it be better to provide substance abuse treatment instead of providing alcohol, marijuana tobacco and other drugs to the homeless? Are

	crack addicts given crack? How about meth or fentanyl?
7	At some point a physician needs to step in. Not a harm reduction specialist. But one that thinks fentanyl is deadly. There need to be consequences and tolerance rules. Enable the residents. Stop denying truth. Audit the homeless budgets. Create metrics and measurable success.
8	because I have more than a couple of friends who are homeless crack and fentanyl addicts who look WAAAAAAY worse than pics I see of Vietnam soldiers in the field. They seem to die of OD's or murder fairly often as well.
9	The Fentanyl most of all and the meth. I know it's a problem all the way down the coast. And the addiction homeless problem. Jury nullification for all cannabis
10	Not a single word on how they are planning to deal with the homeless or addict during this crisis, wait
11	we often refer to street addicts, who are sometimes homeless and seen as

	homeless by many, as Zombies from the way fentanyl and meth affect physical coordination.
12	80% of our homeless are addicts and would choose heroin/fentanyl/meth over housing
13	If you want to understand the true efficacy of emergency services in this country, just know I called the paramedics bc I saw a homeless man overdosing on what I'm presuming to be heroin/fentanyl, and the paramedics simply didn't show up... fucked up shit
14	lure kids into the realm of homelessness and addiction according to them.
15	When I was on the street, dealers would have me sample new batches of Heroin all the time. Free. And I was happy too. I didn't care. I was an addict. There were free drugs to be had.
16	Drug dealers cut heroin & crack with fentanyl to enhance the effect and addictiveness.

1	These people have access to housing but drug addiction and mental illness are huge obstacles
2	Talking Peace With The Most Violent Offender In The Epidemic Fentanyl - Do you see the homeless running from the emotional and mental violence. We see the metal fencing in our community, streets, parks and city hall. We see our police taking
3	Bipolar disorder is real, and it can be devastating. My homeless brother once told me he needed my help to run for the Minnesota Governors office
4	Fentanyl and Carfentanil are deadly drugs and they are easily found. We need to have a better mental health system, STAT!
1	My point was we had a pandemic with the opioid and fentanyl abuse and we did nothing except give our first responders Narcan to revive the addicted.
2	We also have Narcan and fentanyl test strips through our Homeless Hookup program. #testyourdrugs #harmreduction #thriveon

	3	It's the Fentanyl. We must get it off the street. Narcan can't save them all.
Fentanyl use and COVID-19 drain hospital resources	1	box of brand new drug paraphernalia for smoking crack and fentanyl ready to be given out here in San Francisco at a large popular downtown convention center thats been converted into a homeless shelter
	2	Homeless addicts given hotel rooms during Covid-19 are offered the complete range of drug paraphernalia. Boxes of needles, glass pipes for meth and crack, and Fentanyl supplies are laid out in the lobbies like a breakfast buffet. Fatal overdoses, not surprisingly, have spiked.
	3	Homeless addicts given hotel rooms during Covid-19 are offered the complete range of drug paraphernalia. Boxes of needles, glass pipes for meth and crack, and Fentanyl supplies are laid out in the lobbies like a breakfast buffet."
	4	harm reduction" in action: all the drug paraphernalia a user might want, delivered to homeless people placed in hotels. needles and foil for shooting

	heroin and fentanyl, glass pipes for smoking meth and crack. a cheery, handwritten sign for some type of "therapy."
5	These are "harm reduction" kits for SF's homeless housed in hotels. It is my understanding that they include brillo to make a screen for your pipe, foil strips, and 'tooters' (straws) for smoking Fentanyl. 9 ppl have overdosed & died so far. TBD how many overdoses reversed.
6	So San Francisco contracted to put homeless people into free motel rooms, with free needles, booze,cigarettes, meth and pot pipes, foil for smoking fentanyl & Narcan
7	48 people experiencing homelessness in San Francisco died between March 30 and May 24. That’s up from 14 during the same time period in 2019. Public health officials say the deaths are more likely due to overdoses from fentanyl and indirect impacts from the coronavirus pandemic.

