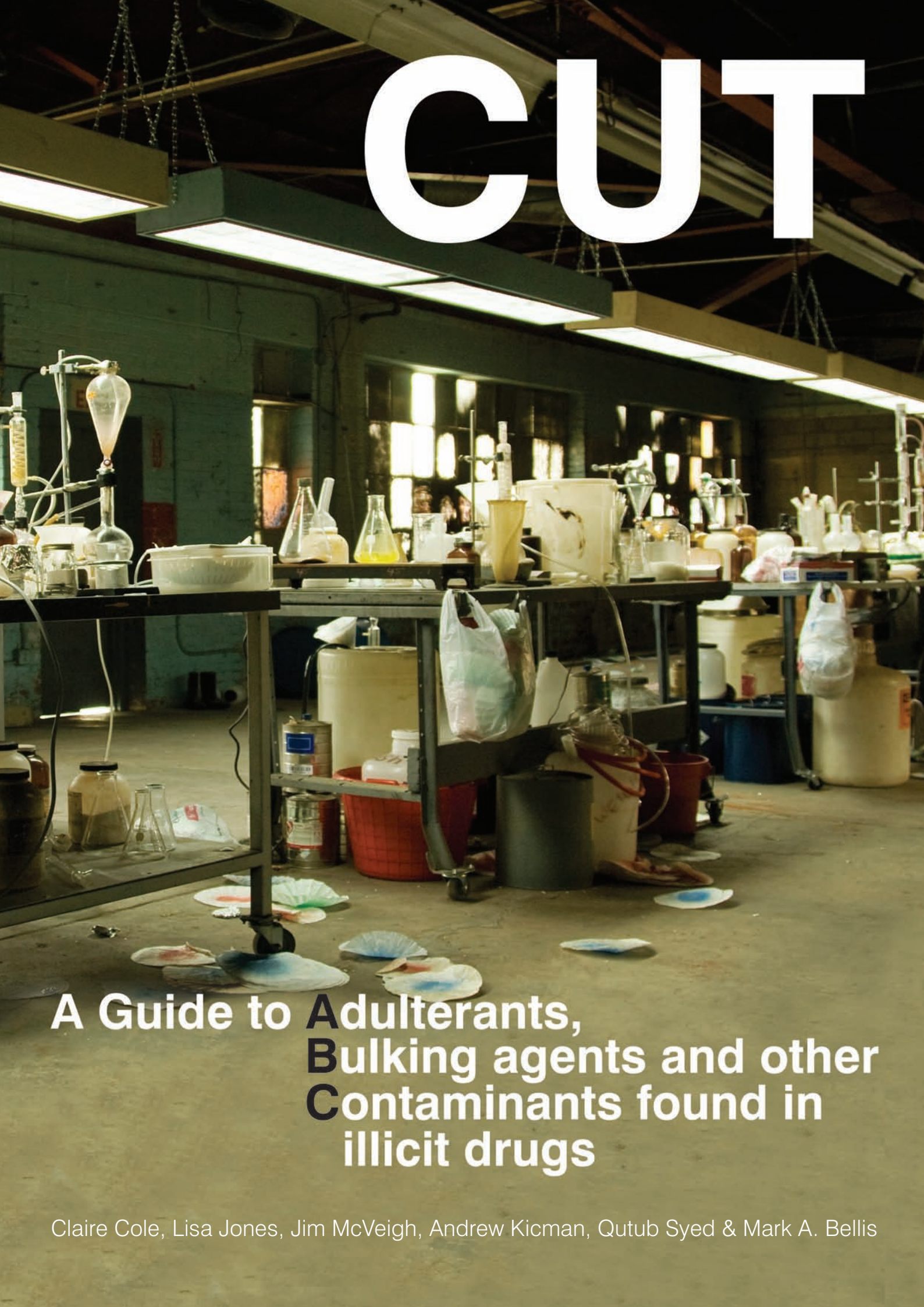

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A Guide to Adulterants, Bulking agents and other Contaminants found in illicit drugs

Claire Cole, Lisa Jones, Jim McVeigh, Andrew Kicman, Qutub Syed & Mark A. Bellis

Acknowledgements

The authors would like to thank the following for their contribution to the literature searching, design, proofing, editing and distribution of this document: Carol Chadwick. Sian Connolly, Layla English, Michael Evans-Brown, Dave Seddon, Olivia Wooding, Lee Tisdall, Ellie McCoy and Gemma Parry of the Centre for Public Health. We would also like to thank the International Harm Reduction Association (IHRA) for their support with launching this report at their 2010 conference.

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Terminology

Box 1: Report terminology

There are a number of terms which are used to describe the additional elements of illicit substances. The three most commonly used terms are[1]:

Contaminants	Refers to by-products of the manufacturing process
Adulterants	Refers to pharmacologically active ingredients added to give either synergistic or antagonistic effects
Diluents	Refers to the inert substances added to illicit drugs to bulk out the drug and therefore decrease the amount of active ingredient

For the purpose of this report contaminants, adulterants and diluents are all referred to as 'adulterants'. Whilst it is shown above that these terms do have differences they share the common feature that they are all additional substances within illicit drugs either intentionally added or synthesised as a result of production and/or distribution.

Key terms

Below are a number of key terms used throughout this report. Additional terms, abbreviations and definitions can be found in the glossary in Appendix 1.

Alkaloids – Any nitrogenous base compound with one or more of the following features: a heterocyclic compound containing nitrogen, an alkaline pH or a marked physiological action on animal physiology. Alkaloids may be organic (from plants) or synthesised.

Amine – Nitrogen-containing organic compounds.

Atomic absorption spectroscopy – Technique for detecting and quantifying metals, such as lead.

Gas chromatography (GC) – A very powerful separation technique for analysing organic volatile compounds.

Gas chromatography-mass spectrometry (GC-MS) – Combination method of the features of gas-liquid chromatography and mass spectrometry. Commonly used in drug detection, this is a gold standard technique for identifying different organic substances within a test sample, as it combines specificity with analytical sensitivity. The data generated can be likened to a chemical fingerprint.

High performance liquid chromatography (HPLC) – A powerful separation technique that can be used for both volatile and non-volatile organic compounds. Detection utilises visible/UV light or by an electrochemical system.

Infra-red spectroscopy - Can be used to help investigate sample composition including, for example, a drug mixed with a sugar.

Mass spectrometry (MS) – Technique for identification of the composition of a sample.

Thin-layer chromatography (TLC) – Technique used to separate and help identify compounds in mixtures. It lacks the resolving power but it can also be applied to non-volatile compounds, such as sugars.

[1] Definitions have been developed from those published in Hamilton et al. (2000).

Executive Summary

Background

Historically, and more recently, it has been a common perception that illicit drugs typically contain other substances in addition to the purported active ingredient that can have serious adverse health consequences or even cause premature death. The reasons for inclusion of additional elements in illicit drugs are often varied and not always intentional by the manufacturer. Additional substances may be added to bulk, dilute, complement or enhance the effects of the drugs. Other adulterants are the result of manufacturing, production or storage techniques, for example alkaloids, microorganisms or other biological and infectious agents. ***This document is an evidence-based overview of adulterants (here, any substance or organism found in illicit drugs at the point of purchase other than the active ingredient[2]), their effects on health and the development of messages and other public health interventions to reduce their impact.***

Adverse reactions to illicitly manufactured drugs are increased by variability in dosage, composition and purity. Many illicit drugs can be synthesised using a number of methods, with many manufacturers also clandestinely manufacturing precursors and therefore adding another unknown element. The illicit drug manufacture process itself may create by-products which adulterate the final product, and the method of manufacturing employed will affect the final composition. The quality of the drug produced is highly dependent upon the skills and abilities of the producer combined with a range of other issues including, the resources available, production environment, distribution infrastructure and varied market and enforcement factors. The variation in substances used to adulterate illicit drugs contributes to the unpredictability of the drug's effects, including the potential for unknown or unexpected synergistic reactions, and health related consequences.

Forensic evidence of adulteration of illicit drugs

Less adulteration than is anecdotally perceived by drug users and dealers actually takes place and stories of illicit drugs cut with household cleaning products, brick dust and ground glass are often inaccurate. However, adulterants are routinely found in illicit drugs. The evidence suggests that illicit drugs are more commonly adulterated with benign substances (such as sugars), substances that will enhance or mimic the effects of illicit drugs (such as quinine in heroin) or substances that will facilitate the administration of the illicit drug (such as caffeine in heroin and cocaine to facilitate smoking). A summary of the published evidence of drug adulterants found in multiple samples of illicit drugs is presented in Table 1. This table provides the potential reasons for inclusion and health effects of the most common adulterants that have been purposefully added or result from manufacture, storage or distribution.

[2] Illicit drugs are often adulterated by the drug user during preparation for administration (such as adding citric acid to heroin for injection). This report does not include adulteration or contamination after the point of purchase by the drug user.

Table 1: Summary of drug adulteration evidence

Drug	Adulterant(s)	Licit use	Potential reason for presence as adulterant	Public health risks	Health consequences
Illicit Drugs	Sucrose Lactose Dextrose Mannitol	Sugars	To dilute/add bulk. Legally and readily available.	Inactive adulterants.	Minimal risk of adverse health effects. Can cause nasal irritation.
	Lead	Soft, malleable metal	**Heroin** Potentially a by-product of the use of lead pots in illicit drug manufacture. **Methamphetamine** Sometimes used in methamphetamine manufacture. Poor manufacturing can result in lead residue in drug product.	In low dosages lead poisoning can have mild effects. Injecting of illicit drugs adulterated with lead causes severe adverse health effects.	• Abdominal pain and cramping • Headaches • Anaemia • Dizziness • Nausea/vomiting • Muscle weakness • Seizures • Coma • Renal injury • CNS damage
	Caffeine	Psychoactive stimulant drug	Caffeine is legal, cheap and more readily available than illicit drugs. **Heroin** Vaporizes heroin at lower temperature when smoked - slightly increases efficiency. **Cocaine/Amphetamine/ Methamphetamine/Ecstasy** Stimulant properties of caffeine can create similar, although usually milder, effects to the primary drug.	In small doses there are few serious health repercussions. Moderate to large doses can cause considerable harms.	• Mood disturbances • Induce anxiety • Addictive • Sleep disturbance • Increases risk of a range of health problems
	Procaine	Local anaesthetic	**Heroin** Facilitates smoking of heroin and may relieve the pain of intravenous injection due to anaesthetic properties. **Cocaine** Similar anaesthetic and subjective effects as cocaine.	Risk of toxicity at high doses.	• CNS problems • Nausea • Vomiting • Dizziness • Tremors • Convulsions • Anxiety
	Paracetamol/ Acetaminophen[3]	Over-the-counter pain relief medication	Easily available, relatively cheap. **Heroin** Analgesic effects and bitter taste of paracetamol may disguise poor quality heroin. May be used because it has similar melting point to heroin.	Low dosages should have minimal impact. Risk of toxicity at high doses.	• Liver damage • Gastro-intestinal effects • Adverse effects when mixed with alcohol
	Strychnine	Pesticide	A fine motor stimulant. Low doses act as a muscle stimulant. **Heroin** Enhances retention of heroin when volatized. Has only been found at non-life threatening quantities. **Cocaine** Reason for inclusion unknown. May have been unintentional.	Whilst it has only been reported in non life threatening quantities, small increases could potentially be fatal.	• Muscle spasm • Opisthotonos (holding of body in awkward rigid position)

Table 1: Continued

Drug	Adulterant(s)	Licit use	Potential reason for presence as adulterant	Public health risks	Health consequences
Heroin	Phenobarbital	Barbiturate	Psychoactive drug which facilitates smoking of heroin.	Risk of overdose in IV users who are hypersensitive.	• Overdose • Death
	Quinine	Antimalarial medication	Bitter taste similar to heroin and may be used as a diluent. Also mimics the respiratory 'rush' felt by injecting heroin users shortly after administration.	Can cause overdose and a host of other adverse health reactions.	• Acute renal failure • Cinchonism • Gastric disturbances • Thrombosis and hypotension (IV use) • CNS overstimulation • Visual disturbances (blindness) • Death
	Clenbuterol	Asthma decongestant and bronchodilator drug[4]	Reason for inclusion unknown but may have been unintentional contamination.	Can cause overdose and poisoning at moderate to high dosages. Low doses typically cause adverse cardiovascular effects.	• Cardiovascular effects • Neuromuscular syndrome • Mydriasis (excessive pupil dilation) • Agitation
	Scopolamine	Anticholinergic alkaloid	Colourless, odourless and tasteless and therefore not easily detectable.	Low doses cause sleepiness and drowsiness. High doses can cause euphoria.	• Anticholinergic toxicity • CNS depressant[5]
Cocaine	Lidocaine	Local anaesthetic	Similar, but stronger, anaesthetic effects as cocaine and gives the impression of higher quality cocaine.	Adverse cardiovascular and CNS reactions can occur at low doses. Overdose can occur at excessive doses. Increases the toxicity of cocaine.	• CNS problems • Nausea • Vomiting • Dizziness • Tremors • Convulsions
	Hydroxyzine	Sedative, anxiolytic, used as an antihistamine	Unknown, but potentially used in the final processing stages of cocaine manufacturing.	Use in combination with sedative drugs can cause unconsciousness. Rare cases of overdose resulting in CNS problems.	• Dizziness • Drowsiness • Gastro-intestinal effects • Tinnitus • Headaches
	Phenacetin	Analgesic substance	Pain relieving properties and similar physical properties to cocaine.	Phenacetin is banned in many countries due to links with renal failure and suspected carcinogenicity.	• Analgesic nephropathy • Haemolytic anaemia • Methaemoglobinaemia • Kidney cancer • Bladder cancer
	Levamisole	An anthelmintic medication (used for expelling parasitic worms)	Unknown, however, it is theorised that it gives a more intense high.	Generally no longer used with humans, but still available as a veterinary medicine. Highly toxic.	• Fever • Agranulocytosis
Methamphetamine	Methylsulfonyl-methane (MSM)	Naturally occuring in some foods and also marketed as a dietary supplement	MSM is readily available and is physically similar to methamphetamine (odourless, white, crystalline powder). Methamphetamine adulterated with MSM creates the impression of high purity methamphetamine[6].	None identified.	None identified.

Table 1: Continued

Drug	Adulterant(s)	Licit use	Potential reason for presence as adulterant	Public health risks	Health consequences
Ecstasy	Dextromethorphan	Antitussive drug (cough suppressant)	A high dose can cause an individual to feel 'high' in a similar way to ecstasy. Dextromethorphan is legal and therefore cheaper and easier to obtain than MDMA[7].	High doses can cause adverse health effects.	• Lethargy • Tachycardia • Ataxia • Nystagmus • Heatstroke
	Amphetamine/ Methamphetamine	Illicit stimulant drugs	Amphetamines have similar properties to the stimulant effects of 'ecstasy' although these adulterants are not entactogens. Amphetamine substances are often sold as, or in combination with, MDMA.	Moderate doses can cause a range of adverse health effects and high doses can cause overdose and death.	• Mood disturbances • Induce anxiety • Addictive • Sleep disturbance • Increases risk of a range of health problems
	Paramethoxymetha-mphetamine (PMMA) and Paramethoxyamphe-tamine (PMA)	Illegal psychoactive chemical	Purposefully added to ecstasy due to stimulant properties.	Relatively unknown, but high dosages have caused death.	
Cannabis	Lead	Soft, malleable metal	To increase weight.	Lead poisoning.	• Abdominal cramps • Anaemia • Nausea • Fatigue • Polyneuropathy • Toxic effects • Seizures • Coma • Death
	Aluminium	Soft, malleable metal	Unknown, but aluminium contamination may have resulted from impure water supply.	Contribute to smoking related diseases.	• Smoking related adverse health effects
	Glass		Unknown, but potentially to improve apparent quality and increase weight[8].	Inhalation of hot glass fumes.	• Sore mouth • Mouth ulcers • Chesty persistent cough • Tight chest

[3] Acetaminophen is the American term for paracetamol.

[4] Clenbuterol is only licensed for use as a medication in some countries.

[5] An anticholinergic toxidrome typically consists of blurred vision; agitation; fever; urinary retention; dry, hot, flushed skin; and dilated pupils.

[6] See: *www.justice.gov/ndic/pubs3/3690/meth.htm*

[7] See: *www.dancesafe.org/documents/druginfo/dxm.php*

[8] *See: www.cas.dh.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=100836*

Bacterial infections and adulterated illicit drugs

Bacterial infections are a common risk associated with illicit drug use, particularly among injecting drug users. Although, the literature presents a wealth of information about drug users who have contracted bacterial infections only a small proportion have been confirmed to be due to drug adulteration, as opposed to unsterile preparation. A summary of bacterial infections either suspected or confirmed to be due to adulterated drugs is presented in Table 2.

