

Institution: University of Dundee		
Unit of Assessment: UoA 12 Engineering		
Title of case study: Development of ground truth datasets of controlled substances to understand Global drug use		
Period when the underpinning research was undertaken: 2014 onwards		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Niamh Nic Daeid	Professor of Forensic Science	2014 onwards
Craig McKenzie	Senior Lecturer in Forensic Chemistry	2016 onwards
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

The illicit production and supply of synthetic drugs is one of the largest challenges facing forensic drug chemists, law enforcement agencies, prison services and policy makers globally. Working with multiple law enforcement and forensic science organisations, our research has been directly used to:

1. Create ground truth datasets underpinning analysis of novel drug samples for forensic laboratories;
2. Identify and prevent drugs entering Scottish prisons; and
3. Provide intelligence to the national and international forensic drug community.

2. Underpinning research

The global illicit drug market is complex and diverse. There have been many changes in the last 10 years in particular in regard to the nature of drug types now prevalent across the globe. The rise in the production of novel psychoactive substances (NPS) as a means to circumnavigate existing Global drug legislation has posed serious challenges to forensic drug chemists as they struggle to maintain a knowledge base to identify these novel compounds. The research undertaken at the University of Dundee is novel, distinctive and ground-breaking in three ways.

Firstly, under our Home Office licence we have synthesised a range of New Psychoactive Substances (NPS) and as a consequence developed a bespoke ground truth dataset of these samples [R1, R2]. These samples have been characterised using a range of analytical techniques which have generated a scientifically robust and reproducible data set which allow for identification in a comprehensive manner. This collection of bespoke and unique samples has facilitated the development of methods to understand the toxicological interpretation of, for example, poly drug use. Our work on similar samples has particular implications for policy development for drug use in wider society by contributing to legislative controls. The data are shared with forensic chemists and forensic toxicologists, through publication and direct data sharing with practitioners.

Secondly, we have co-published a number of research outputs [R3-R5] with colleagues in the Scottish Prison Service (SPS) which address the characterisation of constantly changing synthetic drugs known as synthetic cannabinoid receptor agonists (SCRAs), often referred to as 'spice'. Their use results in high levels of disruption to normal prison life and results in

unpredictable harms to prisoners. SCRAAs are dissolved in volatile solvents and soaked into paper, card or clothing and are sent into prisons via the mail system where they are then placed in e-cigarettes and vaped. Many of these compounds circumvent the existing drug legislation and pose a significant risk to the drug user population because their potency and effects are largely unknown. The research has generated a comprehensive dataset of analytical information which characterises samples prepared using all 8 currently known clandestine methods for the synthesis of methamphetamine and 5 clandestine methods for the synthesis of ecstasy (in excess of 250 bespoke materials). We have also generated characterisation data for a range of NPS samples which include fentanyl, synthetic cannabinoids and cathinone derivatives.

Finally, given our research base we developed early published methods for the analysis of emerging NPS compounds and were commissioned to author the first United Nations guidance for the analysis of these compounds using the analytical method developed by **NicDaeid** and this remains a UN recommended analysis in the second edition of the guidance translated into 5 languages [R6].

3. References to the research

[R1] McKenzie, C, Sutcliffe, OB, Read, K, Scullion, S, Epemolu, R, Fletcher, D, Helander, A, Beck, O, Rylski, A, Antonides, L, Riley, J, Smith, S & Nic Daeid, N (2018) 'Chemical synthesis, characterisation and in vitro and in vivo metabolism of the synthetic opioid MT-45 and its newly identified fluorinated analogue 2F-MT-45 with metabolite confirmation in urine samples from known drug users', *Forensic Toxicology*, vol. 36, no. 2, pp. 359-374. DOI: [10.1007/s11419-018-0413-1](https://doi.org/10.1007/s11419-018-0413-1)

[R2] Antonides, LH, Cannaert, A, Norman, C, Vives, L, Harrison, A, Costello, A, Nic Daeid, N, Stove, C, Sutcliffe, O & McKenzie, C (2019) 'Enantiospecific synthesis, chiral separation and biological activity of four indazole-3-carboxamide-type synthetic cannabinoid receptor agonists and their detection in seized drug samples', *Frontiers in Chemistry*, vol. 7, 321, pp. 1-20. DOI: [10.3389/fchem.2019.00321](https://doi.org/10.3389/fchem.2019.00321)

[R3] Norman, C, Walker, G, McKirdy, B, McDonald, C, Fletcher, D, Antonides, LH, Sutcliffe, OB, Nic Daeid, N & McKenzie, C (2020) 'Detection and quantitation of synthetic cannabinoid receptor agonists in infused papers from prisons in a constantly evolving illicit market', *Drug Testing and Analysis*, vol. 12, no. 4, pp. 538-554. DOI: [10.1002/dta.2767](https://doi.org/10.1002/dta.2767)