Policing of fentanyl sales has failed	1	But one that thinks fentanyl is deadly. There need to be consequences and tolerance rules. Enable the residents. Stop denying truth
	2	San Francisco, we don’t have a homeless+poverty problem, we have a fentanyl crisis with complete legality for drug dealers problem. Stop acting “woke” and wake up to #VoteThemOut
	3	While HIV is somewhat treatable controlled now, other diseases have skyrocket because of the vast homeless encampments and the unsanitary conditions that thrive in them, not to mention the crime. All due to the decriminalising of heroin, fentanyl and meth.
	4	The feds picked up and dropped off every scary looking tweaker in the city at chop and gave them codewords to say at the “aid tents” so they could get free drugs that are actually research chemicals like 5 Meo PCP, DOC, fentanyl etc. too bad the homeless love me n talk to me

	5	While being a cop I overdosed on fentanyl through an airborne exposure and had 2 children die on me
	1	dealers wear gloves and masks and sell heroin, fentanyl, and meth in broad daylight. Residents describe the environment as apocalyptic, with encampments, trash, and drugs in every corner."
	2	the homeless congregate in open-air drug markets; dealers ... sell heroin, fentanyl, and methamfetamine in broad daylight
	3	the homeless congregate in open-air drug markets; dealers wear gloves and masks and sell heroin, fentanyl, and methamfetamine in broad daylight.
	4	I've openly seen people selling fentanyl on the streets DAILY and cops just stand around and smile lo
	5	I've openly seen people selling fentanyl on the streets DAILY and cops just stand around and smile lol
	6	the homeless congregate in open-air drug markets; dealers wear gloves and

		masks and sell heroin, fentanyl, and methamfetamine in broad daylight.

Table 8. Locations the homeless would consume Spice

Country	Area	Quotation	TN
US	Florida	They wanted a regular daily venue like workaday others who had their jobs and careers in Downtown Tampa. Even the grungy funky street homeless population liked their routine of going to the Library, expending most of the day from open 10 AM to close 9 PM, to smoke spice & cigars	1
		Is spice "Bath Salts?" Sounds like that guy that went crazy smoking the stuff in Florida a few years back and ate a homeless guy's face off.	2
		Spice, vulnerability, and victimization: Synthetic cannabinoids and interpersonal crime victimization among homeless adults — a small city, Midwestern United States, 2017	3
UK	Bristol	Okay! Last time I'm retweeting this! I'm up next, reading the story "The Guardian" by A** L*****. Spice here has raised over $2500 to help Bristol's homeless and you should pop	1

		in, listen to an exhausted V****** read for a bit, and toss a couple bucks to this amazing charity.	
	Birmingham	Nothing Manifest has said is untrue, lived in Birmingham Centre since I was born. We need to be honest and admit their is a problem with the youth culture and homelessness / spice addicts in the city centre - a blind man could see these issues.	1
	Cardiff	Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog.. No one else.. Just a cool purple sky and a slither…	1
	Chester	Jailing him for 18 months and banning him from Chester city centre for three years, Judge S****** E***** said he had "no doubt" W**** L****** was selling spice to vulnerable members of the homeless community	1
	Doncaster	Decided to walk to Doncaster town centre to meet the Mrs from and pay for our holiday,was like walking through a zombie apocalypse with the amount of homeless,junkies,benefits scroungers. Walk home wasn't much better having to	1

		navigate a set of spice heads Firmino kung fu kicking	
		Doncaster council is fab #donnygate. 10 plus councillors charged with fraud related offences, mayor gives M*** A***** rate relief of 125k on one of his designer shops.drugs, homelessness, spice, pickpocketing, all rampant. Streets are dirty, and wastes cash on vanity projects	2
	London	Here we go another none local , if he was local he would realise that Manchester has the biggest homeless population outside of London, also the biggest spice epidemic outside of London and the biggest crime percentage in the north west but hey glory supporters dont see this	1
		For those who don't know Manchester, Piccadilly Gardens is traditionally the seat of the homeless and the spice addled. On most days, it looks pretty much the same as it does when there's a BLM protest going on.	2
		C***** H****** and D*** N*** are banned from Manchester city centre after being caught with Spice in Chinatown,	3