Table 2: Summary of common bacterial infections caused by adulterated illicit drugs

Bacterial infection	Public health risks	Health consequences
Bacillus anthracis (anthrax) Bacterium which creates spores which can infect the body through three forms: skin, inhalation or gastrointestinal. Produces lethal poisons and can cause death.	Common public health risks associated with bacterial infection caused by adulterated illicit drugs are cited below. • Cross contamination to other individuals is possible from open wounds. • Contamination of injecting equipment. • Many bacterium survive the heating process common with preparation of heroin for injection.	The health consequences of bacterial infections are relatively common across different bacterial infections and therefore have been listed together below. Most infections can be cured if identified early. • Abscess/inflammation at injecting sites • Respiratory problems • Nausea/vomiting • Tetanus • Septicaemia • Paralysis* • Botulism* • Gas gangrene • Death *Paralysis and botulism are most commonly associated with *Clostridium botulinum*.
Bacillus cereus Soil-dwelling bacteria.		
Clostridium botulinum Anaerobic, spore-forming bacterium.		
Clostridium novyi Anaerobic, spore-forming bacterium.		
Clostridium sordellii Rare anaerobic bacterium.		
Necrotizing fasciitis Deep soft tissue infection.		

Summary of evidence relating to drug adulteration from case study reports

The evidence identified from case reports illustrates that adverse health effects or deaths due to adulterated drugs are commonly due to poisoning, poor manufacturing techniques, poor storage or packaging, or related to the effects of other substances sold as the illicit drug (for example, paramethoxymethamphetamine (PMMA) and/or paramethoxyamphetamine (PMA) sold as ecstasy). Bacterial infections attributed to illicit drug adulteration were most common amongst injecting drug users (particularly heroin and cocaine injectors).

Heroin

Case reports of heroin adulteration mostly detail poisonings or bacterial infections. Multiple cases of poisoning by lead, scopolamine and clenbuterol are reported. Bacterial infections are most common amongst injecting heroin users, suggesting that the chosen route of administration of heroin increases the risk of bacterial infection (See Table 2 for details of common bacterial infections).

Cocaine/crack cocaine

The majority of case reports of cocaine/crack cocaine adulteration detail poisonings. The adulterant responsible for poisonings was different in almost all case reports, these included: phenacetin, thallium, benzocaine, scopolamine, strychnine, levamisole and anticholinergic poisoning.

Amphetamine/methamphetamine

All case studies identified refer to methamphetamine. Two cases discuss poisoning as a consequence of methamphetamine adulterated with lead, in both cases the individuals administered the drug intravenously, and another details poisoning of methamphetamine manufacturers by toxic fumes. One report identifies pulmonary granulomas (lung tissue infection) due to methamphetamine adulterated with talcum powder.

Ecstasy

Two case reports detail the deaths of ecstasy users due to consumption of tablets adulterated with PMMA and/or PMA.

Public health response and harm reduction

Illicit drug adulteration is typically brought to the attention of health or drug services as the result of a disproportionate number of drug users becoming ill or presenting to hospital with atypical drug effects. The public health response to this issue should aim to provide accurate and useful information to all relevant parties. A typical response should include an immediate response, specific response, dissemination of information, treatment and, debrief and review. When adverse health effects and/or fatalities due to drug adulteration are suspected an immediate response from health agencies and organisations is required to manage risk and minimise harm, this should be followed by more specific information targeted at the most vulnerable populations when the adulterant has been identified/confirmed. Information should include signs of adverse reactions, actions to be taken by drug user and family/friends, general public, treatment services and professionals. Dissemination of information should take place through a variety of means (media, drug treatment agencies, peer networks). Once the adulteration incident is considered under control a thorough review process should be undertaken and considerations for future public health responses considered.

In addition to the protocols for responding to health issues due to illicit drug adulteration, harm reduction messages regarding illicit drug adulteration should regularly be provided to drug users (including in the absence of an adulteration incident). All agencies involved should be aware of the potential for, the effects of, and most effective response to drug adulteration.

Conclusions

Illicit drugs are commonly adulterated purposefully with benign substances (such as sugars), substances that will enhance or mimic the effects of the illicit drug (such as procaine in cocaine) or substances that will facilitate the administration of illicit drugs (such as caffeine in heroin). By-products, bacteria or other biological agents can also adulterate illicit drugs due to poor or unsterile manufacturing and production techniques, substandard packaging and inappropriate storage.

A lack of standardised analyses, reporting or detailed reporting, creates difficulties in comparing adulteration practices over time and by country. The majority of analysis techniques identify which additional substances are present in samples of illicit drugs but do not report on the overall composition of the drug and the proportions of adulterants found. Also, it is not standard practice to report the percentage of samples which contain no adulteration. Both of these pieces of information would provide further useful information about adulteration practices and the threats they represent to public health.

Whilst many countries routinely collect data about the adulteration of illicit drug samples seized in their country, much of this data is not routinely reported. An early warning system to identify adulterants and report adverse effects rapidly would enhance understanding of, and public health responses to, illicit drug adulteration. Additionally, a quality assured and robust guide of interventions and communication strategies related to incidences of illicit drug adulteration would provide guidance and create shared protocols for public health responses.

Box 2: Future considerations – summary

- Improved surveillance of illicit drug adulteration could dispel myths and ensure timely medical treatment and prevention is implemented where necessary
- A set of quality assured, robust and rehearsed interventions and information dissemination strategies would enhance public health and the quality and effectiveness of responses to illicit drug adulteration incidents
- Research into the usefulness of media warnings about adulteration of illicit drugs is required
- Drug users should be made aware of the relative and inherent risks associated with drug use and the potential health effects that may arise from adulteration
- Hospital emergency staff should be appropriately trained and equipped to respond to adverse health effects suspected to be caused by adulteration of illicit drugs
- Advice should be provided to those working with drug users about the risks of cross-contamination and infection from coming into contact with adulterated drugs and users of adulterated drugs, and the steps they can take to protect themselves (for example in cases of anthrax contaminated heroin or the manufacture of methamphetamine)

1. Introduction

This document:

1. Examines evidence of adulterants present in illicit drugs using a systematic methodology;
2. Investigates the public health consequences of illicit drug adulteration; and
3. Discusses public health responses and harm reduction messages.

In order to do this the document focuses on:

- Substances added to adulterate illicit drugs at production or any other stage of the distribution chain.
- Contamination as a result of the production, storage, transportation or preparation of illicit drugs (either purposefully or inadvertently).

1.1 Background

Historically, and more recently, it has been a common perception that illicit drugs typically contain other substances in addition to the purported active ingredient which can have serious adverse health consequences or even cause premature death. In 1854 it was reported that only one of 32 samples of powdered opium contained no additional adulteration, the drug was most commonly adulterated with poppy capsule, wheat flour and extraneous woody fibre (The Analytical Sanitary Commission, 1854). A review of opium use in the nineteenth century found that 'foreign substances' (Berridge, 1978; p. 445) were often added to opium pre and post-importation into the United Kingdom (UK). A report on case studies of heroin users commented that the heroin had been 'cut some six or seven times when it reaches the pusher' (Richter & Rosenberg, 1968; p. 1256) with additional substances progressively added after this stage also. Analysis of the stages of distribution of heroin in New York found that a bag of heroin bought on the street in a small quantity was adulterated approximately 24 times (Preble & Casey, 1969) and white powder heroin and cocaine was frequently cut with a variety of other substances (Perry, 1975).

The reasons for inclusion of additional elements in illicit drugs are often varied and not always intentional by the manufacturer. Additional substances may be added to bulk, dilute, complement or enhance the effects of the drugs. Other additional elements are the result of manufacturing, production or storage techniques, for example alkaloids, microorganisms or other biological agents. A review of forensic literature relating to drug 'impurities' identified 48 additives reported in analyses of cocaine (35 pharmacologically active additives, nine inert additives and four volatile compounds) and 60 in heroin (five alkaloids, 33 pharmacologically active additives, 13 inert additives and nine volatile compounds) (Shesser, Jotte & Olshaker, 1991).

Suggestions for cutting substances made by drug dealers, drug users and the general public include mannitol, sugars, gravy powder, chalk, codeine, rat poison, ground glass, household cleaning products and brick dust (Best et al., 2004; Coomber, 1997c, 1997e, 1999). Research has shown that much less adulteration than is anecdotally perceived by drug users and dealers actually takes place and stories of illicit drugs cut with household cleaning products, brick dust and ground glass are inaccurate and potentially created to explain overdose and death amongst drug users (Coomber, 1997c, 1997d). Research has also shown that benign adulteration practices (meaning adulteration with non-harmful substances such as sugars or caffeine) are similar in UK, USA, Canada and Australia (Coomber, 1997c, 1997d; Coomber & Maher, 2006). There are hundreds of examples in the UK alone of media warnings about 'dirty' drugs, 'bad' heroin, 'rogue' heroin or illicit drugs 'cut' with other illicit drugs. Whilst these warnings, which are usually issued from the police to the media, may have usefulness in deterring and informing drug users, they are not evidence-based. In fact, it has been argued that a 'bad' batch of heroin may be more likely to be an unusually pure batch of heroin (Coomber, 2006) with accidental overdoses usually being caused by heroin of stronger purity than expected (Man et al., 2004). Additionally, overdose may be related to the specific circumstances of the drug's use, such as psychological factors, reduced tolerance or polypharmacology.

The stereotypical view of the drug dealer as an evil individual lacing drugs with poisons can be inaccurate, as it does not make good business sense for the drug dealer to poison their clients, therefore cutting off their income supply or ruining their reputation (Coomber, 1997d, 2006). Thus, the drug dealer can be seen as a business person who wants to make the most profit from their substance and is unlikely to add substances such as brick dust, ground glass or bleach to their drugs as they survive on repeat custom (Coomber, 1997c, 2006; Coomber & Maher, 2006; Strang and King, 1996). However in order to enhance profit they are more likely to 'skim' the drugs as they divide them into smaller amounts (i.e. sell slightly underweight amounts) or add substances which complement or enhance the effects of the drug for the users – for example adding substances to heroin which will enhance or prolong its analgesic properties such as over-the-counter pain relief medication. In-depth discussion about the myths and perceptions of drug adulteration is covered elsewhere (see Coomber, 1997a, 1997b, 1997c, 1997d, 1997e, 1999, 2006).

Where cases are reported of death or serious illness due to adulterated drugs it is typical for that country's government departments to circulate information, advice and guidance for drug users and all relevant health professionals. Examples include information and guidance issued from the National Drug Intelligence Center (NDIC) in the USA regarding heroin and cocaine adulterated with fentanyl (National Drug Intelligence Center, 2006) and from the Chief Medical Officer in Scotland regarding an outbreak of anthrax contaminated heroin (Burns, 2010).

All elements of the production, distribution and preparation for use of illicit drugs are confounded by their illegal status, making quality assurance, sterile production and accurate dosage administration impossible. This in turn is a barrier to controlled analysis of samples of illicit drugs, analysis of production techniques and changes over time and also of access to hospital and health services for those suffering adverse consequences of illicit drug use. There are public health effects of the lack of quality control of illicit drug manufacturing and distribution. Drug sellers and users can only make inadequate assessment of the quality, purity and chemical composition of any drugs they buy or use (Reuter & Caulkins, 2004). It is important also to consider that substances used to adulterate drugs may also have been made in clandestine laboratories and may be adulterated also, for example clandestinely manufactured fentanyl has been found in heroin (Behrman, 2008).

There are also reports of 'double' or 'two-tier' markets within illicit drug selling where some dealers will sell two or more different 'qualities' of a drug and which one they sell to an individual may depend on a number of factors, such as: the person's status; the amount they are willing to pay; the environment in which the sale takes place (i.e. home deliveries or selling in a pub); or customer preference (if the dealer is open about the differences) (Coomber & Maher, 2006; Davies et al., 2009; Furst, 2000).

Precursors

Precursors refer to ingredients used in the process of manufacturing a raw drug ingredient into an illicit substance. The International Narcotics Control Board produces regularly updated lists of precursors and chemicals used in the production of illicit drugs[9] and there is an international effort to prevent diversion of these substances for licit uses to clandestine illicit drug manufacturing laboratories. As a consequence the illicit manufacture of precursors has become more common (Burton, 1991). Investigation of the role of, quantity or quality of precursors is not specifically included in this report although they may be mentioned in forensic analysis. Additionally precursors may be more prominent in the manufacture and sale of substances which are not the focus of this report, for example anabolic steroids where precursor chemicals are often sold as drugs.

1.2 Format of report

This document has been produced to provide a user friendly guide to illicit drug adulteration for policy makers, academics, practitioners, those delivering drug treatment and drug users. The report includes:

- Introduction and background to production and purity of illicit drugs;
- Review of evidence of illicit drug adulteration (forensic analysis and case reports);
- Public health consequences and harm reduction messages; and
- Summary and future considerations.

[9] See: *www.incb.org/incb/en/precursors-2008.html* for the most recent lists.

1.3 Brief modern history of illicit drug adulteration

Adulterants typically present in illicit drugs have changed over time. These changes are due to availability of other substances, inclusion of substances as enhancements and due to customer preference for a particular combination of active ingredient and adulterants. This section details a brief summary of the changing patterns of adulteration from the late 1960s onwards*. It is important to note that this analysis is based only on the reporting of adulteration as detailed in this report and does not account for poor reporting or incomplete analysis techniques.

	1960s	1970s	1980s	1990s	2000s
Cannabis					Reports of cannabis adulterated with lead, aluminium and glass.
Ecstasy				Caffeine, amphetamine and other MDMA analogues identified as common adulterants.	
Methamphetamine			Cases of lead poisoning reported in Oregon, USA.		Most common adulterants are caffeine, sugars and dimethyl sulphone (MSM).
Amphetamine			Common adulterants included caffeine, ephedrine and local anaesthetics (e.g. lidocaine and procaine).	Caffeine and sugars are the most common adulterants.	
Cocaine/ Crack Cocaine			Common adulterants included lidocaine and sugars.	Lidocaine and sugars continue to be the most common adulterants. Caffeine also begins to be present in samples.	Lidocaine and caffeine continue to be present. Phenacetin (an analgesic) is also more frequently present.
Heroin	Heroin distributed in Europe until the late 1970s is predominantly white in colour, originating from South East Asia. This heroin consists of heroin and opium alkaloids, the presence of additional adulterating substances being fairly uncommon. Reports of adulteration with substances including caffeine, quinine, sugars (lactose) and mannitol.		Caffeine remains a common adulterant, however, the use of quinine becomes much less common. Procaine and phenobarbital are also commonly present along with paracetamol. Cases of lead-contamiated heroin in Spain and Scotland are reported.	Phenobarbital and procaine less commonly found in heroin. Paracetamol, caffeine and sugars continue to be frequently present.	Reports of heroin contaminated with clenbuterol in the USA. According to the UNODC, heroin synthesised in Afghanistan in 2008 typically contains caffeine, chloroquine (an antimalarial drug), phenolphthalein (a laxative) and paracetamol.

*The review undertaken for this report identified articles relating to illicit drug contamination, adulteration and dilution from the late 1960s onwards. Therefore the brief history detailed refers to this time period and onwards only. However, it is important to recognise that illicit drug contamination, adulteration and dilution took place prior to 1960. For more detail on this issue see Berridge (1978).

2. Methodology

This document examined the adulteration of illicit drugs, including heroin, cocaine, amphetamines, ecstasy, cannabis, ketamine, GHB and LSD[10,11,12,13]. Papers detailing forensic analyses of illicit drug samples and case reports of the adverse health effects or deaths of individuals due to adulterated drugs were sought by reference to published and unpublished sources.

2.1 Retrieval of relevant literature

To ensure the systematic retrieval and collection of relevant peer reviewed literature and case reports, a strategy was developed for searching electronic sources and relevant websites.

Searches of the health and social sciences, and toxicology literature were undertaken in the following databases:

- MEDLINE
- Sociological Abstracts
- TOXLINE
- PsycINFO

Search strategies detailing key terms for inclusion in relevant literature were developed as appropriate to each database platform. There were no restrictions on the year of publication or country of origin, but, only English language papers were selected. Details of the search strategy drug and adulteration terminology is detailed in Box 3 and Box 4.

Box 3: Drug terminology used for selection

- Cannabis (hashish, marijuana)
- Heroin (diamorphine hydrochloride, morphine)
- Ecstasy (N-methyl-3-4-methylenedioxyamphetamine, MDMA)
- Hallucinogens
- Cocaine
- Crack cocaine
- LSD (lysergic acid diethylamide, magic mushrooms, psilocybin)
- Amphetamine (amphetamine sulphate, methamphetamine, crystal meth)
- Ketamine
- GHB (gammahydroxybutrate)

[10] Magic mushrooms (psilocybin) have been excluded from this report as they grow in the wild and are not commonly adulterated.

[11] 'Legal highs' are not included in this report, however it is noteworthy that although these drugs are legal they may also be subject to adulteration or counterfeiting.

[12] Anabolic steroids and other performance-enhancing drugs are not included due to the different target market, population of users, manufacture and distribution processes. These drugs will be examined in a future publication.

