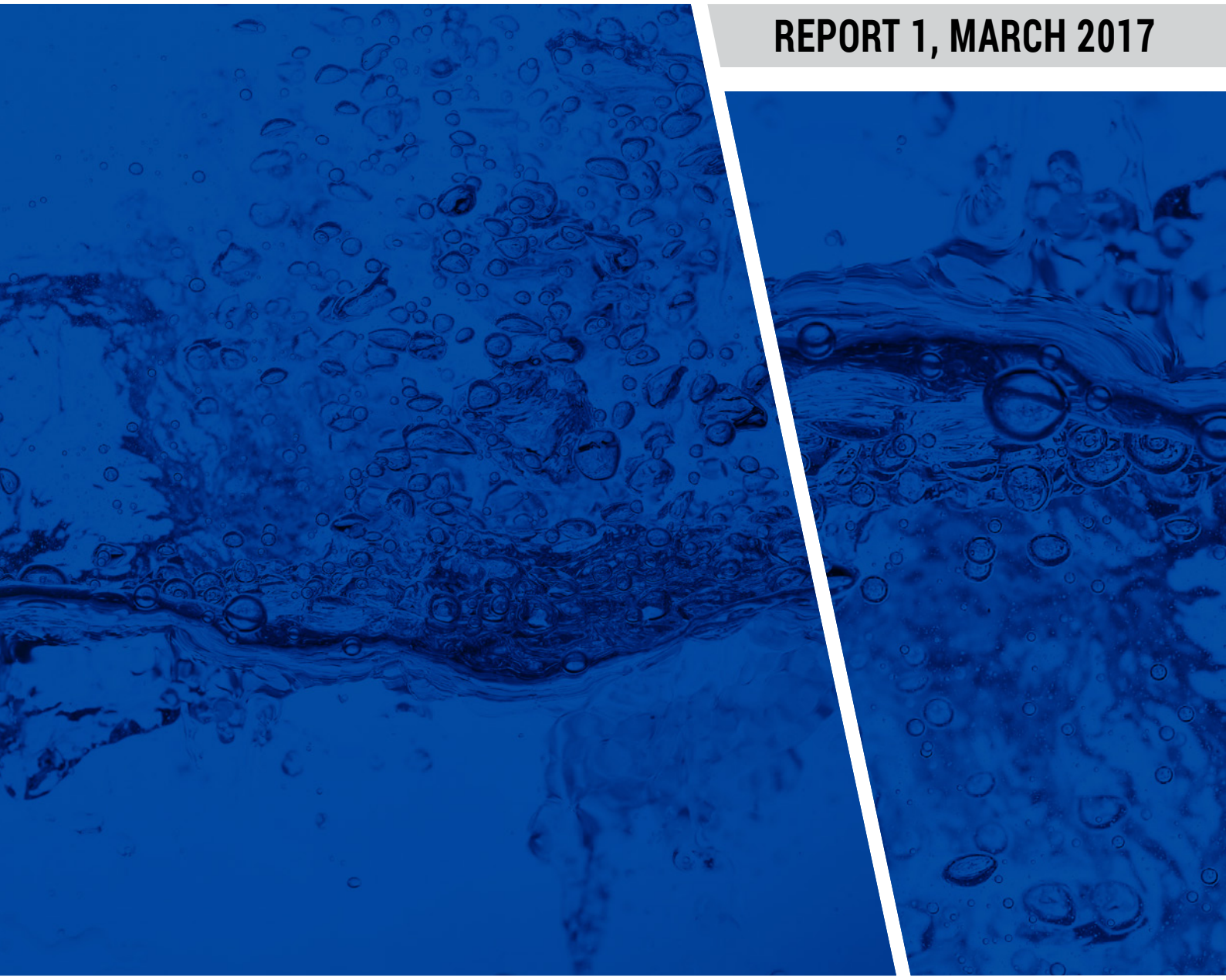
NATIONAL WASTEWATER DRUG MONITORING PROGRAM