		Piccadilly Gardens and the Northern Quarter	
		Neighbourhood Tasking Team officers have arrested a male for dealing Spice to the homeless community on The Strand today. We are still out patrolling the streets night and day.	4
	Manchester	Sick of Manchester just stinking of homeless and spice	1
		Here we go another none local , if he was local he would realise that Manchester has the biggest homeless population outside of London, also the biggest spice epidemic outside of London and the biggest crime percentage in the north west but hey glory supporters dont see this	2
		but all we need to do is go to Manchester centre and see the junkies , homeless, spice heads	3
		Yeh but Manchester has all this and cheap pints so I think ur lying	4
		Listen to myself and Mmu talking about Spice use within the homeless population in Manchester	5

		Manchester has WHP and homeless people smoking spice, all there is to the place	6
		talking about spice use among the homeless population in Manchester.	7
		I've also sent him one called "the spice boys" which sounds good a true story about some Manchester lads who are #homeless and addicted to spice.	8
		C***** H***** and D*** N*** are banned from Manchester city centre after being caught with Spice in Chinatown, Piccadilly Gardens and the Northern Quarter	9
		You may have seen W*** B**** begging in Manchester city centre. He had a house in Moss Side, claimed benefits and was preying on genuinely homeless people to make more money selling Spice...	10
		So many homeless in Manchester it's like a scene from the Walkingdead	11

		I'd like to use #nationalnorthernauthorsday to mention my debut novel seeking representation! It's about homelessness and the spice epidemic set in Manchester in 2010 before the protagonist goes travelling across Europe and winds up in trouble across the Syrian border.	12
		In Northern mill towns culture has changed completely. Life used to be work, drink, football. Now it's County lines, spice, grooming gangs Where did I mention the EU? However food banks, homelessness, and M***** migrants added to apartheid was just too many straws.	13

Table 10. Quotations of the social issues associated with Spice use

Sub-theme	Quote	TN
Very high prevalence of Spice use among homeless population	One of the "homeless" who was put up in the hotel round here for covid has just been evicted for smoking spice in his room and coming out on the street offering everyone a straightener.	1
	no homeless spice zombies like in most places I go to scunny and Lincoln are bad, 630 am people are in the streets drinking special brew	2
	Again it wasnt anything to do with football it was the city rivalry , bin dippers and slumchester but then like I said all the none local glory supporting manc wannabes jumped on board , but all we need to do is go to Manchester center and see the junkies , homeless, spice heads	3
	Looking at that must be another stone roses comeback due looks homeless and on the spice	4
	The city centre is a threat to walk through on a good day. Lots of spice heads, homeless and crazies. Lots of shops closed in key positions and a shambles of a market. It’s a city on its last legs sadly.	5
	then the random spice head homeless man who sat waiting for the bus gasps really loudly and is like "WHAT DO I SEE BEFORE ME?? Is this an angel? what is this beauty... miss! miss! i would just like to thank you for appearing before me today you are an eternal goddess	6
	Is spice "Bath Salts?" Sounds like that guy that went crazy	7