[13] This report does not include contamination of equipment for drug preparation or drug administration (such as notes, straws or injecting equipment). There are many different harm reduction initiatives which aim to protect the drug user after the point of purchase of illicit drugs, however, there is little to protect against the consequences of adulteration prior to purchase.

Box 4: Adulteration terminology used for selection

The terms used to search specifically for reference to drug adulteration in peer reviewed journals is detailed below. A list of common terms was compiled from a number of journal articles and other sources which specifically discussed drug adulteration.

- Adulterant
- Contamination
- Poison
- Precursor
- Agent (cut, bulk, dilute)
- Dilution
- Purity
- Manufacture
- Degradation
- Sub-standard

A list of websites which could provide useful grey literature was also compiled. This list included international and national organisations for the control and surveillance of drugs. In addition to searching the grey literature for relevance to drug adulteration, these documents were also used for background to purity and production of illicit drugs. Websites searched for relevant documents are listed in Box 5.

Box 5: Internet sources searched

Specialist drug organisations

- United Nations Office on Drugs and Crime (UNODC)
- International Narcotics Control Board (INCB)
- International Drug Policy Consortium (IDPC)
- The Commission on Narcotic Drugs (CND)
- European Monitoring Centre for Drugs and Drug Addiction (EMCDDA)
- National Institute on Drug Abuse (NIDA)
- International Harm Reduction Association (IHRA)
- National Drug Intelligence Center (NDIC)
- Office of National Drug Control Policy (ONDCP)
- National Drug and Alcohol Research Centre (NDARC)
- Office of Narcotics Review Board, Thailand
- UK Focal Point

Criminal justice organisations

- European Law Enforcement Agency
- Drug Enforcement Administration (DEA)
- Australian Crime Commission (ACC)
- Australian Institute of Criminology (AIC)
- Serious Organised Crime Agency (SOCA)

Health organisations

- World Health Organisation (WHO)
- Centers for Disease Control and Prevention (CDC)
- Ministry of Health, New Zealand
- Trimbos Instituut

Government organisations

- Home Office, UK
- The Scottish Government, Scotland
- Institute for Defence Analyses (IDA)

In addition to the database and web-based searches, the reference lists of articles and documents included after the second review were reviewed to identify any further potentially useful articles.

2.2 Selection and inclusion of studies

All papers were first and second reviewed. Approximately 1,800 peer reviewed articles were included in the first review. This stage used a broad selection criteria where a document was included if there was mention of one of the illicit drugs and details of adulteration including reference to specific adulterants. A total of 1,381 articles were excluded after the first review. The second review further investigated the detail of adulteration provided in each paper and a further 97 articles were excluded. The remaining 322 articles were examined in-depth and primary studies were included. Forensic analysis detailed in this report included, where reported, the country where the analysis took place, year(s) that the data referred to, analysis technique and detail of adulterants. Details of where and when case reports were recorded, summary of findings, analysis of illicit drugs and analysis techniques were reported where available.

Box 6: Data issues

There are a number of important points which the reader should consider regarding typical terminology used and analysis techniques implemented in forensic analysis of illicit drugs.

- A reported drug purity level of, for example, 75% does not necessarily imply that the remaining 25% are adulterants. The remaining 25% may be made up of by-products, alkaloids or other substances as a result of degradation. It is possible for an illicit drug to be only 75% pure at the point of synthesis as a result of the manufacturing process.
- Much of the forensic analysis of illicit drugs is undertaken for legal reasons to prove that a seized substance is an illegal drug. Forensic analysis is an expensive process and therefore it is typical for analysis to only identify the illicit drug and not be concerned with other elements therefore potentially limiting the findings for the purpose of this report.
- Much forensic analysis reporting does not state the percentage of samples of illicit drugs which were not adulterated and contained only the illicit drug.
- The majority of forensic analyses report the number/percentage of samples from a batch in which an adulterant was present (i.e. in 65% of samples caffeine was detected). It is not typical for the analysis to state the concentration of the adulterant in the samples of illicit drugs (e.g. on average the samples contained 25% caffeine).
- Case studies can provide the first line of identification of an issue that requires further investigation. However, case studies are usually based on a small number of individuals and do not control for confounding variables which may significantly influence the results and conclusions drawn. In many cases of drug adulteration samples of the drug are not available for analysis to confirm the presence of the suspected adulterant.

3. Heroin

Heroin is a depressant drug derived from the opium poppy, most commonly distributed in powder form. Heroin can vary in colour from white to beige to brown depending on the country of production and the manufacturing techniques employed. The drug slows mental and physical functioning and reduces an individual's ability to feel pain.

3.1 Purity and production

According to the United Nations Office on Drugs and Crime (UNODC) in 2007 globally there was the potential for 735 tonnes of heroin to be produced (UNODC, 2009). Much of the processing of opium into heroin takes place close to poppy cultivation sites (UNODC, 2009). The vast majority of opium poppy crops are cultivated and heroin manufactured in Asia (mainly Afghanistan, Pakistan, Myanmar and Lao People's Democratic Republic) and, to a much lesser extent, Latin America (mainly Mexico and Columbia). Heroin production does also take place in other countries and in 2007/08, five clandestine heroin laboratories were detected in Australia (ACC, 2009).

The latex of the field poppy, *Papaver somniferum* L., is extracted and purified to produce morphine. Morphine is then synthesised and purified to produce diamorphine (heroin). During the production of heroin a number of other substances are typically used including (but not limited to) ethanol, diethyl ether, concentrated hydrogen chloride, activated charcoal, sodium carbonate, ammonium chloride and acetic anhydride. For detail on the manufacturing process of illicit heroin see Cole (2003) and Zerell, Ahrens and Gerz (2005).

The purity of heroin seized in Thailand in 2005 ranged between 65% to 98% (Poshyachinda et al., 2005), much higher than the purity of brown and white heroin in Europe seized in 2007 which ranged between 15% to 30% and 30% to 50% respectively (EMCDDA, 2009a). Analysis of the purity of heroin seized by police (street purity) in the UK shows that there has been a 10% increase in purity between 2003 and 2008 (from 32.7% to 42.7%) (Davies et al., 2009). Data collected in Australia indicated median heroin purity in 2007/08 of 22%, a rise from the 2006/07 level but a significant decrease from 1999/2000 (ACC, 2009). Heroin purity varied across Australian states and territories in 2007/08 from 13.5% in Queensland to 70% in Western Australia. Heroin purity in the USA has remained relatively constant at approximately 35% between 2003 and 2007 (Fries et al., 2008). When discussing heroin purity it is important to note that depending on the production techniques the actual heroin produced may not be 100% pure when processing is complete, and 'brown' heroin typically only contains 70% diamorphine when pure. When a purity of less than 100% is stated it does not necessarily imply that the remaining percentage is adulterants, the remaining percentage may be other opiate alkaloids (e.g. monoacetylmorphine, noscapine, papaverine and acetylcodeine), by-products or due to degradation. The distinct make-up of heroin can also be used to accurately determine its country of origin (Johnston & King, 1998).

As aforementioned there is a public perception that illicit drugs, including heroin, are routinely 'cut' with other substances at each stage of distribution in which they pass. However, analysis of samples of heroin seized at importation and of street samples in the UK has shown that the differences in purity are not as large as often speculated (Coomber, 1997a, 1997b). The purity of heroin seized by the UK Border Agency in 2008/09 was reported at 50% purity and that seized by the police (and therefore considered to be 'street' samples) was 39% pure[14] (Hand & Rishiraj, 2009). The difference between import and street samples in 2008/09 was much greater than found in 2007/08 when an importation purity of 54% and an street purity of 51% was reported. Research with heroin dealers has shown that a minority report adulteration, and where it is reported it is most likely to be adulterated with a sugar (Coomber, 1997c). These findings and those in other countries such as the Netherlands (Eskes & Brown, 1975) and Denmark (Kaa, 1994) indicate that the majority of adulteration of illicit drugs takes place at the production source or prior to importation, with relatively little taking place after importation (Johnston & King, 1998). However, in the UK the Serious Organised Crime Agency (SOCA) recently reported that heroin in the UK is frequently adulterated with paracetamol, particularly at wholesale level (SOCA, 2009). Maher, Swift & Dawson (2001) have reported similar trends of adulterants and diluents present in heroin seized in Sydney, Australia to those reported from European countries. Analysis of heroin-related deaths in Australia between 1992 and 1996 found that contaminants were not commonly found in toxicology analysis and concluded that they played a very small role in the deaths of the individuals studied (Darke et al., 2000).

[14] During 2008/09 the UK Border Agency made 171 heroin seizures (totalling 1,035 kg) and the Police made 13,102 seizures (totalling 517 kg). There is no mention of how many of these samples were analysed, however the report indicates that the Forensic Science Service (FSS) 'analyse seizures made by most police forces and the UK Border Agency (including HMRC)'.

Transportation and storage can be damaging to heroin. However, it has been shown that where samples have been stored appropriately (i.e. in dark, dry conditions with a consistent temperature) the heroin will not degrade hugely (Kaa, 1994).

Preparation of heroin for injection

Whilst preparing heroin for injection it is usually mixed with vitamin C powder or citric acid powder (commonly available at needle and syringe programmes in many European countries and Canada). However, when neither of these substances are available users may add other household substances such as vinegar and lemon juice (Best et al., 2004). In Glasgow 23 heroin users were diagnosed with *Candida endophthalmitis* (intraocular fungal infection), bio-typing analysis indicated that the lemon juice used to prepare heroin injections was the source of contamination (Shankland & Richardson, 1988). In Spain, contaminated lemon juice was also suspected as the cause of an outbreak of *Candida albicans* amongst injecting heroin users (Miro et al., 1987).

Whilst heroin is traditionally sold as crystalline or powder, there have been reports of 'ready-to-use' heroin sold in pre-loaded syringes on the Russian black market (Bobkov et al., 2005). This method of preparation and distribution increases the potential for contamination with HIV through contaminated solution or the sharing of the solution from one container amongst several injecting drug users each using their own (potentially infected) syringe.

3.2 Findings from studies reporting forensic analysis

Table 3: Details of studies where adulterants have been reported in heroin

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[15]	Adulterants identified (% of samples)[16]	
Atasoy et al. 1988	January 1986 to April 1987	Marmara, Turkey	140	Colour tests, TLC and GC	Procaine (Concentration range 0.7-22%)	47%
					Salycilate, antipyrine and paracetamol	NS
					None of the samples contained caffeine, strychnine, quinine or barbitone.	
Chaudron-Thozet, Girard & David 1992	1991	France	980	GC, MS & HPLC	Caffeine	67%
					Paracetamol	40%
					Mannitol	35%
					Lactose	15%
					Saccharose/Sucrose	15%
					Glucose, procaine, phenobarbital, lidocaine, methaqualone, citric acid, piracetam, lysine acetylsalicylate, ascorbic acid and phenolphthalein	<15%
Chiarotti, Fucci & Furnari 1991	No details	Rome, Italy	33	Head space GC, GC/MS, TLC, HPLC & atomic absorption	Acetic acid	94%
					Methanol	61%
					Acetone	58%
					Sugars (saccharose, glucose, lactose)	55%
					Diethylether	45%
					Ethanol	30%
					Phenobarbital	24%
					Caffeine	21%
					Metaqualone	15%
					Benzene	12%
					Acetaldehyde	9%
					Procaine	6%
Coomber 1997a	1995-1996	UK	228	GC & MS	Paracetamol	33%
					Caffeine	32%
					Procaine	5%
					Bupivacaine	5%
					Phenobarbitone	4%
					Griseofulvin, diazepam and methaqualone	<=3%
					44% of samples contained no adulterants	
Cunningham, Venuto & Zielezny 1984	1974-1980	USA (Washington, Chicago, New York, Buffalo & Los Angeles)	3,300 (white heroin)	Qualitative analysis	Quinine	68%
					Mannitol	38%
					Starches	21%
					Sucrose	21%
					Lactose	17%
					Caffeine	7%
					Dextrose	6%
			6,108 (brown heroin)	Qualitative analysis	Lactose	59%
					Procaine	47%
					Quinine	17%
					Mannitol	13%
					Acetylprocaine	10%
					Starches	9%
					Sucrose	8%
					Morphine	8%
					Methapyrilene	5%

Table 3: Continued

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[15]	Adulterants identified (% of samples)[16]	
Eskes & Brown 1975	1973	Netherlands	No details	No details	Caffeine	50% con[18]
					Strychnine	2% con
de la Fuente et al. 1996	1985-1993	Madrid, Spain	No details	GC & High-performance TLC	Caffeine	40-60%
					Phenobarbital	39-52%
					Piracetam and paracetamol	>30%
					Procaine	15-30%
					Lidocaine	<10%
		Sevilla, Spain	No details	GC & High-performance TLC	Caffeine	85-90%
					Piracetam	40-60%
					Paracetamol	30%
					Procaine	5%
					Lidocaine	<6%
Furst 2000	1991-1996	New York City, USA	406	Chemical assay	Procaine	26%
					Quinine	21%
					Caffeine	11%
					Acetaminophen (Paracetamol)	10%
					Cocaine	7.3%
					Diphenhydramine	7.3%
					Thiamine	7.1%
					Lidocaine	<5%
Gomez & Rodriguez 1989	September 1985 to May 1987	Spain	263	Combination of TLC, GC, HPLC and MS	Sugars (glucose, lactose and mannitol)	73%
					Caffeine	68%
					Phenobarbital	20%
					Methaqualone	13%
					Procaine	13%
					Piracetam	7%
					Lidocaine	5%
Hendrickse, Maxwell & Young 1989	No details	Merseyside, UK	13	HPLC	Aflatoxin[19]	31%
Infante, Dominguez, Trujillo & Luna[20] 1999	No details	Andalucia, Spain	198	Atomic absorption spectrophoto - meter	Iron	100%
					Zinc	100%
					Calcium	93%
					Magnese	88%
					Copper	62%
					Cadmium	54%
Kaa 1994	1981-1992	Denmark	383	GC, HPLC & TLC	Caffeine	39%
					Lactose	33%
					Glucose	30%
					Paracetamol	22%
					Phenobarbital	14%
					Mannitol	13%
					Procaine	10%
					Sucrose	9%
					Methaqualone	5%

Table 3: Continued

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[15]	Adulterants identified (% of samples)[16]	
Klemenc 2000	1997-1999	Slovenia	132	GC/MS	Acetylcodeine	0.5-5% con[21]
					Acetylmorphine	0.08-13% con
					Diacetylmorphine	1.9-68% con
					Pavaverine	0.3-2.8% con
					Noscapine	2.4-61% con
Maher, Swift & Dawson 2001	October 1996 to March 1997	Cabramatta, Australia	88	GC/MS	Sugars (predominantly sucrose)	65%
					Paracetamol	41%
					Caffeine	36%
Neumann 1994	1986-1992[22]	Germany	No details	Capillary GC	Caffeine	57%
					Acetaminophen (Paracetamol)	52%
					Procaine	16%
					Phenobarbital	6%
					Methaqualone, nicotinamide, phenolphthalein and salicylic acid	<2%
Risser et al. 2000	1987-1995	Vienna, Austria	386	GC & GC/MS	Sugars (predominantly lactose)	100%
					Caffeine	25%
					Paracetamol and metaqualon	<2%
Risser et al. 2007	1999	Vienna, Austria	415	GC	Caffeine (Median concentration 29%)	92%
					Paracetamol (Median concentration 36%)	91%
					Cocaine (Median concentration 15.5%)	3%

In addition to the adulterants reported in Table 3 above other substances have been reported in heroin. These have not been included in the table above as forensic details were not available. Other substances include:

- Xylazine – a veterinary sedative (Wong, Curtis & Wingert, 2008)
- Arsenic (Eaton, 1977)
- Phenazone (Simonsen et al., 2003)
- Caffeine, paracetamol, procaine, diazepam, griseofulvin and phenobarbitone (King, 1997)
- Quinine (Dover, 1971).

As discussed previously, the evidence detailed above suggests that adulterants are added to heroin typically either to (1) dilute the product with benign substances making it less pure and increasing profits, or (2) to enhance the heroin (i.e. to make it more efficient when smoked) (Huizer, 1987). The evidence does not concur with the mythology of the addition of gravel, brick dust, household cleaning products or poisons by unscrupulous drug dealers.

[15] TLC – Thin layer chromatography GC - Gas chromatography MS - Mass spectrometry HPLC - High-pressure/performance liquid chromatography. Techniques cited are those reported in the original articles, other techniques may also have been employed.

[16] NS – Not stated

[17] Substances which were found in less than 5% of samples were not reported.

[18] Con – concentration. In this study the concentration of the samples was detailed rather than the percentage of samples where adulterants were identified.

[19] A naturally occurring carcinogenic substance which may contaminate the plant. Note: analysis was only performed for aflatoxin (presence of other adulterants was not investigated).

[20] It is important to note that the analysis performed in this study was only concerned with investigations into metal contamination. No other substances were investigated.