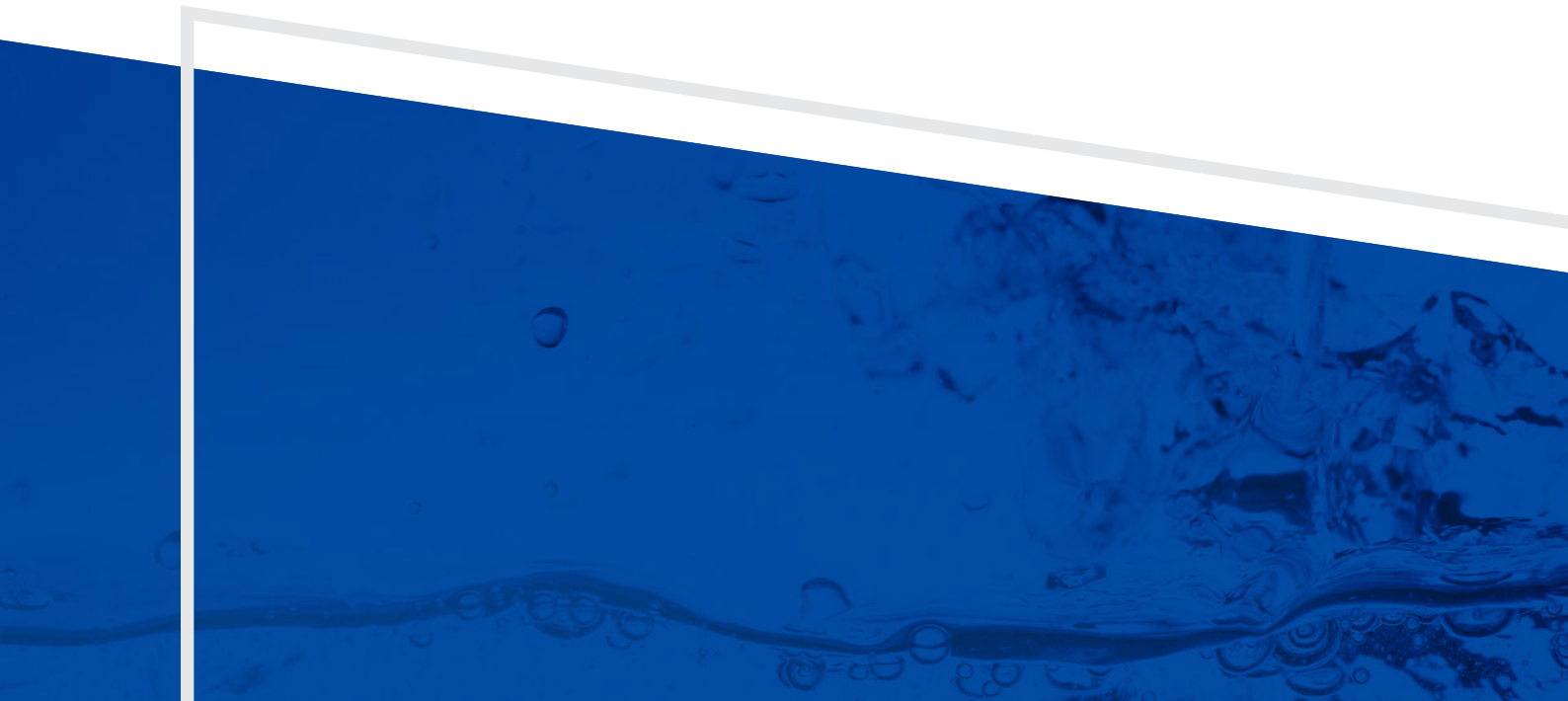
REPORT 1, MARCH 2017



AUSTRALIAN CRIMINAL INTELLIGENCE COMMISSION

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

University of South Australia



CONTENTS

i: CEO FOREWORD 1
ii: SNAPSHOT 3
iii: INTRODUCTION 5
RESEARCH FINDINGS 10
1: EXECUTIVE SUMMARY 12
2: INTRODUCTION 14
2.1: Preamble 14
2.2: Background 14
3: METHODS 16
3.1: Participating wastewater treatment plants (WWTPs) 18
3.2: Sample collection and preparation 19
3.3: Solid phase extraction (SPE) analysis 19
3.4: Direct injection analysis 20
3.5: Quality assurance and quality control (QA/QC) 20
3.6: Calculations 20
3.7: Presentation of data and interpretation of graphs 21
4: RESULTS 24
4.1 Individual site comparison of drug use 24
4.2 State and territory comparison of drug use 34
4.3 Drug profile for each state and territory 38
4.4 International comparison of drug use 41
5: ACKNOWLEDGEMENTS 45
6: REFERENCES 46
7: APPENDICES 48
Appendix 1: Drug-specific parameters for analytical reporting and usage calculations 48
Appendix 2: Further information on WWTPs 49
Appendix 3: Uncertainties related to wastewater analysis 51
Appendix 4: Correlation between amphetamine and methylamphetamine 53
CONCLUSIONS 54

CEO FOREWORD

The Australian Criminal Intelligence Commission (ACIC) has a national responsibility to provide information and intelligence on criminal activity. Much of the harm that Australians suffer is due to illicit and licit substances through serious and organised crime groups who traffick, distribute and profit from the drug trade.