	smoking the stuff in Florida a few years back and ate a homeless guy's face off	
	For those who don't know Manchester, Piccadilly Gardens is traditionally the seat of the homeless and the spice addled. On most days, it looks pretty much the same as it does when there's a BLM protest going on.	8
	First time in the town centre for 2 months and a homeless guy is knocked out on spice. Classic.	9
	Damn drunk homeless goats. And since Disney asked for a season with only the “most essential arcs,” what do you think will happen in next week’s episode that makes this spice running arc essential	10
	The homeless have more complications than it being that simple, they all don’t want help and unfortunately they are not all homeless, yes they really need help but we need to find another option for them than getting wasted on spice and alcohol	11
	Load say it’s shite but it’s a quiet town really , no homeless spice zombies like in most places I go to scunny and Lincoln are bad, 630 am people are in the streets drinking special brew	12
	Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog.. No one else.. Just a cool purple sky and a slither	13
	This was always bullshit. Homelessness was never improved and over the years it's become much,	14

	much worse. I've witnessed fights, strangling's, people defecating on the sidewalk and constant spice smoking. They fudged the numbers, pure and simple.	
	The spice epidemic has completely took over the homeless scene, same in prisons, and it makes people either zombies or dangerous	15
	Decided to walk to Doncaster town centre to meet the Mrs from and pay for our holiday,was like walking through a zombie apocalypse with the amount of homeless,junkies,benefits scroungers. Walk home wasn't much better having to navigate a set of spice heads Firmino kung fu kicking	16
	Here we go another none local , if he was local he would realise that Manchester has the biggest homeless population outside of London, also the biggest spice epidemic outside of London and the biggest crime percentage in the north west but hey glory supporters dont see this	17
	I'd like to use #nationalnorthernauthorsday to mention my debut novel seeking representation! It's about homelessness and the spice epidemic set in Manchester in 2010 before the protagonist goes travelling across Europe and winds up in trouble across the Syrian border.	18
	used to believe that a widespread drug #pandemic (#meth, #spice, #flakka, or something not yet developed and distributed) could lead to mass addiction and homelessness, so much so that public sentiment could be shifted towards "eliminating" the problem via vigilante justice.	19

	says Spice is his drug of choice and that he doesn't use any other drugs	20
	I spoke to 1 girl, I had seen her before, shes bang on Spice (its a drug often smoked or snorted)	21
	J****** says Spice is his drug of choice and that he doesn't use any other drugs.	22
	The first in-depth study of homeless Spice users reveals the drug's harmful effects, yet its popularity continues.	23
	Spice use within the homeless population remains a serious issue. P*** G***, R** R***** and L*** W***** analyse motivations, harms and the implications for developing a response:	24
	Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog	25
	I'm going to ask the same question every morning Where is Ward 7 testing site for Covid-19? How do we keep out clusters of the homeless and K2 epidemic or rather isolate them and get them tested and in facility where they can recover?	26
	If we're all quarantined, where are all the homeless people going to get their money for drugs? Spice and homelessness is ripe in Bristol, so will they detox...or possibly mug people. What are the withdrawal symptoms? What's to be expected? #homelessness #coronaUK	27

Spice consumed in public areas	drug zombies passed out on the circle after the spice is delivered and the city closing homeless services are.	1
	A big problem why they may walk by is to do with the drugs. The spice epidemic has completely took over the homeless scene, same in prisons, and it makes people either zombies or dangerous. They refuse help, it such a hard thing to solve, but like you I wish it didn't exist.	2
	Lots of drug addicts, and people that smoke spice, and break down, their muscles lock up and paralyze them for about 10 mins.	3
	Decided to walk to Doncaster town centre to meet the Mrs from and pay for our holiday,was like walking through a zombie apocalypse with the amount of homeless,junkies, benefits scroungers. Walk home wasn't much better having to navigate a set of spice heads Firmino kung fu kicking	4
	Load say it's shite but it's a quiet town really , no homeless spice zombies like in most places I go to scunny and Lincoln are bad, 630 am people are in the streets drinking special brew	5
	So many homeless in Manchester it's like a scene from the Walkingdead	6