[21] See footnote 18.

[22] Figures reported in this table refer to 1992.

3.3 Poisoning, bacterial infections and other reported health effects of adulterated heroin: Findings from case studies

It is well known that unsterile preparation and administration of illicit drugs can cause bacterial, fungal and viral infections to be present during heroin administration (Brazier et al., 2002; Brett et al., 2005; McLauchlin et al., 2002). In an investigation of the microflora in samples of heroin, McLauchlin et al. (2002) identified 17 species of bacteria from 58 heroin samples. However, when heroin is adulterated there are additional health concerns which are consequence of the adulterants.

This section includes findings from case studies published in peer reviewed journals detailing adverse health effects of adulterated heroin (Table 4). Case studies have been categorised according to the type of health consequence reported. Details of the health effects, where and when the case was recorded and analysis results are included.

Table 4: Details of case reports where adverse health effects and death were reported as a consequence of adulterated heroin/opium

Author	Year	Location	Details	Heroin/ Opium analysed?	Analysis & findings
Poisoning					
Lead poisoning					
Chia, Leng, Hsii, Yap & Lee	1973	Singapore	Two cases of lead poisoning due to adulterated opium - the lead poisoning was due to the lead in the pot used to prepare the opium.	✓	Analysis of prepared opium and the pot used for preparation. Also urine and blood analysis on patients.
Parras, Patier & Ezpeleta	1987	Madrid, Spain	One case of lead poisoning by lead-adulterated heroin.	✓	Flameless atomic-absorption spectrophotometry indicated high levels of lead in users heroin.
Fitzsimons & Dagg	1982	Glasgow, Scotland	Lead poisoning was reported in one case where the individual had attempted to obtain opium for injecting from suppositories.	✗	Patient blood analysis confirmed high levels of lead.
Masoodi et al.	2006	Iran	Lead poisoning confirmed in three individuals with a history of opium ingestion.	✗	Patient blood analysis confirmed high levels of lead.
Verheij et al.	2009	Iran	Lead poisoning as a result of adulterated Iranian heroin.	✗	Analysis showed elevated serum lead and zinc protoporphyrin levels.
Scopolamine poisoning					
Perrone, Shaw & De Roos	1999	Philadelphia, USA	Anticholinergic toxidrome[23] caused by heroin adulterated with scopolamine.	✓	Gas chromatography-mass spectrometry showed scopolamine in the heroin sample. Urine analysis showed scopolamine also.
Hamilton et al.	2000	USA (New York, Philadelphia, Maryland & New Jersey)	244 cases of anticholinergic toxidrome as a result of scopolamine-adulterated heroin.	✓	Assay analysis was conducted randomly on either urine or samples of heroin.
Clenbuterol poisoning					
Centers for Disease Control and Prevention	2005	Five states of USA	Adverse cardiovascular effects caused by heroin adulterated with clenbuterol or clenbuterol sold as heroin reported by 26 individuals.	✓	Drug and urine analysis undertaken where possible. eight confirmed cases, 16 probable and two suspected.
Dimaano, Burda, Korah & Wahl	2008	Illinois, USA	Two confirmed and five suspected cases of adverse cardiovascular reactions to clenbuterol adulterated heroin.	✗	Urine tests were undertaken in two cases.
Hoffman, Kirrane & Marcus	2008	East Coast, USA	Probable exposure to clenbuterol via adulterated heroin in 34 individuals during the first 6 months of 2005. Thirteen cases were confirmed.	✗	Urine and blood analysis tests.
Manini et al.	2008	New York, USA	Five cases of an 'atypical reaction' to heroin use. Users presented with novel neuromuscular syndrome caused by clenbuterol-tainted heroin.	✗	Urine and blood analysis undertaken by gas and liquid chromatography and mass spectrometry.

Table 4: Continued

Author	Year	Location	Details	Heroin/ Opium analysed?	Analysis & findings
Bacterial infections					
Dancer, McNair, Finn & Kolsto	2002	No details	One case of *bacillus cereus* in a heroin user who had injected subcutaneously.	✓	Heroin was subject to molecular typing analysis.
Mulleague et al.	2001	UK	Wound botulism caused by *Clostridium botulinum* in two injecting heroin users.	✗	Serum bioassay.
O'Sullivan & McMahon	2005	Ireland	*Clostridium botulinum* caused descending polyneuropathy.	✗	Conclusion based on patient symptoms and response to treatment.
Ringertz et al.	2000	Oslo, Norway	*Bacillus anthracis* (anthrax) infection at skin popping site on buttocks of a heroin using individual.	✗	*Bacillus anthracis* confirmed by Polymerase Chain Reaction (PCR). However, no tests performed on heroin or injecting equipment.
Christie	2000	UK	*Clostridium novyi* was the likely cause of death of 35 injecting drug users.	Unknown	No details.
Dunbar & Harruff	2007	Seattle, USA	Fifteen deaths in a ten-year period caused by soft tissue infection (necrotizing fasciitis) from bacteria in black tar heroin.	✓	Microbiological analysis of wounds and where available analysis of the black tar heroin.
Kalka-Moll et al.	2007	Cologne, Germany	Wound botulism in 12 individuals - suspected cause of the source of *Clostridium botulinum* was adulterated heroin.	✗	Analysis of serum and abscess specimens confirmed *Clostridium botulinum* cultures.
Kimura et al.	2004	California, USA	Nine injecting drug users presented with deep-tissue infections caused by clostridial contamination from black tar heroin. *Clostridium sordellii* was the most commonly identified bacteria amongst the patients (n=6).	✓	Wound specimens confirmed the identification of anaerobic bacteria. Analysis of the black tar heroin sample found no organism but there are concerns about its connection to these cases[24].
McGuigan et al.	2002	Scotland, UK	Sixty cases of soft tissue inflammation caused by bacterial infection in injecting drug users. *Clostridium novyi* was the most commonly found pathogen (n=13).	✓	Heroin, blood, tissue and fluid sample analysis was conducted.
Other Health Effects					
Moss & Okun	1979	California, USA	Six cases of acute thrombocytopenic purpura (low blood platelet levels with bleeding onto the skin) after heroin use.	✗	In vitro biological tests on patients. The specific agent could not be identified.
Hollander & Lozano	1993	New York, USA	One case of myocardial infarction as a result of heroin contaminated with cocaine.	✗	Urine toxicology confirmed cocaine metabolites yet the individual denied recent cocaine use but admitted to daily heroin use.

Table 4, above, indicates that there are a number of common adverse health effects which may result as a consequence of using adulterated heroin. The case studies highlighted different adulterants to those detailed in the forensic analyses (Table 4) including lead, scopolamine, bacteria (including anthrax) and clenbuterol. In the cases where bacterial contamination was present the individuals had infected injecting sites and death as a result was common, however, in the cases discussed above it is important to note that in less than half of the cases was the administered drug analysed and unsterile preparation of heroin may have caused the bacterial contamination.

[23] An anticholinergic toxidrome typically consists of blurred vision; agitation; fever; urinary retention; dry, hot, flushed skin; and dilated pupils.

[24] The heroin analysed in this case was confiscated during a raid on a local drug dealer. It was not found at the scene of drug use by any of the patients nor on their person. No organisms were recovered from the confiscated sample of black tar heroin.

Anthrax outbreak 2009/10

In addition to the case studies detailed above, during production of this report there were a number of public health warnings (December 2009-March 2010) regarding an outbreak of anthrax *(Bacillus anthracis)* amongst injecting drug users in Scotland, England (specifically London and Blackpool) and Germany, confirmed through forensic analysis. At the time of writing there were 29 confirmed cases of anthrax in Scotland, three in England and one in Germany, of which 11 individuals had died[25]. In response to this outbreak frequent letters were written from the Chief Medical Officer for Scotland providing information, guidance and advice for medical personnel, drug treatment services, ambulance services and the Crown Office (Burns, 2010). Guidance for those working with heroin users to help identify individuals who may be infected with anthrax and the steps to be taken in a suspected case was also distributed to all relevant agencies. Guidance stated that health professionals should be aware of potential infection amongst injecting drug users presenting with severe soft tissue infections or sepsis.

3.4 Chapter summary

The evidence presented in this chapter supports the arguments (Coomber, 1997a, 1997b, 1997c, 1997d, 1997e, 1999, 2006) that adulteration of heroin is more likely to be undertaken with benign substances or substances that will enhance the heroin, than with products which will cause serious health problems or death. Additionally, the evidence suggests that the majority of adulteration of heroin takes place at or close to the time of synthesis and significantly less 'cutting' than would be generally perceived takes place after heroin leaves the country of origin. The most common identified substances for adulterating heroin include caffeine, sugars and paracetamol. The case studies show that despite the inclusion of relatively non-toxic substances in heroin, users may experience serious health problems including infections, cardiovascular problems and poisoning as a result of heroin use. Whilst some of these problems are undoubtedly caused by adulterated heroin (with substances such as lead or clenbuterol) many of the cases may be the result of bacterial contamination through poor wrapping, storage and transportation of heroin; unsterile equipment used for administration or contamination of diluents used to prepare heroin for injection.

Heroin users and the public need to be accurately informed about the typical adulteration practices associated with heroin, and specific health warnings, advice and guidance should be disseminated when necessary.

[25] See: *www.hps.scot.nhs.uk/anthrax/index.aspx and www.hpa.org.uk/* for more information.

4. Cocaine and Crack Cocaine

Cocaine is a stimulant drug made from the leaves of the coca plant (*Erythroxylon coca*). The powdered hydrochloride salt form of cocaine is usually snorted, but can also be prepared for injection. The drug is a fast-acting psychomotor stimulant, with short lived effects. Crack cocaine, a crystalline form of cocaine which is usually sold in 'rocks', is typically smoked. It is synthesised from cocaine through an extraction process using an alkaline solution. There are various ways to produce crack cocaine from powder cocaine and different methods may have different implications with regards to purity and presence of adulterants. Crack cocaine is typically a more powerful and more addictive form of cocaine.

Given that both cocaine and crack cocaine come from the same raw ingredient and it is differences in the final synthesis stages that distinguish them[26]; they have been considered together within this section of the report. It is important to note that in countries where cocaine is not manufactured, crack cocaine is often created from imported cocaine supplies and therefore adulteration which occurred prior to importation may continue to exist in crack cocaine or the crack cocaine may be further adulterated during and after synthesis (Coomber, 1997e; Laposata & Mayo, 1993).

4.1 Purity and production

In 2008 global cocaine production decreased by 15% from the previous year to 845 metric tonnes (UNODC, 2009). The majority of coca cultivation and cocaine production takes place in Columbia, Bolivia and Peru. Naturally occurring alkaloids from the coca plant include *cis- and trans-cinnamoylcocaine*, methylecgonine, tropa-cocaine, pseudotropeine, truxilline, hygrine, cuscohygrine, and nicotine (Schlesinger, 1985).

The purity of cocaine in Australia has fluctuated between 1999/2000 and 2007/08 across all states and territories (ACC, 2009). In 2007/08 the median cocaine purity ranged from 6.2% in Australian Capital Territory to 80% in Western Australia. The mean range of cocaine purity in Europe generally declined between 2002 and 2007, with the reported mean purity range between 22% and 57% in 2007 (EMCDDA, 2009a). In England and Wales the purity of cocaine seized at importation in 2008 was 63% and at street level was 29% suggesting extensive adulteration (Davies et al., 2009). In the USA the national index of cocaine purity between 2003 and 2007 has remained relatively steady at 65% to 70% (Fries et al., 2008).

The purity of crack cocaine in Europe in 2007 was reported at the mean purity range between 35% to 98%[27] (EMCDDA, 2009a). Street level average purity of crack cocaine in England and Wales has decreased from 70% in 2003 to 43% in 2008 (Davies et al., 2009). Australian national drug reports do not include data on crack cocaine purity as the drug is not commonly available in Australia (ACC, 2009). Between 2003 and 2007 the quarterly expected purity of crack cocaine in USA was fairly consistent between 75% to 80% (Fries et al., 2008).

Research conducted in Belgium showed that amongst cocaine users there was a general perception that cocaine is adulterated and that some drug dealers adulterate because they believe that other dealers adulterate thus creating a 'self-fulfilling prophecy' (Decorte, 2001; p.163). Respondents in Decorte's (2001) study most commonly mentioned 'speed' (amphetamines) as a cocaine adulterant, followed by novocaine/lidocaine, milk powder, ground glass, crushed tablets/medicines and a variety of other substances. Forensic analysis of 30 samples of cocaine provided by the respondents showed that perceptions of purity and adulterants present in samples amongst the respondents were inaccurate (and notably amphetamine was not detected in any samples). Research in the UK (Coomber, 1997c) found that cocaine dealers believed that cocaine was adulterated with sugars (specifically mannitol and glucose), caffeine or crushable over-the-counter white tablets. Approximately half of those who admitted cocaine dealing indicated that they adulterated their supply with glucose, paracetamol or amphetamine (Coomber, 1997c). Analysis of almost 3,000 cocaine samples in the Netherlands showed a significant increase in the percentage of adulterants present between 1999 and 2007 (from 6.5% in 1999 to 57% in 2007) (Brunt et al., 2009). Cocaine is commonly contaminated by benzoyl pseudotropine and benzoyltropine (Soine, 1989).

[26] A typical method for making crack cocaine involves dissolving powder cocaine mixed with water and baking soda (sodium bicarbonate), which is heated until it makes a 'cracking' noise. It is then dried and broken into rocks.

[27] The EMCDDA advise caution when interpreting this figure due to a small number of countries who reported data.

4.2 Findings from studies reporting forensic analysis

In a review of cocaine adulterants, Shannon (1988) found that common adulterants fell within five general categories: local anaesthetics, sugars, stimulants, toxins and inert compounds. This assertion is supported by the forensic analysis detailed below (Table 5).

Table 5: Details of studies where adulterants have been reported in cocaine/crack cocaine

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[28]	Adulterants identified (% of samples)[29]	
Bernardo et al. 2003	January to December 2001	Brazil	209	TLC, GC/flame ionization detector & qualitative tests	Lidocaine (Concentration range 0.5-92.0%)	65%
					Starch	51%
					Caffeine (Concentration range 2.8-63.3%)	50%
					Carbonates/biocarbonates	42%
					Sucrose	15%
					Glucose	12%
					Prilocaine (Concentration range 1.2-20.7%)	11%
					Lactose	6%
					Fructose	3%
					11.1% samples tested negative for cocaine[30]	
					Cocaine concentration ranged from 4.3-87.1%	
Brown & Malone 1976	July 1973 to January 1975	California, USA	939	No details	Procaine	22.5%
					8.3% samples tested negative for cocaine[31]	
Brunt et al. 2009	1999-2007[32]	Netherlands	683[33]	TLC & GC/MS	Phenancetin	41%
					Caffeine	16%
					Diltiazem	12%
					Levamisole	12%
					Procaine	8%
					Lidocaine	6%
					Benzocaine and atropine	<1%
Cunningham, Venuto & Zielezy 1984	1974-1980	USA (Washington, Chicago, New York, Buffalo & Los Angeles)	2,944	Qualitative analysis	Lactose	29%
					Lidocaine	29%
					Mannitol	26%
					Inositol	10%
					Dextrose	8%
Decorte 2001	August 1996 to April 1997	Antwerp, Belgium	30	Infra-red spectrometry	Mannitol	13%
					Lidocaine	10%
					Glucose	7%
					Caffeine	3%
					Starch	3%
					60% of samples had no adulterants identified[34]	

Table 5: Continued

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[28]	Adulterants identified (% of samples)[29]	
Fucci & Giovanni 1998	January 1996 to June 1997[35]	Rome, Italy	156	GC/MS	Lidocaine	12.3%
					Caffeine	6.1%
					Phenacetine	6.1%
					Salicylamide	3.1%
					Diphenidramine	1.5%
					Dipyrone	1.5%
					Phendimetrazine	1.5%
					Phenmetrazine	1.5%
					Procaine	1.5%
Gomez & Rodriguez 1989	September 1985 to May 1987	Spain	52	TLC, GC, HPLC & MS	Lidocaine	52%
					Sugars (mannitol and glucose)	45%
					Caffeine	NS
					Procaine	NS
Kenyon et al. 2005	January to March 2004	London, UK	14	TLC & GC/MS	Phenacetin	29%
					Lidocaine	21%
	July 2003 to September 2004	Manchester, UK	13		Phenacetin	8%
					Lidocaine	8%

In addition to the studies detailed in Table 5 other studies have conducted forensic analysis on samples of cocaine but have not reported the adulterant percentage of samples nor the composition of the drug. Grabowski (1984) reported in a National Institute on Drug Abuse report that the most common adulterants and diluents found in cocaine were mannitol, lactose, inositol, lidocaine, and phenylpropanolamine. Fucci (2007) reported the presence of hydroxyzine and levamisole in cocaine seized in Rome. Fucci (2007) theorised that the presence of hydroxyzine may have been due to its addition during manufacturing of the drug, rather than as a diluent. Morales-Vaca (1984) reported the presence of sodium bicarbonate, procaine and benzocaine in samples of cocaine hydrochloride.