[R4] Antonides, LH, Cannaert, A, Norman, C, Nic Daeid, N, Sutcliffe, OB, Stove, CP & McKenzie, C (2020) 'Shape Matters: The Application of Activity-Based In Vitro Bioassays and Chiral Profiling to the Pharmacological Evaluation of Synthetic Cannabinoid Receptor Agonists in Drug-Infused Papers Seized in Prisons', *Drug Testing and Analysis*, vol. 13, no. 3, pp. 628-643. DOI: [10.1002/dta.2965](https://doi.org/10.1002/dta.2965)

[R5] Norman, C, McKirdy, B, Walker, G, Dugard, P, Nic Daéid, N & McKenzie, C (2021*) 'Large-scale evaluation of ion mobility spectrometry for the rapid detection of synthetic cannabinoid receptor agonists in infused papers in prisons', *Drug Testing and Analysis*, vol. 13, no. 3, pp. 644-663. DOI: [10.1002/dta.2945](https://doi.org/10.1002/dta.2945)

[*First published 15 October 2020]

[R6] United Nations. Office on Drugs and Crime (2020). *Recommended methods for the Identification and Analysis of Synthetic Cathinones in Seized Materials*, Vienna: United Nations, ST/NAR/49-Rev.1. Available at: <https://www.unodc.org/unodc/en/scientists/recommended-methods-for-the-identification-and-analysis-of-synthetic-cathinones-in-seized-materials.html> [Accessed 19 March 2021].

4. Details of the impact

The overarching impact of this research lies in the enhancement of the capabilities of law enforcement agencies and forensic providers to deal with matters relating to (1) understanding illicit drug production; (2) drug detection in the field and specifically within prisons; and (3) influencing of policy and analytical processes to facilitate the understanding and analysis of new and emerging drug compounds nationally and internationally through interactions with organisations such as the Advisory Council on the Misuse of Drugs (ACMD) and the United Nations Office on Drugs and Crime (UNODC).

4.1. The development of ground truth datasets underpinning analysis of novel drug samples by forensic chemists: The chemical nature of NPS samples changes on a regular basis making their identification challenging for forensic chemists. It also means that the provision of standard reference materials used to confirm the identity of seized samples are often not available when the samples are seized and that the toxicological analysis of emerging NPS is largely unknown. The expertise of the team has generated comprehensive analytical information enabling the identification of novel SCRA compounds which are then submitted to the national and international drug early warning systems.

This work has:

- (a) enabled the markers for specific ways of making the drug compounds to be identified and has been used in casework for the corroboration of synthetic methods;
- (b) facilitated the identification of illicit materials at point of response within the Scottish Prison Service using Rapiscan libraries validated by the University of Dundee team [E5, E7];
- (c) provided characterisation information for drug compounds and metabolites particularly for the metabolism of polydrug use (where more than one drug is ingested at the same time). This data has been used for example, by the Karolinska Institute in Sweden (Sweden's top University and one of the most respected medical institutes globally and host to the Nobel Assembly) to inform the re-analysis of existing postmortem samples where our identified metabolites were subsequently indicated, confirming a particular compound had been ingested [R1,R3];
- (d) provided information on novel drug compounds to the UK and international early warning systems collated by the European Monitoring Centre for Drugs and Drug abuse (EMCDDA), the World Health Organisation (WHO) and United Nations Office of Drugs and Crime (UNODC). Early warning systems provide information to front line forensic drug chemists to aid in the identification of new compounds where standard reference samples may not be available:

*To date, data from the Project has been cited in the critical review documents prepared by the World Health Organisation (WHO), **leading to the global ban [on the] production and export of two SCRA**s (5F-MDMB-PICA and 4F-MDMB-BINACA). [E5, E8, E9]*

4.2. The development of new understanding of drug use in prisons: There are 17 prisons in Scotland housing approximately 7,500 inmates in 2020 and approximately 40% of prisoners admitted to drug use (2017 figures). We have established a strong relationship with the Scottish Prison Service, leading to the development of evidence-led intelligence to support operational decision making. This includes the development of protocols for safe handling of prison mail by prison officers and the development of sampling methodologies for prison mail, as well as other procedures such as cell entry:

It has helped to provide an evidence base for the safety procedures to adopt in cell entry, searching and post room screening procedures [E6].

The research has also formed the basis for understanding the health implications to prison officers in regard to exposure to NPS materials, helping to define new safety procedures within UK prisons – these have been described by the prison service as “*invaluable, particularly at a time when staff concerns were heightened around the impact on their well-being*” [E5].

We have analysed samples seized within Scottish prisons since June 2018. As of the 25th August 2020 more than 800 samples from 543 separate drug seizures have been received for testing with 62.6% of samples testing positive for SCRA. Often SCRA detected in papers are present as mixtures of two, three or, on one occasion four SCRA. This work has allowed us to undertake trend predictions for SPS, identify and report new drug materials and expand the work to include the detection and monitoring of novel benzodiazepines in a prison context as they emerge [E7]. Several emerging SCRA were detected for the first time in Scottish prisons between May 2020 and August 2020 as a result of routine monitoring and our collaboration has facilitated a highly reactive response to emerging drug threats and to operational matters relating to drug detection:

Understanding local, national and international trends in the SCRA market is essential in ensuring the continued effectiveness of... systems to detect emerging drugs in prisons. The work... pre-empts the appearance of new drugs which might not alarm on the detection systems in future. Without the collaboration with University of Dundee, SPS would effectively be running... 'blind' in a drug market that changes rapidly [E5].