	they really need help but we need to find another option for them than getting wasted on spice and alcohol	7
	Homeless people like to smoke spice ect. they don't like to tidy up either so they get kicked out and that's why they're there, not all of them but most of them.	8
	The man doesn’t have any belongings with him so I very much doubt he’s sleeping rough. More like begging. I reckon he’s on heroin or spice. It’s morally wrong for you to be taking photos of people without their knowledge and consent, and profiting by selling them	9
	These are the same middle class snobs who petition their local councils to prevent social housing being built near their homes and step over the homeless vet sleeping on the street, or judge the young spice addict sleeping rough due to severe mental health issues.	10
	I'M ACTUALLY LOOKING FORWARD TO BEING IN THE HOMELESS CAMP WITH SOME NON COWARDS.. AND HAVE SOMEONE TO TALK TO...CAN'T WAIT....I'LL FIND SOME FENTANYL IN THAT MOTHER!WHY DO YALL STAY DRIVING BY..AND NOT STOP..O YA RACIST!! YALL ALREADY GOT A PIC OF ME WHAT U WANNA U?? THAT IS DUM	11
	one time i met a homeless man on the train who told me he supplements his grin addiction by smoking k2 all day and that’s ok because it’s not illegal	12
	Somebody needs to educate you about the difference	13

	between people who sleep rough and people with flats out of it on spice	
	And the majority would rather smoke spice than get a job is the reality, there is a bed for almost every homeless person but no beer or drugs.....always a choice	14
	some spice this homeless guy gave me.	15
	next thing i know a homeless man comes up to me and offers me spice, in which i said no to	16
	The peaceful and older homeless seeking shelter and safety has also been happening here in Manchester too in recent months, they are scared witless of what is going on with others in the city centre with spice and other drugs	17
	I'm sure the hobos are sharing their K2 blunts (and COVID) right as I type. They'll just end up in the ARCH and spread it like wildfire later.	18
	Labour council will build a new library, but shut down family centres, they build a new council building whilst drugs, spice and homelessness frequents the town centre and beyond. The centre is shocking on a Saturday, i feel unsafe.	19

Table 12. Quotations of services provided to homeless Spice users

Sub-theme	Quote	TN
General public use podcast to broadcast issues regarding spice among the homeless	Listen to myself and Mmu talking about Spice use within the homeless population in Manchester	1
	Spice use within the homeless population remains a serious issue. P*** G***, R** R**** and L*** W******* analyse motivations, harms and the implications for developing a response:	2
	Did you know the transcript for our #RAH_Podcast episode on #Homelessness and #Spice has now been released? Read along to discussion of the complex problem of homelessness and #druguse in the community:	3
	Take a lazy Sunday and check out our #RAH_Podcast! Our latest full-length episodes have covered topics such as #Homelessness and #Spice, #GranadaTV and #Writing about #Love and #Sex	4
	Click the link below to listen to the latest episodes of our #RAH_Podcast. Topics covered recently have included #PlaceWriting #BadReligion and #Homelessness and #Spice Have a scroll through and see what peaks your interest!	5
	I've also sent him one called "the spice boys" which sounds good a true story about some Manchester lads who are	6

	homeless and addicted to spice	
Government failed in reducing Spice consumption	These numbers won't persist. My point was we had a pandemic with the opioid and Spice abuse and we did nothing except give our first responders Narcan to revive the addicted. A decade of neglect cost the lives of 500k and a homelessness crisis.	1
	We gonna have the CITY HALL AREA LOOKING LIKE MYRTLE AND BROADWAY FROM MAY- OCTOBER WIT ALL THE STILL ALIVE HOMELESS K2 SMOKERS WATCH THIS SHIT U U SHOULD OF JUST HUNG US U FUCKIN SLAVE OWNER GET YA FREE K2 OR THEY GIVIN OUT FREE K2 IN THE CITY HALL AREA #ALLSUMMER2020	2
	I'm sure the hobos are sharing their K2 blunts (and COVID) right as I type. They'll just end up in the ARCH and spread it like wildfire later. Funny how homeless shelters aren't closed…	3
	NYGovC**** NYCMayor Thats the homeless or the K2 addicts doing that. And if more people like you rode the M or J trains they'd be much cleaner than they are now.	4
	The homeless have more complications than it being that simple, they all don't want help and unfortunately they are not all homeless, yes they really need help but we need to find another	5