Contrary to popular belief cocaine is more commonly adulterated with benign substances such as caffeine and sugars than toxic household products or other illicit drugs (such as amphetamine). However, since the beginning of the 21st century analysis shows that phenacetin (an analgesic substance now banned in many countries due to its carcinogenic and kidney-damaging properties) is increasingly commonly present in cocaine. It is thought that phenacetin is used as an adulterant due to its similarity to the properties of cocaine.

[28] TLC – Thin layer chromatography GC - Gas chromatography MS - Mass spectrometry HPLC - High-pressure/performance liquid chromatography. Techniques cited are those reported in the original articles, other techniques may also have been employed.

[29] NS – Not stated

[30] These samples did contain lidocaine and starch.

[31] These samples contained local anaesthetics, phencyclidine, caffeine, sugars, quinine. No detail of the percentage of samples containing each of these substances was provided.

[32] Figures reported in this table refer to 2007.

[33] A total of 3,230 samples were collected between 1999 and 2007, 2,824 tested positive for cocaine. Figures reported in this table refer to 2007 data when 683 samples were analysed.

[34] This does not necessarily indicate that no adulterants were present, the drugs were only analysed for particular adulterant compounds.

[35] Figures reported in this table refer to January to June 2007 data when 683 samples were collected, of which 156 were identified as cocaine.

4.3 Poisonings and bacterial infections caused by adulterated cocaine or crack cocaine: Findings from case studies

Case study reports of adverse health consequences related to use of adulterated cocaine or crack cocaine are detailed in Table 6. Case studies have been categorised according to the type of health consequence reported. Details of the health effects, where and when the case was recorded and analysis results are included.

Table 6: Details of case reports where adverse health effects and death were reported as a consequence of adulterated cocaine

Author	Year	Location	Details	Cocaine analysed?	Analysis & findings
Poisoning					
Fucci	2004	Individual had travelled from Columbia to Rome	Acute intoxication of cocaine adulterated with phenacetin (an analgesic) of a 25 year old male who had 24 packages of cocaine in his digestive tract.	✓	Analysis of the cocaine and also urine, blood and gastric content analysis confirmed cocaine with a 30% concentration of phenacetin.
Insley, Grufferman & Ayliffe	1986	Baltimore, USA	Three cases of individuals presenting to hospital with abdominal pain and/or hypertension due to thallium poisoning from what they thought was cocaine. The three individuals knew each other and had snorted the same substance.	✓	The substance was analysed by mass spectrometry scanning electron microscopy and x-ray diffraction and showed it was 99% thallium sulphate.
McKinney, Postiglione & Herold	1992	USA	One case of methemoglobinemia due to ingestion of street cocaine adulterated with benzocaine.	✗	Urinary analysis identified cocaine and benzocaine. A 'cutting agent' supplied by the patient's girlfriend showed only benzocaine.
Nogue, Sanz, Munne & de la Torre	1991	Barcelona, Spain	Five cases of poisoning due to scopolamine sold as cocaine.	✗	Urine analysis identified high concentration of scopolamine.
O'Callaghan et al.	1982	Dublin, Ireland	Eight cases of strychnine poisoning caused by the inhalation of the substance which was thought to be cocaine.	✗	Urinary analysis confirmed the presence of strychnine.
Weiner et al.	1998	Connecticut, USA	One case of anticholinergic poisoning caused by adulterated cocaine.	✗	Urine analysis confirmed presence of cocaine and anticholinergic drug - atropine.
Levamisole poisoning					
Knowles et al.	2009	Alberta & British Columbia, Canada	Severe neutropenia (haematological disorder caused by low white blood cell count) was identified in 60 individuals caused by cocaine adulterated with levamisole. Most individuals were regularly smoking crack cocaine.	✓	One drug sample and two crack pipes were tested. Both confirmed the presence of levamisole. Current patients were also urine tested.
Zhu, LeGatt & Turner	2009	Alberta, Canada	Five cases of agranulocytosis due to consumption of levamisole adulterated cocaine.	✗	Urine toxicology using gas chromatography/mass spectrometry confirmed presence of cocaine and levamisole.
Bacterial infections					
Gardner, Kestler, Beieler & Belknap	2008	Denver, USA	One case of *Clostridium butyricum* in an injecting drug user - it was suspected that the infection was caused by contaminated cocaine.	✗	Case was not confirmed.

Brunt et al. (2009) collected data on reported adverse effects of 172 samples of cocaine and investigated their association with the main adulterants present in the cocaine samples. The authors categorised the adverse health effects into five categories: nausea; headache; cardiac effects; allergic reactions; and hallucinations. There was a significant association between the adulterants and all adverse effects ($p<0.05$) and cardiac effects ($p<0.01$). Significant associations were found between phenacetin, an analgesic, and all adverse effects ($p<0.01$), cardiac effects ($p<0.01$) and hallucinations ($p<0.05$); hydroxyzine, a sedative anxiolytic, and all adverse effects ($p<0.05$) and hallucinations ($p<0.05$); and diltiazem, a calcium channel blocker, and all adverse effects ($p<0.01$), cardiac effects ($p<0.01$), and hallucinations ($p<0.01$).

Table 6 above details the findings from case studies where adverse health effects from adulterated cocaine have been recorded. Many of the case reports indicate the presence of substances as cocaine adulterants which were also identified in the forensic analysis (Table 5), such as phenacetin, benzocaine and levamisole. Assessment of case studies indicated other substances which have caused poisoning in cocaine users which were not identified in the forensic analysis, such as thallium, scopolamine and strychnine. The reason why these substances may not have been identified in forensic analysis is due to the potential absence of cocaine. The case studies suggest that in these cases another substance was sold to the individuals as cocaine, but in fact did not contain any of the drug.

4.4 Crack cocaine

When compared to reports of forensic analysis and adverse health effects of adulterated cocaine, there is a dearth of reports specific to crack cocaine. In a report of five cases of phenytoin toxicity due to adulterated crack cocaine amongst individuals presenting to emergency departments in New York, three of the individuals admitted intentionally adding phenytoin (an antiepileptic drug) to their crack cocaine (Katz, Hoffman & Silverman, 1993). The authors concluded that the practice of adding phenytoin to crack cocaine was becoming more common.

Crack cocaine is not soluble without the addition of a weak acid (such as lemon juice, lime juice, vinegar, citric acid or ascorbic acid) and therefore cannot be injected without this preparation. Waninger et al. (2008) reported on a case where a female crack cocaine user presented with abscesses (*staphylococcus aureus* and streptococcus) after subcutaneous injection of crack cocaine prepared with lemon juice.

4.5 Chapter summary

The evidence presented here for adulteration of cocaine and crack cocaine supports the notion that public perception of cocaine/crack cocaine adulterants differs considerably from reality. The perception that cocaine/crack cocaine is regularly adulterated with other illicit drugs, specifically amphetamine, is not supported by forensic analysis nor previous research (Coomber, 1997d). According to the evidence presented here lidocaine, caffeine, sugars and phenacetin are the most common adulterants of cocaine/crack cocaine. There are particular concerns about the addition of phenacetin to cocaine/crack cocaine as it is an analgesic which is no longer widely used, and is banned in some countries, as it has been linked to bladder and kidney cancer. The case study analysis highlights a trend for adverse health effects amongst cocaine users who are sold another substance as cocaine. Cases of poisoning with scopolamine and strychnine have been noted (McKinney, Postiglione & Herold, 1992; Nogue, Sanz, Munne & de la Torre, 1991). The wide variation in substances used for adulteration of cocaine and crack cocaine contributes to the unpredictability of the effects of use and the potential for adverse health reactions.

5. Amphetamine and Methamphetamine

Amphetamine and methamphetamine are synthetic central nervous stimulants. These drugs are most commonly manufactured as powders, but are also created as tablets, paste and crystalline solutions. They are usually inhaled, ingested or snorted, but can also be prepared for injection. The two drugs are chemically similar, but methamphetamine produces more potent and longer lasting effects than an equivalent dose of amphetamine. The form of methamphetamine is generally related to purity with powder being of the lowest purity, paste more pure than powder and crystalline with the highest purity.

5.1 Purity and production

In 2007 the global production estimate of amphetamine/methamphetamine ranged between 230 and 640 tonnes (UNODC, 2009)[36]. The majority of amphetamine production is concentrated in Europe, with a considerable proportion also taking place in North America (UNODC, 2009). Methamphetamine is mostly manufactured in south-east Asia and North America, with increasing productivity in Latin America and Oceania (UNODC, 2009). In Europe methamphetamine laboratories have been identified, with most concentrated in Eastern European countries (Czech Republic, Slovakia and Lithuania) (EMCDDA, 2009a). UNODC (2009) reported a 15% decline in amphetamine type stimulant laboratories worldwide in 2007 on the previous year[37].

Unlike other recreational drugs such as heroin or cocaine, amphetamine and methamphetamine can be synthesised through the combining of household products using instructions readily available on the internet. Commonly used methods of amphetamine and methamphetamine synthesis include the Leuckart method and reductive amination of benzyl methyl ketone. Chemicals used in the preparation of amphetamine and methamphetamine include, but are not limited to, over-the-counter cold and flu medications, P-2-P (1-phenyl-2-propanone), norephedrine, pseudoephedrine, ephedrine, ethers, hydrochloric acid, sulphuric acid and phenylacetic. Many of the precursors and chemicals required to synthesise methamphetamine can be substituted for others (which may be subject to less legal restrictions or easier for the manufacturer to obtain) (Burton, 1991).

The manufacture of amphetamine and methamphetamine naturally creates by-products and residues and therefore a sample of 60% purity does not automatically indicate 40% adulteration. The purity of amphetamine and methamphetamine seized in Europe in 2007 varied widely (EMCDDA, 2009a). Amphetamine purity ranged between 4% to 40% and methamphetamine purity ranged from 3% to 66%. Reported amphetamine purity ranged widely across states and territories in Australia during 2007/08, purity ranged from 1% in Victoria to 35% in Australian Capital Territory (ACC, 2009). In Australia the purity of methamphetamine has remained relatively steady at approximately 15% between 1999/2000 and 2007/08, with the purity in 2007/08 ranging from 7% in Tasmania to 20% in Western Australia (ACC, 2009).

In the UK the purity of amphetamine has fluctuated between 2003 and 2008, with the mean purity in 2008 reported at 7.8% (Davies et al., 2009)[38]. The average purity of amphetamines seized at the UK border and by police in 2008/09 was 44% and 7% respectively (Hand & Rishiraj, 2009). In the USA, the average purity of methamphetamine at national and local level ranged from 40% to 55% in 2007 (Fries et al., 2008).

Coomber (1997c, 1997d) discussed the adulteration of drugs with a sample of drug dealers. Findings showed that whilst there was a general perception that amphetamine was 'cut' with other substances those who reported adulteration of amphetamine used relatively benign substances such as glucose, bicarbonate of soda and paracetamol.

[36] Only an aggregate estimate for amphetamine and methamphetamine is available.

[37] This includes ecstasy laboratories.

[38] Due to the small number of seizures of methamphetamine the average purity of this drug was not reported.

Organic impurities in amphetamine and methamphetamine

Organic impurities in amphetamine and methamphetamine may be present as a result of careless manufacturing processes, contamination of precursors, side and subsequent reactions, diluents, unsterile laboratories, handling and packaging. Reports of organic impurities indicate there is a wide variety of potential compounds which may be synthesised in the manufacturing or distribution process, and these may be different in amphetamine and methamphetamine (Soine, 1986). Commonly identified impurities include N-Formylamphetamine, 4-Methyl-5-phenylpyrimidine, N,N-Di(β-henylisopropyl)formamide, N,N-Di(β-phenylisopropyl)amine and N,N-Di(β-phenylisopropyl)methylamine (Bailey et al., 1974; Huizer, Brussee & Poortman-van der Meer, 1984; Kram & Kruegel, 1977; Lambrechts et al., 1986; Sinnema & Verweij, 1981; Soine, 1986; Verweij, 1989).

Risks associated with methamphetamine manufacture

The synthesis of methamphetamine in uncontrolled illicit laboratories presents a risk of release of toxic gasses, fire and explosion. Toxic substances released due to improper manufacture of methamphetamine include lead oxide, aluminium hydroxide, mercury vapour, iodine, phosphine and yellow phosphorus (Holton, 2001; Lineberry & Bostwick, 2006). There is a risk of serious injury, particularly chemical burns or injury due to explosion and fire whilst combining volatile chemicals during the manufacturing process. This is also a potential risk for first responders to these incidents (Centers for Disease Control and Prevention, 2000; Lineberry & Bostwick, 2006). The National Drug Intelligence Center in the USA reported that over 1,000 children had been injured or killed at, or removed from sites where methamphetamine was manufactured from September 2007 to September 2008 (NDIC, 2008).

Preparation of amphetamine for injection

As with many of the other illicit drugs which are prepared for injection, the preparation of amphetamine in unsterile conditions can lead to increased risk of infection. Chuang et al. (2007) reported the death of an amphetamine injector who became infected with *serratia liquefaciens*. The authors concluded that it was most likely that unsterile water used for injection preparation was the cause of illness rather than the amphetamine.

5.2 Findings from studies reporting forensic analysis

Unlike analytical reports of heroin or cocaine, those reviewed for amphetamine and methamphetamine did not detail the percentage of samples where each adulterant was identified.

Brown and Malone (1976) reported that approximately 40% of samples (n=563) contained only amphetamine. The other samples were a mixture of amphetamine and caffeine (26%) and 34% were a mixture of non-amphetamine substances (caffeine, ephedrine and phendimetrazine). Huizer et al. (1985) identified mannitol in samples of amphetamine.

Lambrechts et al. (1986) reported the presence of caffeine, ephedrine chloride, penazone and procaine chloride in samples of amphetamine seized in Norway. Gomez & Rodriguez (1989) reported that 56% of amphetamine samples seized and analysed in Spain (n=36) contained adulterants. The adulterants present included: caffeine, ephedrine, piracetam, paracetamol, lidocaine, heroin and acetylsalicylic acid. According to Simonsen et al. (2003) analysis of amphetamine samples seized in Denmark between 1995 and 2000 revealed that the most common adulterants were caffeine and sugars. More uncommon adulterants were also identified, including phenazone, ascorbic acid and 1-phenylethyamine.

King (1997) stated that the most common adulterants present in amphetamine seized in the UK were caffeine, glucose, other sugars, 1-phenylethyamine, paracetamol and ephedrine.

Kenyon et al. (2005) reported that of 12 samples of amphetamine handed in during a club door amnesty in London, three (25%) contained caffeine.

Quinn et al. (2008) reported that adulterants typically present in methamphetamine in Victoria, Australia included sugars (glucose, lactose, sucrose, mannitol), caffeine, dimethyl sulphone[39] (MSM) and a variety of other pharmaceuticals (including paracetamol and ephedrines). MSM was also mentioned as a cutting agent of methamphetamine in the 2007 Australian Drug Trends report (NDARC, 2008).

According to the EMCDDA methamphetamine is typically adulterated with a variety of other substances, including caffeine, sugars, ephedrine and ketamine (EMCDDA, 2009b).

[39] Also known as Methylsulfonylmethane (MSM), DMSO2 and methyl sulfone.

5.3 Poisonings and other health effects of adulterated methamphetamine: Findings from case studies

Table 7, below, details the findings of a small number of case studies where adverse consequences or death have been reported as a consequence of adulterated methamphetamine[40]. The case studies reported below are specific to those who use or manufacture methamphetamine. However, there are also many examples in the literature where reports of the effects for emergency response teams after entering methamphetamine laboratories without protective clothing and equipment, and of the effects of contamination of health personnel who come into contact with methamphetamine manufacturers (Burgess, 1999; Burgess et al., 2002; Centers for Disease Control and Prevention, 2000; Lineberry & Bostwick, 2006).

Table 7: Details of case reports where adverse health effects and death were reported as a consequence of adulterated methamphetamine

Author	Year	Location	Details	Methamphetamine analysed?	Analysis & findings
Poisoning					
Allcott, Barnhart & Mooney	1987	Oregon, USA	Two cases of lead poisoning due to intravenous use of methamphetamine.	✓	Lead confirmed in urinary analysis. One sample of methamphetamine analysed showed lead contamination[41].
Centers for Disease Control	1990	Oregon, USA	Eight cases of lead poisoning due to methamphetamine use. All individuals were intravenous methamphetamine users.	✓	Lead confirmed through blood analysis. One sample of methamphetamine analysed had up to 60% lead weight present.
Norton et al.	1989	Oregon, USA	Thirteen cases of lead poisoning caused by injecting of adulterated methamphetamine. Individuals presented with gastrointestinal problems and five developed renal injury.	✗	Cases confirmed by patient blood analysis.
Willers-Russo	1999	California, USA	Three cases of poisoning by phosphine gas due to release of toxic gas during methamphetamine manufacture.	✗	Analysis of air and equipment at the scene confirmed the presence of phosphine gas and was consistent with the manufacture of methamphetamine.
Other Health Effects					
Johnson, Petru & Azimi	1991	Chicago, USA	One case of pulmonary granulomas due to inhalation of powdered methamphetamine adulterated with talc or starch.	✗	Open lung biopsy confirmed a foreign body consistent with starch or talc.