The ACIC has been warning for several years that one of the most harmful substances impacting on Australia is crystal methylamphetamine. While not the only substance of abuse, crystal methylamphetamine is considered by the ACIC as an illicit drug of disproportionate harm and this first National Wastewater Drug Monitoring Program Report confirms the concerns expressed in the former ACC report *The Australian Methylamphetamine Market—The National Picture* of March 2015.

In response to growing concern around crystal methylamphetamine use in Australia, a National Ice Taskforce was established in 2015 to advise the Government on the development of a National Ice Action Strategy. One of the recommendations of the National Ice Taskforce focused on improving and expanding available data sources to provide a more accurate understanding of drug use in Australia. This document is the first of nine public reports which will share results of a national wastewater drug monitoring program over the next three years. This data will provide statistically valid datasets of methylamphetamine usage and distribution patterns across 51 sites in capital city and regional areas across all states and territories. The analysis extends to 13 drug types and will give the first national evidence base of illicit drug usage and distribution.

WHY WASTEWATER ANALYSIS?

Wastewater analysis is widely applied internationally as a tool to measure and interpret drug use within national populations. The Australian Government has recognised the considerable benefits of wastewater analysis and has partnered with established scientific expertise within Australian academic institutions to introduce a national program based on international models.

The National Ice Taskforce found self-report user surveys, seizure and arrest data and medical statistics provide only a limited picture of drug consumption. Consequently, the Taskforce recommended that a national wastewater capability be established to provide a more accurate and comprehensive understanding of drug use in Australia. Moreover, the National Ice Action Strategy 2015 recognised that national responses to problematic drug use need to be guided by better data and research to inform how governments respond to current and emerging drug trends.

IMPLEMENTING A NATIONAL PROGRAM

In June 2016, the Minister for Justice Michael Keenan approved the allocation of $3.6 million over a three year period from the Confiscated Assets Fund for the ACIC to develop a National Wastewater Drug Monitoring Program (NWDMP).

The ACIC has contracted the University of Queensland and through it the University of South Australia to deliver the capability on behalf of the ACIC. Relationships have been established by the universities with operators of wastewater facilities nationally to permit the collection of samples.

WHAT THE PROGRAM WILL DELIVER

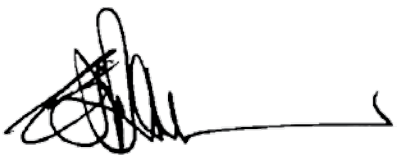
Wastewater analysis provides a measure of one important aspect of national health. The data provides a measure of the demand for a range of licit and illicit drugs. An understanding of this behaviour then permits governments to effectively direct resources to priority areas, and also to monitor the progress of demand and supply reduction strategies. Better data enables emerging trends to be identified. The strengths of wastewater analysis include that it is in near real-time, it is non-intrusive and is able to measure average drug use in both large and small populations. Further, wastewater analysis offers flexibility to address emerging problems and identify previously unknown drug threats and consumption patterns. These features permit governments to focus on areas which are deserving of particular attention.

THE FIRST REPORT

This document establishes the baseline assessment of national drug consumption. It contains data on usage patterns across states, territories and nationally; provides data on capital city and regional drug use; comparisons between some Australian locations and overseas countries, and where possible, comparisons with previous use in Australia. Future reports will contribute further data to permit identification of changes in usage patterns nationally and to build a comprehensive and increasingly detailed picture of national drug consumption.

The report is intended to provide concrete data to inform a range of disciplines—including health, education, law enforcement and the not-for-profit sector—in formulating their responses to the complex issues posed by drug markets. As the program evolves, it will be possible to evaluate existing and future response initiatives.