	option for them than getting wasted on spice and alcohol	
	Be helpful to try to do something about the homeless and the spice heads	6
	Can you call a meeting to make it so people feel safe I their own city centre. We have a town centre full of open visible drug dealing and packs of homeless people and spice heads. Nothing has been done to sort this problem and it is just getting worse and worse constantly	7
	big cities. That's always where you will see more homeless. Fl. and Ca. are warm states. I live in FL,a red state, and there are plenty of homeless. Lots of drug addicts, and people that smoke spice, and break down, their muscles lock up and paralyze them for about 10 mins.	8
	If this poor lad high on spice, homeless (he said) and desperate, had been given the right support then this wouldn't have happened He left when I said no after his threat but I feel sorry for him	9
	agree, some great bars but walking between them past the homeless, spice heads, mouthy mancs and building sites just ruins the whole thing.	10
	Nothing Manifest has said is untrue, lived in Birmingham Centre since I was born. We need to be honest and admit	11

	their is a problem with the youth culture and homelessness / spice addicts in the city centre - a blind man could see these issues.	
	Doncaster council is fab #donnygate. 10 plus councillors charged with fraud related offences, mayor gives Mike Ashley rate relief of 125k on one of his designer shops.Drugs, homelessness, spice, pickpocketing, all rampant. Streets are dirty, and wastes cash on vanity projects	12
	The city centre is a threat to walk through on a good day. Lots of spice heads, homeless and crazies. Lots of shops closed in key positions and a shambles of a market. It's a city on its last legs sadly.	13
	These are the same middle class snobs who petition their local councils to prevent social housing being built near their homes and step over the homeless vet sleeping on the street, or judge the young spice addict sleeping rough due to severe mental health issues.	14
Spice consumption among homeless linked with an increase in crime	Jailing him for 18 months and banning him from Chester city centre for three years,	1
	officers have arrested a male for dealing Spice to the homeless community	2

	Jailing him for 18 months and banning him from Chester city centre for three years, Judge S**** E**** said he had "no doubt" W**** L***** was selling spice to vulnerable members of the homeless community	3
	Neighbourhood Tasking Team officers have arrested a male for dealing Spice to the homeless community on The Strand today. We are still out patrolling the streets night and day.	4
	Spoke to a homeless chap this morning and he pointed out a favourite hiding spot for a spice dealer and his stash. It's not their now. 22 packets of misery now in safe custody and awaiting destruction. Thank you.	5
	M***** been going around Cardiff Chinese burning people. Apparently there's a 1 arm homeless man on spice who was undercover and that's how they caught him.	6
	You may be right. But I started the Crisis Intervention Team when I was mayor, where SLC police were trained to recognise and deal with mental illness. I called police when a homeless friend violently reacted to Spice and the CIT responding officer was terrific, got him med help.	7
	Those poor shops get robbed constantly. Homeless is on spice or PcP	8
	Spice and homelessness is ripe in Bristol, so will they detox...or	9

	possibly mug people? What are the withdrawal symptoms? What's to be expected? #homelessness #coronaUK	
	Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog	10
	It is so embarrassing when I see tourists coming off the train in Piccadilly station and then being welcomed to Manchester with the homeless and drug addicts littering the streets around the station and Piccadilly gardens with the stench of spice in the air.	11
	Corner of main and 100 s. is packed with homeless on drugs. From my office I watch drugs deals, them smoke meth and spice all day and fight. predominantly Caucasian for sure	12
	Just got back from the freakiest walk.. Cardiff Friday night... 8 homeless people in the whole of the city centre... Off it on spice with a terrifying looking dog	13
	I'll bring kratom and some spice this homeless guy gave me. He said he stole from the Indian mart where they let him sweep up trash	14
	One of the "homeless" who was put up in the hotel round here for covid has just been evicted for smoking spice in his room and coming out on the street offering everyone a straightener.	15