5.4 Chapter summary

The forensic analysis of amphetamine and methamphetamine included in this report was not as detailed as reports extracted for other drugs. However, similar to other drugs the adulterants reported were more likely to be benign than toxic, with the most commonly reported including caffeine, ephedrine, sugars and paracetamol. This finding supports the patterns of amphetamine adulteration reported by a sample of drug dealers interviewed in Coomber (1997c, 1997d). More recently dimethyl sulphone (MSM), a substance used as an industrial solvent and also marketed as a dietary supplement, has been reported to be present in methamphetamine. The case study analysis highlighted the risk of lead poisoning due to adulterated methamphetamine. This chapter also highlights the risk of chemical burns, fire, explosion and release of toxic gasses to those involved in or in close proximity to methamphetamine manufacture.

[40] No case studies relating amphetamine adulteration were extracted during the literature search.

[41] No details of the analysis methodology were provided.

6. Ecstasy

'Ecstasy' originally referred to MDMA (3,4-Methylenedioxymethamphetamine), is a synthetic drug chemically similar to amphetamine. However, since MDMA became common place in the recreational drug scene, other MDMA-related analogues have also become popular (MDA[42] [3,4-Methylenedioxyamphetamine], MDEA[43] [N-methyl-diethanolamine] and MBDB [N – methyl – 1 – (3,4 – methylenedioxyphenyl) – 2 – butanamine]), which are chemically similar to MDMA and many 'ecstasy' tablets may now contain a combination of these substances.

Ecstasy boosts serotonin within the central nervous system creating feelings of euphoria, stimulation, heightened alertness, empathy with others and mild hallucinogenic effects. Typically ecstasy is found in tablet form; however, MDMA powder is becoming increasingly common. It was estimated that in 2007 between 11.5 and 23.5 million individuals aged 15-64 years worldwide had used ecstasy in the previous year (UNODC, 2009).

Whilst ecstasy refers to MDMA and related analogues, drugs sold as ecstasy often contain other substances, such as ketamine, benzylpiperazine, methylamphetamine, amphetamine, caffeine and over-the-counter medications such as dextromethorphan (Banta-Green, 2005; Battisti et al., 2006; Davies et al., 2009; Gaffney et al., 2010; Spruit, 2001). There is an inaccurate perception amongst some ecstasy users that bad ecstasy experiences are caused by ecstasy tablets adulterated with heroin (McElrath & McEvoy, 2001).

6.1 Purity and production

The global production of ecstasy in 2007 was estimated between 72 and 137 tonnes (UNODC, 2009). The majority of ecstasy production takes place in Europe, however in recent years manufacture has become more widespread taking place in North America, Asia and Oceania.

The average weight of an ecstasy tablet is approximately 250mg (Cole et al., 2002). The purity of ecstasy tablets seized in Europe in 2007 ranged between 19mg and 75mg of MDMA per tablet (EMCDDA, 2009a). Most of the tablets analysed contained only MDMA or an analogue (MDA, MDEA) as the only psychoactive ingredient. In Luxembourg, Cyprus and Turkey high percentages (over 50%) of analysed tablets did not contain any MDMA or derivatives (EMCDDA, 2009a).

In the UK the mean mg of MDMA per ecstasy tablet decreased from 52mg in 2007 to 33mg in 2008 (Davies et al., 2009). There were also reports that MDMA powder was becoming increasingly popular due to higher levels of purity; wholesale purity was estimated at 79% in 2008 and street level purity at 62% (Davies et al., 2009).

Ecstasy is synthesised through a complex set of chemical reactions incorporating distillation and crystallisation (chemicals used include safrole, piperonal, isosafrole and 3,4-Methylenedioxyphenyl-2-propanone [PMK]). The number of clandestine MDMA laboratories detected in Australia decreased from 19 in 2006/07 to 11 in 2007/08, with the vast majority detected in 2007/08 located in New South Wales (ACC, 2009). The EMCDDA reported that many ecstasy tablets seized in Denmark and the Netherlands did not contain MDMA or related analogues, but instead contained meta-Chlorophenylpiperazine (mCPP), a piperazine[44] (EMCDDA, 2009a). It was theorised that the recent trend for ecstasy synthesised with mCPP may be the result of a PMK shortage. The UNODC also commented on ecstasy tablets available that contained no MDMA but were actually piperazines (UNODC, 2008).

Johnston et al. (2006) conducted a study investigating ecstasy user's perceptions and methods of testing for purity in Australia. Findings indicated that approximately one quarter of respondents used ecstasy testing kits (22%), with the most widely used method of purity assessment coming from word of mouth from dealer/supplier. Of those who used testing kits more than half said they would not take a tablet that contained ketamine and three-quarters would not take a tablet that did not show any results in the test (therefore of 'unknown' composition). The authors also found that a high percentage of participants showed an interest in ecstasy testing kits, and there was moderate awareness of their limitations[45] amongst those who already used the kits. The research showed that many of those who used testing kits would alter their drug use depending upon the results of the test.

[42] Similar to MDMA but with longer lasting effects (8-12 hours) and effects more similar to amphetamine.

[43] Similar to MDMA but with shorter lasting effects (3-5 hours).

[44] An anthelmintic drug, typically used in treating worm infections.

[45] Limitations of reagent testing kits include their ability to only identify the most prominent substance in a sample, they do not provide information about how much of this substance is present and there are problems with subjectivity amongst the individual interpreting the colour shown in the test. Marquis and Mandelin kits do not differentiate between different MDMA-type substances. Winstock, Wolff and Ramsey (2001) argue that the limitations of ecstasy tablet testing techniques outweigh the potential harm reduction benefits and create an inaccurate perception of safety.

6.2 Findings from studies reporting forensic analysis

Table 8: Details of studies where adulterants have been reported in ecstasy

Author & publication year	Year(s) of data collection	Location	No. samples	Analysis technique[46]	'Ecstasy' composition[47] (% samples)		Adulterants identified (% of samples)[48]	
Baggott et al. 2000	Feb 1999 and March 2000	California, USA	107	GC & MS	MDMA or related analogue	63%	Dextromethorphan (Average concentration 136mg)	21%
					No MDMA or related analogue	29%	Caffeine, ephedrine, pseudoephedrine and salicylates	NS
					No identifiable drug	8%		
Cheng, Poon & Chan 2003	2000-2001	Hong Kong, China	No detail[49]	GC/MS & Electrospray ionization-MS	MDMA	55%	No detail	
					Methamphetamine	40%		
					MDA	<5%		
					Amphetamine	<1%		
Cole et al. 2002	2001	England, UK	136 tablets	HPLC	MDMA	94.1%	**Average MDMA content 60-69mg**	
					MDMA and MDEA	5.9%		
Renfroe 1986	1973-1985	USA	101	TLC & GC	MDMA	58%	No detail	
					MDMA and another substance[50]	24%		
					No identifiable drug	2%		
Sherlock, Wolff, Hay & Conner 1999	1999	Leeds, UK	25 tablets	GC/MS	MDMA	32%	Caffeine	44%
					MDMA and other stimulant	16%	Amphetamine	12%
					MDEA	16%	Paracetamol	12%
					Stimulant only	36%	Ephedrine	8%
							Ketamine	8%
							Methamphetamine	4%
Spruit 2001	1993-1997[51]	Netherlands	2,653	'Quick test'[52] and laboratory analysis	MDMA	44.1%	Other compounds[53]	18.2%
					MDMA and other compounds[54]	12.5%		
					MDMA and amphetamine	1.2%		
					Amphetamine only	4.0%		
					Amphetamine and other compounds[55]	11.5%		
					MDEA	6.8%		
					MDA	1.7%		
Tanner-Smith 2006	1999-2005	USA	1,214 tablets	GC/MS	MDMA	39%	Caffeine	16.6%
					MDA	5.2%	Dextromethorphan	8.0%
					MDE	<1%	MDA	12.6%
					Methamphetamine	1.5%	Methamphetamine	8.7%
							Pseudoephedrine	7.6%
							MDE	5.1%
							Acetminophen, benzylpiperazine, ketamine, methyl salicylate, phencyclidine, Trifluoromethylphenpiperazinemonohydrochloride[56]	<5%

[46] TLC – Thin layer chromatography GC - Gas chromatography MS - Mass spectrometry HPLC - High-pressure/performance liquid chromatography. Techniques cited are those reported in the original articles, other techniques may also have been employed.

[47] Primary active ingredient(s).

[48] NS – Not stated

[49] Ecstasy tablets were categorised into 212 categories based on physical properties, the number of samples in each category varied. The number of tablets analysed in the sample detailed was not provided.

[50] Mostly MDA

[51] Figures reported in table refer to 1997.

[52] The quick test was conducted by trained individuals who identified the drug through measurements, Marquis test and a recognition list.

[53] No further details provided.

[54] Not including amphetamine and methamphetamine.

[55] Not including MDMA.

[56] Seventeen additional substances were also found in less than 1% of samples. See original article for further detail.

In addition to the adulterants reported in Table 8 above studies have reported adulterants present in ecstasy. These have not been included in the table above as forensic analysis details were not available.

According to Siegel (1985) ecstasy has been found to contain a variety of adulterants including ephedrine, phenylpropanolamine, procaine and niacinamide. Clandestine manufacture of ecstasy can cause toxic contamination. The EMCDDA (2009b) and NDIC (2008) also reported that methamphetamine is used as an ecstasy adulterant.

King (1997) reported that ecstasy seized in the UK commonly contained lactose. Other ecstasy adulterants reported by King (1997) included other sugars, cellulose, talc, calcium phosphate, magnesium stearate and other pharmacologically active substances (paracetamol, ephedrine, caffeine, procaine, amphetamine and 1-phenylethylamine).

6.3 Poisonings caused by adulterated ecstasy: Findings from case studies

Case study reports of adverse health consequences related to use of adulterated ecstasy are detailed in Table 9. All cases studies which met the criteria for inclusion in this section relate to poisoning by ecstasy adulterants. Details of the health effects, where and when the case was recorded and analysis results are included.

Table 9: Details of case reports where adverse health effects and death were reported as a consequence of adulterated ecstasy

Author	Year	Location	Details	Ecstasy analysed?	Analysis & findings
Poisoning					
Becker et al.	2003	Germany	One case of death after ingestion of ecstasy tablet containing paramethoxymethamphetamine (PMMA) and paramethoxyamphetamine (PMA).	✗	Urinary, femoral blood and heart blood analysis indicated the individual had ingested PMMA, PMA and a trace amount of amphetamine.
Byard et al.	1998	Adelaide, Australia	Six cases of death due to consumption of tablets sold as ecstasy. Post mortem analysis indicated the presence of PMA in all cases, meth/amphetamine in four cases and MDMA was present in only two cases.	✗	Post mortem analysis indicated that death was most likely caused by PMA.

6.4 Chapter summary

During the 1990s there was much media interest in ecstasy and a perception, perpetuated by media outlets, that ecstasy tablets were maliciously adulterated with other drugs (LSD, heroin), rat poison and crushed glass (Coomber, 1997e). Forensic analysis shows that the media perception is not accurate and ecstasy is generally a combination of MDMA and/or related analogues in combination with caffeine, dextromethorphan and amphetamines. The evidence also shows that selling of 'counterfeit ecstasy' is also common i.e. the selling of other stimulant drugs (amphetamine, caffeine, ketamine etc) as ecstasy, yet the drug does not contain any MDMA or related analogues. The case studies detailed the fatalities of a number of individuals who had consumed paramethoxymethamphetamine (PMMA) and/or paramethoxyamphetamine (PMA). This evidence supports the notion that often other substances are sold as 'ecstasy' but contain little or no MDMA or related analogues.

7. Cannabis

Cannabis comes from the cannabis plant *(Cannabis sativa L.)* and is a mild sedative and hallucinogenic drug which can be either smoked or eaten. There are three commonly used forms of cannabis – cannabis resin, herbal cannabis and 'skunk' (a genetically modified version of herbal cannabis). Within each of these types there is huge variety. Cannabis oil can also be extracted from cannabis resin but is much less common than other types of cannabis.

Cannabis is the most commonly used illicit drug worldwide, with an estimate of between 143 and 190 million worldwide users in 2007 (UNODC, 2009) and an estimated 22.5 million Europeans having used the drug in the last year (EMCDDA, 2009a).

7.1 Purity and production

Cannabis is produced worldwide, with almost all countries having the potential for outdoors growing (UNODC, 2009). The main source of cannabis resin is Morocco and Afghanistan, and the main source of herbal cannabis is the Netherlands and South Africa (UNODC, 2009). It was estimated that between 2,200-9,900 metric tonnes of cannabis resin and 13,300-66,100 metric tonnes of herbal cannabis were produced globally in 2007 (UNODC, 2007).

Stambouli et al. (2005) analysed the average tetrahydrocannabinol[57] (THC) content of cannabis shortly after harvesting or preparation in Morocco[58], before the THC levels were altered by oxidation. The authors reported the average THC content of fresh, dried and powdered cannabis at 0.5%, 2.21% and 8.3% respectively.

The mean THC content of cannabis resin in Europe in 2007 ranged from 2.9% to 13.3%, and the mean THC content of herbal cannabis ranged from 1.2% to 10.2% (EMCDDA, 2009a). The mean THC concentration of herbal cannabis and cannabis resin in England and Wales in 2007 were 8.4% and 5.9% respectively (Hardwick & King, 2008). In 2008/09 the average THC content of herbal cannabis in the USA was 9.6% and for cannabis resin was 19.8%[59] (ONDCP, 2009).

The Australian Crime Commission reported on the detection of three clandestine laboratories for the extraction of cannabis oil in 2007/08 (ACC, 2009)[60].

In their review of cannabis potency and contamination McLaren et al. (2008) concluded that cannabis users believe the drug is likely to have been contaminated with pesticides and other substances to enhance yield during cultivation, this perception was particularly linked to indoor grown cannabis. An Australian study found that users of cannabis for medicinal purposes considerably favoured outdoor grown cannabis because it was considered more organic and to have received less chemical treatment than indoor grown cannabis (Swift et al., 2005). In Rome forensic analysis of a seizure of 80 cannabis plants grown indoors and a grey-white powder, also found at the scene, confirmed the presence of naphthalene (which is commonly used as a pesticide) (Fucci, 2003). Unlike the cultivation of other plants, there is no control over or guidelines about the use of pesticides when growing cannabis due to its illegal status. Stambouli et al. (2005) noted a reduction in the average THC level of cannabis powder and of seized samples of cannabis resin (from an average THC level of 8.3% to 6%). The authors stated that this difference may be due to the process of manufacturing cannabis resin from cannabis powder, adulteration or the degradation due to the storage conditions of cannabis resin blocks.

[57] The active ingredient in cannabis and therefore THC is used as a measure of purity.

[58] 245 samples from 30 plots in three provinces of Morocco were analysed.

[59] This figure is based on 27 samples and therefore should be interpreted with caution.

[60] The Australian Crime Commission did not include data on purity of cannabis in their latest illicit drug data report.

7.2 Findings from studies reporting forensic analysis and case studies

There are a small number of peer reviewed papers which discuss adulteration of cannabis.

In Germany in 2008 there was a report of 29 patients admitted to hospital in the Leipzig area for lead poisoning as a consequence of smoking adulterated cannabis (Busse et al., 2008). Analysis of cannabis samples revealed the drug had been adulterated with lead to increase the drug weight by approximately one tenth. An anonymous screening programme undertaken after the source of lead poisoning was confirmed screened 145 individuals, of which 95 had blood lead levels which required treatment.

In 2006, Exley et al. conducted an investigation into the aluminium content of tobacco and cannabis products. They found that the aluminium content of two samples of cannabis ranged from 0.01% to 0.04%. The authors also showed that the aluminium content is biologically available (i.e. able to be absorbed into the body, rather than pass straight through) and may contribute to an increased risk of respiratory, smoking-related or neurological diseases.

In 2007 the Department of Health in the UK issued three health alerts about herbal (skunk) cannabis contaminated with microscopic glass particles[61,62,63]. In the May 2007 alert it was stated that approximately 5% to 10% of herbal cannabis seizures forensically examined were contaminated with glass, and in September 2009 the alert stated that there had been 151 cases in the UK and Ireland in the previous year. All alerts advised that cannabis users should stop using herbal cannabis to reduce their risk of adverse health effects as a result of smoking glass particles, and gave information on what to do if they did suffer an adverse reaction.