The ACIC's role as Australia's criminal intelligence agency, our unique expertise and experience and our relationships with key stakeholders, particularly in the academic community, provide us with the capability to undertake this project. I would like to thank our Minister for having the confidence and foresight to contribute the funding which made this initiative possible. I would also like to acknowledge those ACIC officers who contributed to the project. I am grateful for the valuable support and specialist expertise of Jochen Mueller, Wayne Hall, Sharon Grant, Ben Tscharke and Jake O'Brien of the University of Queensland and Jason White, Cobus Gerber and their team from the University of South Australia who have undertaken the data collection and analysis which underpins this report.



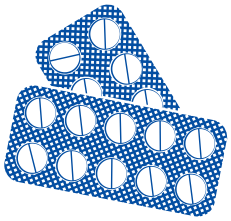
Chris Dawson APM
Chief Executive Officer
Australian Criminal Intelligence Commission

SNAPSHOT

Methylamphetamine is the **highest consumed** illicit drug tested across **all regions** in Australia.

This report covers approximately **58 per cent** of Australia's population—about **14 million people.**

Compared with methylamphetamine, consumption of **other stimulants** was generally much lower.



Oxycodone and **fentanyl** consumption (licit and illicit) across all jurisdictions is at **concerning levels**.

Consumption levels for tested **new psychoactive substances** confirm this is a **niche market**.

Alcohol and tobacco are the **highest consumed substances** in all states and territories.

METHYLAMPHETAMINE CONSUMPTION

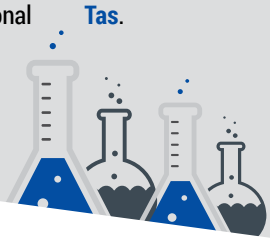
Capital city sites in **Tas** and the **ACT** showed the **lowest** levels nationwide.

SA capital city sites **exceed** levels in SA regional sites.

Monitored **Qld** and **SA** sites show a consistent pattern of **increasing levels** (for at least the last five years).

WA has the highest levels, with both city and regional sites **far exceeding** national averages.

High levels seen at several regional sites in **Qld**, **Vic** and **Tas**.



COCAINE CONSUMPTION

NT regional levels **lowest** across all participating regions.

While capital city **NSW** levels **dominated** the national landscape, **ACT** and capital **NT** sites showed **higher levels** compared to other states.

MDMA CONSUMPTION

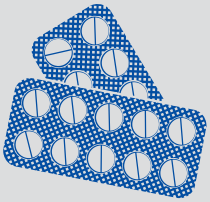
Apart from one capital city site in NT and one regional site in Tas, **consumption levels** nationally were **unremarkable**.

CONSUMPTION OF OTHER SUBSTANCES

Alcohol and **tobacco** levels in **NT** are considerably **higher** than the national averages.

Vic and **Qld** regional sites showed **higher than average oxycodone** levels.

NSW, **SA** and **WA** regional sites had **higher than average fentanyl** levels.



INTERNATIONAL COMPARISONS

Of the European countries with comparable reported data for the four common stimulants considered (MDMA, cocaine, amphetamine and methylamphetamine), **Australia** has the **second highest** total estimated consumption **overall**.

Australia ranks **second** of the **18 countries** for consumption of **methylamphetamine**.

INTRODUCTION

This report contains a summary of the evolution and context of the National Wastewater Drug Monitoring Program (NWDMP), and the findings of the two contracted universities during the initial collection period.

In March 2015, the (then) Australian Crime Commission publicly released a report which summarised our concerns in relation to the threat posed by the methylamphetamine market. The purpose of the report was to help shape Australia's understanding of the market and the challenges it posed, so stakeholders could focus their collective efforts to combat the harm the market was causing to the nation. Soon after, the Government announced a National Ice Taskforce to address the issues raised in the report and related matters. One of the key issues considered by the National Ice Taskforce in 2015 was whether existing data sources provided an adequate representation of trends in illicit drug markets, and whether there was scope to seek data from additional sources. In addition, the Taskforce aimed to ensure that decisions by Government and other key stakeholders on drug issues were founded on timely and accurate data.

The National Ice Taskforce Report recommended the Government should, "expand and improve data sources available for the central analysis of illicit drug trends by...establishing a national wastewater analysis capability which should be drawn upon to provide a more accurate analysis of drug use in Australia."[1] Subsequently, the Council of Australian Governments (COAG) endorsed the National Ice Action Strategy 2015, which included recognition that there was a need for better research and data. The strategy commented that, "our efforts need to be informed by better data and research...including continuing wastewater testing...to inform how governments respond to ice and other emerging drug trends."[2]

The National Ice Taskforce concluded, and the National Ice Action Strategy reinforced, that effective responses to address the diverse aspects of drug problems rely heavily on access to quality data. Moreover, it is essential that holistic responses are developed that do not merely transfer the threat posed by one drug market to another market. Agreed strategies must also contain elements to drive both demand reduction and supply reduction in an appropriately balanced manner.