	So was walking back from the shop earlier and saw a drug deal taking place (probably spice), the buyer looked homeless	16
	Can you call a meeting to make it so people feel safe I their own city centre. We have a town centre full of open visible drug dealing and packs of homeless people and spice heads. Nothing has been done to sort this problem and it is just getting worse and worse constantly	17
	Corner of main and 100 s. is packed with homeless on drugs. From my office I watch drugs deals, them smoke meth and spice all day and fight. predominantly Caucasian for sure	18
	So was walking back from the shop earlier and saw a drug deal taking place (probably spice), the buyer looked homeless and as soon as he broke away from the dealers spotted me and asked me for change straight away.	19
	It had it's fair share of problems too - but nowhere near the level there now thanks to the Berlin Wall and the Cafe Nero bit giving all the friggin' 'dealers' a nice hidey-hole while they flog Spice to the homeless...Even the strongest weed ever wouldn't cause the probs Spice is	20
Spice use increases the rate of hospitalisation in the	there's little to be done, apart from arrest those who attack the public, or for the police to move them on and destroy	1

homeless population	their camps, and belongings. There are fewer this year from the number of homeless addicts who have accidentally overdosed on Spice, or even Carfentanyl.	
	Tackle Spice use among the homeless by prioritising improved services addressing mental health needs and access to detox and rehabilitation argues @MMU_	2
	took me a minute to remember, but this guy was in rehab with me! His drugs of choice were Meth and Spice. He graduated the 6 month program, relapsed, and this is the result. Clearly there were other issues here, but I know the drugs played a big part. #Meth #spice	3
	I spoke to 1 girl, I had seen her before, shes bang on Spice (its a drug often smoked or snorted)	4
	These are the same middle class snobs who petition their local councils to prevent social housing being built near their homes and step over the homeless vet sleeping on the street, or judge the young spice addict sleeping rough due to severe mental health issues.	5
	Tackle Spice use among the homeless by prioritising improved services addressing mental health needs	6
	The homeless have more complications than it being that simple, they all don't want help and unfortunately they are not	7

all homeless, yes they really need help but we need to find another option for them than getting wasted on spice and alcohol	
dealers' a nice hidey-hole while they flog Spice to the homeless… Even the strongest weed ever wouldn't cause the probs Spice is	8
He goes on to say Spice is a drug no one can handle	9
You may be right. But I started the Crisis Intervention Team when I was mayor, where SLC police were trained to recognise and deal with mental illness. I called police when a homeless friend violently reacted to Spice and the CIT responding officer was terrific, got him med help	10
There are panhandling homeless on every block now. Many more people on the streets are buying $2 joints of 'spice'. Whatever the f*** that shit is, it is rotting brains.	11
Synthetic marijuana. I work with the homeless and I see this a lot	12
Letting the homeless in is a bit of a stretch, they'd all smoke spice and piss up the walls but should defo be being put to use, housing nhs workers who've come into contact with infected and don't wanna go to their family with it.	13
rather isolate them and get them tested and in facility where they can recover?	14
The coronavirus pandemic will affect those experiencing homelessness and we are not prepared for that	15
THE CURE FOR COVID 19 IS PYRETHRIN, AN INSECTICIDE. IT IS FOUND IN K2 OR SPICE AND WHEN INGESTED, IT PREVENTS ITS ABILITY TO	16

	REPLICATE. YOUR HOMELESS, MOST VULNERABLE WERE LEAST AFFECTED DUE TO HIGH USE OF K2 IN THAT COMMUNITY.	
	if we're all quarantined, where are all the homeless people going to get their money for drugs? Spice and homelessness is ripe in Bristol, so will they detox...or possibly mug people? What are the withdrawal symptoms? What's to be expected?	17