Verweij et al. (2000) analysed samples of cannabis in the Netherlands and found that all seven samples tested positive for mould cultures, with six of the seven testing positive for *penicillium* species. In the national drug report of the Netherlands for 2006 there was mention of further research conducted at the University of Leiden which confirmed the presence of bacteria and fungus in cannabis being sold in Dutch coffee shops[64] (van Laar et al., 2007).

In a study undertaken in Milwaukee, USA 24 cannabis samples were analysed for the presence of fungi and actinomycetes (Kurup et al., 1983); the findings showed that only one sample tested negative, although it was heavily contaminated with bacteria, and of the others the presence of various fungi and actinomycetes were confirmed. Half of the samples tested positive for *aspergillus flavus* (a fungus associated with aspergillosis of the lungs). Llamas et al. (1978) also produced a case report of an individual who developed allergic bronchopulmonary aspergillosis as a result of smoking cannabis contaminated with *aspergillus fumigates, aspergillus niger* and *aspergillus flavus.*

7.3 Chapter summary

Cannabis users believe that during cultivation the plants are typically sprayed with pesticides and other cultivation chemicals, particularly those grown indoors under hydroponic conditions. Cannabis is less likely to be adulterated than illicit drugs which are available in powder or tablet form. However, cases of adulterated cannabis do occur and in recent years there have been reports of cannabis adulterated with lead, aluminium and glass. In the Netherlands, where cannabis is legally sold in coffee shops, samples of cannabis bought from these establishments tested positive for mould cultures. Although cannabis is less likely to be adulterated, cannabis users are still at risk of potential adverse health effects due to adulterants.

[61] *www.cas.dh.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=100850*

[62] *www.cas.dh.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=100836*

[63] *www.cas.dh.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=100817*

[64] The research conducted by the University of Leiden was published in Dutch and therefore not directly referenced.

8. Other Illicit Drugs

For some other illicit drugs, such as ketamine, GHB and LSD, there is only a small amount of information relating to their adulteration. This may be because these drugs are not typically adulterated, are relatively new, are usually diverted from legitimate sources as opposed to clandestinely manufactured or because they are more commonly used as adulterants of other illicit drugs.

As with the previous chapters information on purity, forensic analysis and case studies are included where available.

8.1 Ketamine

Ketamine is an arylcycloalkylamine, a powerful anaesthetic used in humans (mainly in surgery) and animals. When taken recreationally it creates feelings of euphoria, dissociative psychedelic effects and at high doses can cause hallucinations. It is available as a tablet, powder or liquid. It is usually swallowed, snorted or injected. Ketamine itself does not present a great overdose risk, but the risk is much greater when mixed with other substances (including alcohol) (Wood et al., 2008).

Ketamine is not typically adulterated and the majority of ketamine that is found on the illicit market is diverted from legitimate sources (i.e. pharmaceutical companies, hospital and veterinary clinics) (Copeland & Dillon, 2005; EMCDDA, 2000). However, the UNODC reported an increase in clandestine ketamine laboratories in China from 17 in 2006 to 44 in 2007 (UNODC, 2009) and the Australian Crime Commission has reported an increase in ketamine seizures at border controls since 2004/05 (ACC, 2009).

Rather than being subject to adulteration, ketamine is often cited as a common adulterant of ecstasy or as a substance sold as ecstasy (ACC, 2009; Coomber, 1997e; EMCDDA, 2000; Sherlock et al., 1999; Shewan, Dalgarno & King, 1996; Tanner-Smith, 2006; UNODC, 2009). Ketamine has also been cited as an adulterant of methamphetamine (EMCDDA, 2009b). Kenyon et al. (2005) analysed illicit drugs handed in as part of a nightclub door amnesty. In London nine samples of ketamine powder were provided, with caffeine detected in five of the samples. In Manchester seven samples of ketamine powder were provided, no further details of their composition was provided and therefore it is assumed they did not contain caffeine.

8.2 Gammahydroxybutrate (GHB)

Gammahydroxybutrate (GHB; also known as 'liquid ecstasy' and 'liquid E') is synthesised as a liquid, and makes the user feel euphoric, drowsy and reduces inhibitions. It has sedative and anaesthetic effects and has been cited as a drug used in facilitated sexual assaults as it can cause unconsciousness. There is an increased risk of overdose when GHB is mixed with other substances (Liechti et al., 2006).

In a comparative paper examining the differences between GHB and pharmaceutical sodium oxybate (pharmaceutical GHB) the authors highlighted the differences in synthesis and manufacturing processes, with illicit GHB potentially more risky due to clandestine manufacture and therefore difficulties with the consumer having accurate information about dosage, drug composition and the presence of adulterants (Carter et al., 2009). The authors also noted that a few small alterations in the manufacturing of illicit GHB can result in the synthesis of GBL (γ-butyrolactone)[65] which has been shown to be more potent than GHB and could increase the risk of overdose.

8.3 Lysergic acid diethylamide (LSD)

Lysergic acid diethylamide (LSD) is a semi-synthetic psychedelic drug. LSD is a white powder, but is sold on the street as a liquid absorbed into small tablets or impregnated into small pieces of perforated paper, with each piece representing a dose. Purity data is not commonly reported and is therefore not included in this report.

Of all the illicit drugs LSD is considered to be least likely to be adulterated, somewhat due to its small size which does not facilitate adulteration. Brown and Malone (1976) found that over 90% of 746 LSD samples only contained LSD. Coomber (1997d) reported a perception amongst drug dealers that LSD was commonly adulterated with strychnine, although this has not been supported by forensic analysis.

[65] When GHB is consumed it converts to GBL, however, direct ingestion of GBL is thought to be more toxic than GHB.

In a report of the observations of staff at a medical facility in Haight-Ashbury, San Francisco, USA, the authors referred to the adulteration of LSD with methamphetamine and a substituted amphetamine (2,5-Dimethoxy-4-methylamphetamine or STP) (Smith and Rose, 1968). However, it is important to note that this study is limited given that no forensic analysis of the LSD was undertaken.

8.4 Chapter summary

The evidence presented in this chapter indicates that drugs which are typically diverted from legitimate sources rather than clandestinely manufactured, such as ketamine and GHB, are less adulterated. In the case of ketamine it is more likely to be an adulterant of other illicit drugs, particularly ecstasy. Clandestine manufacture of GHB can lead to the synthesis of GBL, a more toxic form of the drug. The reports of adulteration of LSD are not supported by forensic analysis, therefore indicating that this drug is not typically adulterated.

9. Public Health Response and Harm Reduction Messages

This section briefly outlines proposed steps of a suggested public health response to adulterated drugs. Harm reduction messages and techniques are also discussed in this section.

9.1 Public health response

The public health consequences related to the use of adulterated drugs are wide ranging and vary according to the drug used and the specific adulterant. However, there is very little published on the public health responses and their effectiveness[66]. Illicit drug adulteration is typically brought to the attention of health or drug services as the result of a disproportionate number of drug users becoming ill or the presentation of drug users with atypical symptoms. Suggested steps in a response to these incidences, and issues of concern at each stage, are discussed below. Refinement of emergency response plans should be undertaken by those responsible for health protection (in a specific country, state or area as appropriate) and rely on accurate information and good methods of communication. The information below is a brief guide to the possible components of a response.

Immediate response

When adverse health effects and/or fatalities due to drug adulteration are suspected an immediate assessment and response is required to manage risk and minimise harm. At this stage the adulterant may not have been confirmed and a generic response should be made in absence of knowing exactly what the adulterant is or how the adulteration occurred. The response should be proportionate and realistic reflecting an accurate appraisal of the supporting evidence. See dissemination of information below for the type of information that should be included in a warning campaign.

Specific response

Once knowledge about the adulterant has been refined and the suspected source confirmed (through analysis of adulterated samples of illicit drugs or serum of affected individuals), the immediate response materials should be updated with either confirmation of the previous information or provision of new information.

Dissemination of information

Information should be shared amongst all relevant health agencies in contact with drug users (A&E, primary health care, drug support and treatment agencies, needle and syringe programmes, sexual health services, poison control centres etc), the police, community wardens, criminal justice services, coroners' office and any other organisation considered appropriate. Specific decisions in relation to information releases via the media should be made in relation to the target audience i.e. drug users, families/friends of drug users or others, and developed accordingly.

Materials should be targeted towards the particular group vulnerable to this adulteration (e.g. cocaine users, injecting drug users), use accessible terminology and be provided in multiple languages (where required). The materials should include information about:

- The (potential) adulterant and (suspected) source
- Potential harm(s)
- Spread of contamination (and how to avoid further spread)
- Guidance for drug users and those in contact with drug users (including how to identify someone who has been affected by the adulterant)
- Alternative routes of drug administration
- Information regarding available treatment and support

[66] A recent study conducted in the Netherlands evaluated the effectiveness of a warning system for contaminated cocaine (Keijsers, Bossong & Waarlo, 2008). The study found that changes were required in warning protocols to improve communication and make clear roles and responsibilities of different agencies/individuals. Coverage of the warning was also improved through contact with new organisations/agencies.

- Treatment and emergency response
- Further dissemination of the warning to relevant organisations
- Who or where to contact for further information

Organisations with direct contact with drug users should disseminate this information, along with appropriate harm reduction advice to drug users. Health organisations, and specifically drug support/treatment agencies, play an important role in the dissemination of information about drug adulteration incidents to drug users with reading and language difficulties and those without access to the internet or traditional media sources. Drug users should also be asked to further pass these messages on to their peers (particularly those not in contact with drug services). Basic, factual resources should be provided to drug users (e.g. card/small leaflet) containing the main warning and advice points regarding the adulteration to ensure accurate dissemination across user groups.

Treatment

Emergency treatment for a person affected by drug adulteration presents a significant challenge for emergency treatment personnel given that the individual may not admit to drug use, may not suspect that their drug was adulterated or may not be able to tell emergency personnel anything about what they have used. It is important for all emergency and frontline medical personnel to have access to information about typical adulteration practices, to consider that an individual may present with symptoms atypical for the drug they are believed to have ingested and to be able to recognise, diagnose and treat accordingly.

Review and debrief

Once the adulteration incident is considered under control it is important that all organisations, agencies and individuals involved in the identification of the adulterant, treatment and care of those exposed to the adulterant, and the dissemination of advice and guidance about the adulterant to debrief and review the process. This group should consider:

- Methods for better prevention, earlier identification of adulteration should it reoccur (if possible)
- Usefulness of the advice, guidance and materials disseminated and ensure they are ready and up-to-date for use in the future
- Whether the correct agencies, organisations and individuals were involved in the guidance development and dissemination process
- The ongoing messages to those vulnerable to the adverse effects of adulterated drugs
- The overall effectiveness and coordination of the response

Box 7: The Health Protection Agency, UK

In the UK the Health Protection Agency (HPA) is an independent organisation, set up by government in 2003, to protect the public from threats to their health from infectious diseases and environmental hazards. It does this by providing advice and information to the general public, to health professionals such as doctors and nurses, and to national and local government[67]. Their work has included advice and information in the area of illicit drug adulteration and associated health impacts, most recently publishing information related to the recent outbreak of anthrax amongst injecting heroin users.

The HPA is a specialist organisation. This type of organisation is not present in every country. Their published resources may contribute to the development of emergency response protocols in other countries/areas.

[67] See: *www.hpa.org.uk/HPA/*

9.2 Harm reduction messages and techniques

Drug users, drug dealers and the general public are often aware that illicit drugs are commonly adulterated with other substances, compounds or bacteria, but there is confusion about which adulterants are typically present (Best et al., 2004; Coomber, 1997c, 1997e, 1999). The need for advice for drug users is twofold; (1) there is a requirement for drug users to regularly be made aware of and given advice about typical illicit drug adulteration and the potential adverse health effects that may result, and, (2) when a batch of adulterated drugs causing serious health consequences and death comes into circulation, specific advice and guidance about this drug should be disseminated (see Section 9.1). This section details harm reduction messages and techniques, the target audience of the messages are also detailed (these lists are suggestive, not exhaustive).

Early warning systems and surveillance should be employed internationally, nationally and locally

Target audience: *Emergency medical personnel, general health professionals, drug treatment agencies, needle and syringe programmes, harm reduction specialists/educators, policy makers, public health organisations, sexual health and outreach, police, health protection organisations, poisoning control centres, infectious disease centres, coroners*

An early warning system to identify adulterants and report adverse effects rapidly, similar to the process used by the EMCDDA to identify trends in the use of new substances[68] would be useful. A system of this type would enhance understanding of, and public health responses to, illicit drug adulteration. Improvements in international data sharing through such a system could assist in dispelling myths about adulteration and improve timely public health advice. This system could also include surveillance of new trends in drug use linked to new population groups (such as immigrants).

An early warning system would not only be useful internationally but also nationally and locally. Poison control centres, drug enforcement agencies and forensic science agencies in many countries routinely test and monitor illicit drug samples. However, adulteration findings are not routinely published to allow trend analysis and investigation of changes in adulteration practices. Additionally, much of the reported findings of adulteration do not facilitate comparison by area or over time.

Locally, health and drug agencies conduct informal case control and highlight anything unusual regarding illicit drug composition or the effects of drug use in their area. Questions about physical properties of the drugs, administration techniques and changes in dealer/locality for purchasing drugs should be asked of anyone reporting atypical effects of drug use.

Evidence-based interventions that respond to drug adulteration are required

Target audience: *Emergency medical personnel, general health professionals, drug treatment agencies, needle and syringe programmes, harm reduction specialists/educators, primary health care, community health care, policy makers, public health organisations, police, health protection organisations, poisoning control centres, infectious disease centres, coroners*

Research examining public health and evidence-based responses to drug adulteration is scarce (Keijsers, Bossong & Waarlo, 2008). Published analysis and assessment of previous practices and protocols used would enhance understanding and improve techniques used to respond to adulteration incidents. Information about the effectiveness of communication strategies across public health systems, relevant organisations and drug users would provide a basis for others to build their own strategies upon. Additionally, analysis and development of the dissemination of warnings and advice about drug adulteration through drug users peer networks could have wider public health and harm reduction benefits.

[68] The early warning system provides a quick response when new psychoactive drugs are identified. For more information, see: *www.emcdda.europa.eu/themes/new-drugs/early-warning*

Dissemination of information and advice regarding adulterated drugs

Target audience: *Drug users, families/friends of drug users, emergency medical personnel, general health professionals, drug treatment agencies, needle and syringe programmes, harm reduction specialists/educators, policy makers, public health organisations, sexual health and outreach, lesbian, gay and transgender support services, police, health protection organisations, poisoning control centres, infectious disease centres, coroners, general public*

Drug users require education about the risks associated with their drug(s) of choice, and of the potential adulterants which may be present in these drugs. Harm reduction messages should be specific to the vulnerable population, as too should the methods of delivery of these messages i.e. through needle and syringe programmes, treatment agencies and outreach services as well as the media, general health establishments and hospitals.

Staff at accident and emergency services are often the first to come into contact with an individual who has been affected by adulterated drugs (for example, Dimanno et al., 2008; O'Sullivan & McMahon, 2005; Perrone et al., 1999) and they play an important role in dissemination of this information to drug treatment services, other health professionals and the police. Once the distribution of adulterated drugs causing serious adverse health effects has been confirmed it is typical for the public health agencies, police and drug treatment services to issue warnings[69,70].

Warnings about adulterated drugs should be factual and should not use ambiguous terminology such as 'rogue heroin', 'bad heroin' or 'dirty cocaine'[71,72,73]. Drug treatment services should be equipped to disseminate information when adulterated drugs are found to be in circulation. Also, messages on how to identify adulterants (if it is possible without forensic analysis) or testing of drugs should be given to users.

Where the biggest risk is to those who are injecting drugs, harm minimisation advice about alternative methods of administration should be provided. While a specific route may be less dangerous overall (for example smoking rather than injecting) the less dangerous route may have associated adverse health effects due to the drug or specific adulterants. Where alternative methods of administration are advised there is a need to highlight the potential effects to drug users. It is important to consider that some individuals may not be able to stop injecting and therefore advice about safer injecting practices should also be disseminated.

Illicit drugs may be synthesised for specific routes of administration

Target audience: *Drug users, families/friends of drug users, emergency medical personnel, general health professionals, drug treatment agencies, harm reduction specialists/educators, policy makers*

Analysis of the patterns of adulteration in recent decades shows that a certain amount of changes in adulteration may be due to customer preferences (de la Fuente, 1996; Furst, 2000). There is also evidence to suggest that specific adulterants are added to drugs specifically to facilitate smoking, and that administration of these drugs via another route (e.g. through injection) may cause adverse health effects (Eskes & Brown, 1975; Furst, 2000; Huizer, 1987; Risser et al., 2007). It is important for treatment services, emergency services and other relevant organisations to be aware and disseminate health messages about the potential health consequences when these substances become available amongst injecting drug users.