As a consequence of the knowledge gained, we have also worked directly with Rapiscan, the company which provides screening technology to the SPS, validating their equipment and updating their internal instrumental libraries with research generated data so that they are deployable within the Scottish prisons with accurate data. This ongoing relationship has enabled continued use of our research expertise in the monitoring of samples entering the Scottish prison service.

The data arising from the project has greatly increased understanding of the illicit drug market operating within prisons in Scotland and provides timely and important drug trend monitoring data to national and international agencies... this project has supported the reduction in drug supply in SPS establishments, supported increased investment in drug detection technologies in Scottish prisons and has allowed the effectiveness of such technologies to be continually assessed in an evolving drug market. [E5]

4.3. The development of international guidance documents for the UNODC: As a result of the research profile in the area of NPS drug identification, **NicDaeid** was invited to develop the original analytical guidance and protocols for the characterisation of synthetic cathinones issued by the UNODC. The manual was revised and republished in 2020 where the Dundee method was endorsed by international reviewers. The UNODC manuals are developed by ‘*scientific experts recognised for their exceptional contribution to knowledge and/or the promotion of best practice in the area of interest*’ and are provided for free by the UNODC to forensic science laboratories across the 193 member states of the UN as the accepted industry standard. The revised guidance manual, ‘UNODC Recommended Methods for the Analysis of Synthetic Cathinones in Seized Materials’, was published in 2020 [E4] and is available in the UN recommended languages, Chinese, English, French, Russian and Spanish [R6].

As a result of her research and expertise **NicDaeid** was invited onto the international panel of forensic experts for the UNODC. This panel is made up of a small number of subject matter experts from around the world who assist and advise the United Nations Office on Drugs and Crime in relation to the International Quality Assurance Programme, the International Collaborative Exercises (ICE) programme and the UNODC publications for forensic analysts and practitioners.

McKenzie sits on the Advisory Council for the Misuse of Drugs drug early warning and monitoring panel and on Scottish and UK expert groups on drug use and secondary exposure to psychoactive drugs in prisons, both of which inform the development of policy directives.

NicDaeid is a commissioner and vice chair of the Dundee Drug Deaths Commission which reports directly to the Scottish Government Drugs Deaths Taskforce feeding directly into drugs policy [E1, E2, E3]. Evidence relating to the use of illicit drugs in Dundee informs the work of the Commission, in particular the factual ground truth dataset which underpins and corroborates the lived experience of drug users within Dundee. She is also an appointed forensic expert advisor to the United Nations Office on Drugs and Crime which advises on and assesses the international collaborative trials implemented by the United Nations across its 193-member state countries.

5. Sources to corroborate the impact

[E1] Dundee Drugs Commission. (2019). Responding to Drug Use with Kindness, Compassion and Hope. Part One – the Report. Available at: <https://www.dundee.gov.uk/sites/default/files/publications/part1reportfinal.pdf> [Accessed 19 March 2021].

[E2] Dundee Drugs Commission. (2019). Responding to Drug Use with Kindness, Compassion and Hope. Part Two – Supporting Evidence - Background. Available at: <https://www.dundee.gov.uk/sites/default/files/publications/supportingpart2.pdf> [Accessed 19 March 2021].

[E3] Dundee Drugs Commission. (2019). Responding to Drug Use with Kindness, Compassion and Hope. Part Three – Supporting Evidence - Fieldwork. Available at: <https://www.dundee.gov.uk/sites/default/files/publications/supportingpart3.pdf> [Accessed 19 March 2021].

[E4] United Nations. Office on Drugs and Crime (2020). *Recommended methods for the Identification and Analysis of Synthetic Cathinones in Seized Materials*, Vienna: United Nations, ST/NAR/49-Rev.1. Available at: <https://www.unodc.org/unodc/en/scientists/recommended-methods-for-the-identification-and-analysis-of-synthetic-cathinones-in-seized-materials.html> [Accessed 19 March 2021].

[E5] Testimonial Scottish Prison Service

[E6] Testimonial HM Prison and Probation Service

[E7] Testimonial Rapiscan

[E8] European Monitoring Centre for Drugs and Drug Addiction (2020), EMCDDA initial report on the new psychoactive substance methyl 2-({[1-(4-fluorobutyl)-1H-indol-3-yl]carbonyl}amino)- 3,3-dimethylbutanoate (4F-MDMB-BICA), Initial reports, Publications Office of the European Union, Luxembourg. Available at: <https://www.emcdda.europa.eu/system/files/publications/13362/emcdda-initial-report-4F-MDMB-BICA.pdf> [Accessed 28 March 2021]

[E9] World Health Organisation (2019) *Critical Review Report: 5F-MDMB-PICA*, Report of the 42nd meeting of the Expert Committee on Drug Dependence, Geneva. Available at: https://www.who.int/medicines/access/controlled-substances/Final_5F-MDMB-PICA.PDF?ua=1 [Accessed 28 March 2021]