[69] *www.news.bbc.co.uk/1/hi/england/kent/3202094.stm*

[70] *www.news.bbc.co.uk/1/hi/england/2883449.stm*

[71] *www.news.bbc.co.uk/newsbeat/hi/health/newsid_7693000/7693575.stm*

[72] *www.news.bbc.co.uk/1/hi/scotland/3100937.stm*

[73] *www2.news.gov.bc.ca/news_releases_2005-2009/2008HLS0027-001879.htm*

Toxic gasses and waste products can be created during illicit drug manufacture

Target audience: *Drug users, families/friends of drug users, emergency medical personnel, first response teams, general health professionals, policy makers, police, chemical disposal teams*

The manufacture of illicit drugs (particularly methamphetamine) creates waste products, which are not commonly disposed of in a legal and proper manner, and areas which may require decontamination (Holton, 2001). In addition to the direct risks for those manufacturing the illicit drugs and those residing in close proximity to the laboratory (Danks et al., 2004; Lineberry & Bostwick, 2006), there are also risks for emergency personnel and police who attend these scenes (Centers for Disease Control and Prevention, 2000; Lineberry & Bostwick, 2006; McFadden, Kub & Fitzgerald, 2006). First response teams and police who attend illicit drug manufacture sites should receive training on how to recognise and protect against exposure to toxic gasses, waste and contamination from the laboratory. Guidance outlining safe procedures for disposal of waste products, dismantling of laboratories and decontamination are issued by the Government/state health agencies of many countries[74]. This guidance is an essential part of public safety for those involved in the clean up after discovery of a methamphetamine laboratory.

Emergency and drug treatment personnel must be aware of typical patterns of adulteration

Target audience: *Emergency medical personnel, general health professionals, drug treatment agencies*

In order to enhance both emergency and longer term treatment for drug use it is important that first response teams, emergency medical personnel, general health professionals and drug treatment staff have access to information and are aware of the effect of adulterants when treating drug users. To enhance the early identification and diagnosis of health effects caused by illicit drug adulterants the awareness of typical and atypical signs of drug overdose, poisoning and bacterial infections caused by drug adulteration should be increased amongst emergency and frontline medical staff. Expertise should be built through professional development and illicit drugs experts amongst staff. Addressing the potential effects of adulterants with regard to their physical and psychological health effects, and their effects on drug treatment, can reduce the risk of long term health consequences and failure of drug treatment. When drug adulteration is suspected, where possible, samples of illicit drugs should be tested along with the serum of the affected individual.

[74] For example: *www.dhss.mo.gov/TopicsA-Z/MethLabCleanupGuidelines.pdf*

10. Summary

10.1 Evidence summary

This document has reviewed the evidence for the presence of adulterants in illicit drugs, namely heroin, cocaine and crack cocaine, amphetamine and methamphetamine, ecstasy, cannabis, GHB, ketamine and LSD. The evidence suggests that illicit drugs are more commonly adulterated with benign substances (such as sugars), substances that will enhance or mimic the effects of the illicit drug (such as quinine in heroin) or substances that will facilitate the administration of illicit drugs (such as caffeine in heroin and cocaine which facilitates smoking). This assessment of the available evidence supports research undertaken in this area (Coomber, 1997a, 1997b, 1997c, 1997d, 1997e, 1999, 2006) that reports of the routine adulteration of illicit drugs with 'dangerous'[75] substances are a myth.

Reports of the purposeful adulteration of illicit drugs with toxic substances were identified, including the adulteration of heroin with strychnine. However, when further investigated, the amount of strychnine was not found to be present in life-threatening quantities and as the substance has been shown to increase the retention of heroin when volatized (Huizer, 1987), it is assumed that its purpose was to facilitate drug administration rather than malicious intent. However, this is not an assurance that the use of strychnine and other poisons in illicit drug manufacturing does not have the potential to cause serious health issues. There are particular concerns about the addition of phenacetin to cocaine and crack cocaine, an analgesic which has been linked to bladder and kidney cancer. Cannabis was found to be less likely to be adulterated than illicit drugs sold in powder or tablet form, but reports of cannabis adulterated with lead, aluminium and glass in recent years highlight the potential health risks of adulterants to cannabis users. The evidence indicated that LSD is not typically adulterated and there was little evidence identified for the adulteration of ketamine and GHB, which are typically diverted from legitimate sources. Ketamine was found to be more likely to be used as an adulterant in other illicit drugs. The evidence identified from case reports illustrates that adverse health effects or death due to adulterated drugs are commonly due to poisoning, poor manufacturing techniques, poor storage or packaging, or related to the effects of other substances sold as the illicit drug (for example, PMMA and/or PMA sold as ecstasy). Bacterial infections attributed to illicit drug adulteration were most common amongst injecting drug users (particularly heroin and cocaine injectors). The recent outbreak of anthrax in the UK provides an example of a public health response to an adulteration incident and examples of the types of information which should be disseminated in such an event and the variety of audiences who could receive the information.

10.2 Limitations of the evidence

Reports of drug adulteration were examined from worldwide sources and revealed the lack of standardised forensic analysis and reporting practices. Representative sampling of illicit drug samples is not routinely undertaken to quantify and qualify the extent of adulteration; most forensic analysis is undertaken for legal reasons to provide evidence for prosecution. The case reports, where the information typically comes from health services or coroners, identified indicated that analysis of drug samples is not routinely undertaken or that drug samples may not be available for analysis. The majority of analysis is undertaken retrospectively following either a drug seizure or an adverse health effect in an individual or group of drug users. Specifically, the lack of standardised analyses, reporting and, in some cases, lack of detailed reporting, created difficulties in comparing adulteration practices over time and by country.

The majority of analysis techniques identify which additional substances are present in samples of illicit drugs but do not report on the overall composition of the drug and the proportions of adulterants found. Also, it is not standard practice to report the percentage of samples which contain no adulteration. Both of these pieces of information would provide further useful information about adulteration practices. However, it is understood that financial implications may prevent routine analysis beyond the identification of the primary drug and adulterants.

This document specifically focused on the adulteration of illicit drugs, however substances, including tobacco, alcohol, prescription medicines and legal highs, may also be illicitly manufactured and subject to risks associated with contamination, adulteration and dilution. For example, the World Health Organisation[76] estimates that up to 1% of prescription medicines available in developed countries may be counterfeit.

[75] Coomber acknowledges that illicit drugs are dangerous substances. However in this context he is referring to substances such as brick dust, talcum powder, rat poison, ground glass and household cleaning products.

[76] *www.who.int/mediacentre/factsheets/fs275/en/index.html*

Box 8: Future considerations

Surveillance and monitoring

Improved surveillance of illicit drug adulteration could dispel myths and ensure timely medical treatment and prevention is implemented where necessary

Overall, there is a requirement for improved surveillance of illicit drug adulteration. In order to address the public health consequences of drug adulteration, improvements in international data sharing and collaborative working across the many disciplines that may come into contact with illicit drugs and drug users are required. Creating links between public health principles, analytical expertise, community-based professionals and the police could enhance the dissemination of messages regarding illicit drug adulteration, dispel myths and improve the provision of effective, and timely, public health advice.

A set of quality assured, robust and rehearsed interventions and information dissemination strategies would enhance public health and the quality and effectiveness of responses to illicit drug adulteration incidents

There is a lack of information providing structured advice on responses to the consequences of illicit drug adulteration. A set of quality assured, robust and rehearsed interventions and communication strategies would provide a basis for response for a wide variety of organisations.

Media warnings

Research into the usefulness of media warnings about adulteration of illicit drugs is required

In the UK alone police warnings about 'dirty' drugs and 'rogue' heroin are commonly made through the media, however, there is very little evidence about their usefulness in accurately informing drug users about the health consequences of adulteration. Media reports can potentially perpetuate scare mongering and reinforce myths regarding illicit drug adulteration. Research investigating the usefulness of these warnings with illicit drug users would enhance our understanding of the information requirements of drug users in relation to drug adulteration and potentially improve reporting practices.

Drug users

Drug users should be made aware of the relative and inherent risks associated with drug use and the potential health effects that may arise from adulteration

In addition, to health problems caused by adulterated drugs, users may experience serious health problems as a result of bacterial contamination through unsterile equipment used for administration or contamination of diluents used to prepare illicit drugs for injection. In the event of an outbreak of a bacterial infection it is important for users to be made aware of the relative and inherent risks associated with different routes of administration, including the potential harms caused by different methods of injecting. Alternative routes of administration should also be detailed, such as rectal administration and smoking.

Healthcare workers

Hospital emergency staff should be appropriately trained and equipped to respond to adverse health effects suspected to be caused by adulteration of illicit drugs

Hospital emergency staff and other frontline emergency personnel are often the first professionals encountered by those experiencing adverse health effects due to adulterated drugs. It is therefore important that emergency personnel are sufficiently trained and equipped to respond appropriately in cases where use of adulterated drugs is suspected, and to disseminate this information to poison control centres, drug treatment agencies and where necessary to drug users. These individuals should be made aware of typical health reactions associated with illicit drugs so that they can recognise and diagnose atypical reactions and investigate the potential for effects of adulterants.

Advice should be provided to those working with drug users about the risks of cross-contamination and infection from coming into contact with adulterated drugs and users of adulterated drugs, and the steps they can take to protect themselves

Providers of drug treatment services are at risk of cross-contamination (mainly an issue for methamphetamine manufacture exposure) and infection through contact with adulterated drugs and users of adulterated drugs. Advice provided should outline how healthcare workers can best protect themselves and what steps should be taken if they come into contact with adulterated drugs and users of these drugs. For example, in the case of the recent anthrax outbreak in the UK advice was circulated about the use of protective equipment when treating a potentially infected individual or when handling any potentially contaminated heroin.

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Appendix 1 - Glossary

Acetic acid	A weak organic acid used in the production of vinegar. Diluted acetic acid is often used in descaling agents.
Acetone	Simplest example of the ketones, a solvent and active ingredient in nail polish remover.
Actinomycetes	Pathogenic actinobacteria, the leading killer of humans being *Mycobacterium tuberculosis (the causative agent of most cases of tuberculosis)*.
Aflatoxin	A naturally occurring mycotoxin produced by fungus, they are toxic and carcinogenic.
Agranulocytosis	An acute condition involving a severe and dangerous leukopenia (severe lack of one major class of infection-fighting white blood cells). Causes high risk of severe infection due to immune system suppression.
Allergic bronchopulmonary aspergillosis	Relatively rare lung disease – characterised by a hypersensitive immune system response to fungus (most commonly *Aspergillus*).
Anthrax	A bacterium which creates spores which can infect the body through three forms: skin, inhalation or gastrointestinal. It produces lethal poisons and can cause death.
Antipyrine	The American adopted name for phenazone; an analgesic (painkilling) and antipyretic (fever-reducing) compound.
Arsenic	A poisonous metalloid.
Ascorbic acid	A soluble sugar acid, also known as Vitamin C.
Assay analysis	Analysis of the activity of a drug or biochemical in an organic sample.
Barbitone	Also known as barbital; a barbiturate used as a sleeping aid.
Benign adulteration	Adulteration with non-harmful substances.
Benzylpiperazine (BZP)	A recreational drug with euphoric, stimulant properties. Reported to have similar effects as ecstasy and methamphetamine.
Bio-typing analysis	Determination of the genotype group of the organism(s).
Bupivacaine	A local anaesthetic drug belonging to the amino amide group, trade name Marcain.
***Candida* endophthalmitis**	Intraocular fungal infection.
Citric acid	A weak organic acid, used to aid the solubility of illegal substances in the preparation for intravenous injection.
Clenbuterol	A decongestant and bronchodilating drug with stimulant properties.
Dextromethorphan (DMX)	An antitussive (cough suppressant) drug. When exceeding label-specified maximum dosages, DMX acts as a dissociative hallucinogen.
Diazepam	A benzodiazepine derivative drug used to treat anxiety disorders, muscle spasms and alcohol withdrawal. Has hypnotic, sedative, anticonvulsant and amnestic properties. Trade name Valium.
Diethyl ether	Also known as 'ether', a common solvent and was once used as a general anaesthetic.
Diltiazem	A calcium channel blocker (benzothiazepine) used in the treatment of high blood pressure, angina and some heart rhythm disorders.
Flameless atomic-absorption spectrophotometry	Technique to analyse trace metal elements in aqueous solutions.
Gammahydroxybutrate (GHB)	Sedative, anaesthetic drug which produces feelings of euphoria, drowsiness and reduces inhibitions.
Griseofulvin	An antifungal drug used to treat ringworm and fungal infections of skin, nails and hair. Trade name Grisovin.
Hydroxyzine	First generation antihistamine.
Isosafrole	An organic chemical precursor to MDP2P which is converted to MDMA. Similar smell to aniseed or liquorice.
Lactose	A sugar found in milk.

Leuckart method	A commonly used amphetamine and methamphetamine manufacturing method.
Levamisole	An anthelmintic medication used as a dewormer.
Lidocaine	A local anaesthetic and antiarrhythmic drug.
Lysergic acid diethylamide (LSD)	A semi-synthetic psychedelic drug.
Lysine acetylsalicylate	Soluble form of acetylsalicyclic acid, otherwise known as aspirin.
Mannitol	A sugar alcohol.
Methanol	The simplest alcohol, also known as methyl alcohol; used as anti-freeze, solvent and a denaturant for ethanol.
Methaqualone	A sedative-hypnotic drug and a general CNS depressant, trade name Mandrax.
Methemoglobinemia	A blood disorder where excessive levels of haemoglobin are present in the blood (and therefore oxygen-carrying ability is reduced). Can cause tissue hypoxia.
MBDB ([N-methyl-1-(3,4-methylenedioxyphenyl) -2-butanamine])	Related analogue of MDMA (see below).
MDA (3,4-Methylenedioxyamphetamine)	Related analogue of MDMA (see below).
MDEA (N-methyl-diethanolamine)	Related analogue of MDMA (see below).
MDMA (3,4-Methylenedioxymethamphetamine)	A synthetic drug chemically similar to amphetamine. Commonly referred to as 'ecstasy'.
Methylsulfonylmethane (MSM)	A substance used as an industrial solvent and also marketed as a dietary supplement.
Microbiological analysis	Study of microorganisms or microscopic organisms.
Molecular typing analysis	Molecular identification of organisms present in sample.
Niacinamide	Also known as 'Nicotinamide', a water-soluble B-complex vitamin (B3).
Noscapine	An alkaloid from the poppy plant, used primarily for its cough suppressant effects. It can survive the manufacturing process of heroin.
Paramethoxyamphetamine (PMA)	A psychoactive drug producing stimulant and psychedelic effects.
Paramethoxymethamphetamine (PMMA)	A stimulant drug related to PMA, but with effects more similar to MDMA.
Phenacetin	An analgesic substance now banned in many countries due to its carcinogenic and kidney-damaging properties.
Phenazone	An analgesic (painkilling) and antipyretic (fever-reducing) compound.
Phendimetrazine	A stimulant drug used as an appetite suppressant.
Phenobarbital	Also known as phenobarbitone; a barbiturate used as an anticonvulsant, also has hypnotic and sedative properties.
Phenolphthalein	A chemical compound that turns colourless in acidic solutions and pink in basic solutions. It was previously used as a laxative, but now has been removed from over-the-counter laxatives due to carcinogenicity concerns.
Phenylpropanolamine	Also known as norephedrine; a psychoactive drug with stimulant, decongestant and anorectic properties.
Phenytoin	A commonly used anticonvulsant used in the treatment of epilepsy.
Piperonal	Aromatic aldehyde used in flavouring and perfume. May be used in the synthesis of 3,4-methylenedioxyamphetamine (MDA).
Piracetam	A nootropic supplement, a cyclic derivative of GABA.
Procaine	A local anaesthetic of the amino ester group, trade name Novocain.
Pulmonary granulomas	Minute, granular, inflammatory lesions caused by granulomatous diseases (e.g. tuberculosis).
Quinine	An antimalarial and muscle relaxant medication. Also synthesised as an ingredient of tonic water.

Reductive amination	An organic reaction converting a carbonyl group to an amine, via an intermediate imine.
Saccharose/Sucrose	Organic compound commonly known as table sugar.
Safrole	A colourless or slightly yellow oily liquid obtained from sassafras oil, or synthesized from other related methylenedioxy compounds. A precursor in the synthesis of MDMA.
Salicylate	Salts and esters of salicylic acid.
Scopolamine	A tropane alkaloid drug with anticholinergic, anti-muscarinic properties. Used in the treatment of motion sickness, nausea and intestinal cramping.
Serratia liquefaciens	A typical phytosphere bacterium that is found on a wide range of plants and is known to have beneficial antifungal properties.
Serum bioassay	Measurement of the effects of a substance from bodily fluid.
'skim'	Sell slightly underweight amounts of drugs.
Strychnine	A very toxic, colourless, crystalline alkaloid. Commonly used as rat poison.
Xylazine	An antagonist used as a veterinary sedative.
Zinc protoporphyrin	Compound present in red blood cells used to screen for lead poisoning or iron deficiency.

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April 2010

ISBN: 978-1-907441-47-9 (print)
ISBN: 978-1-907441-48-6 (pdf)