Economic theory defines demand as the quantity of a good or service that consumers are willing and able to buy at a given price, in a given time period. It follows that a mechanism must be found to measure the quantity of drugs consumed by a given population in order to accurately identify the level of demand. Inherently, the survey data currently available in Australia is unable to provide reliable information on the quantity of drugs that is being consumed.

1 Recommendation 35 of the *Final Report of the National Ice Taskforce 2015* <https://www.dpmc.gov.au/sites/default/files/publications/national_ice_taskforce_final_report.pdf>.

2 *National Ice Action Strategy 2015* <https://www.coag.gov.au/sites/default/files/communique/2015%20National%20Ice%20Action%20Strategy.pdf>.

Accordingly, the Taskforce found that existing estimates of drug use in Australia did not adequately measure the demand for drugs. To address this shortcoming, innovative sources of data were needed. Wastewater analysis was found to provide the best opportunity to complement existing data sources and fill the identified gap.

Following on from the above recommendations and actions, the Commonwealth Minister for Justice approved $3.6 million over three years from the Commonwealth Confiscated Assets Account for the Australian Criminal Intelligence Commission (ACIC) to develop a national program to monitor drug consumption through wastewater analysis. This program of sampling and analysis is known as the NWDMP.

IMPLEMENTATION

Contractual arrangements have been entered into between the ACIC, the University of Queensland (UQ) and, through UQ, the University of South Australia (UoSA). UQ and UoSA are working collaboratively to deliver the national program in consultation with the ACIC.

The contract provides that the universities will enter into arrangements with the operators of a series of wastewater facilities across Australia to collect samples, which will then be analysed and interpreted by the universities.

The contract provides that for the first twelve months the wastewater analysis will measure the presence[3] of the following substances:

- methylamphetamine
- amphetamine
- cocaine
- 3,4-methylenedioxymethamphetamine (MDMA)
- 3,4-methylenedioxyamphetamine (MDA)
- JWH-018
- JWH-073
- mephedrone
- methylone
- oxycodone
- fentanyl
- tobacco
- alcohol.

The first five substances are widely recognised illicit stimulants. The next four substances are also illicit and are described as new psychoactive substances (NPS). JWH-018 and JWH-073 are synthetic cannabinoids, while mephedrone and methylone are synthetic stimulants. Oxycodone and fentanyl are pharmaceuticals which have therapeutic application, but are also diverted to the illicit market.

3 The contract recognises that threshold levels are substance dependent and will vary accordingly. Refer to the report for further information on detection levels, and whether it was possible to measure all substances.

The UQ and UoSA will monitor wastewater at approximately 50 sites across Australia for the next three years. The capital city sites cover Canberra and all state and territory capital cities. The remaining sites cover regional cities and towns. The capital city sites will be monitored for the duration of the trial, but the remaining sites will be re-assessed after 12 months. Sites were selected to permit the ACIC to provide data on major population areas, sites of actual or potential concern to the ACIC and stakeholder agencies from a drug use perspective and sites where the local authorities have established relationships with the two universities.

The breakdown of sites by jurisdiction for this report is as follows:

The location of sites within and between jurisdictions may alter over the three years of the contract, depending on results during the first 12 months of the program. Once the contract has been in force for 12 months the ACIC will review the appropriateness of the sites and the selected substances with the two universities and other stakeholders. There will be a further review after 24 months.

REPORTING

The ACIC will provide data from this program in the form of a comprehensive public report three times per year in accordance with an agreed timeline. The public reports will not identify specific sites at which wastewater sampling was conducted. Sites will be identified by codes in tables within the reports. Stakeholders in law enforcement, health and other relevant policy agencies will be provided with classified reports which identify actual sampling locations in order to inform appropriate responses. The public reports will incorporate discussion of trends in drug use within jurisdictions where there are distinct trends (e.g. between regional and capital city areas), between jurisdictions and nationally. There will be comparisons with testing from previous years, where that data is available. The data also offers an assessment of where Australian demand for some substances sits in comparison with international trends.

EXPLOITATION OF THE NWDMP DATA

It is the ACIC's intention that the information derived from NWDMP analysis will become fundamental to government policy making. The reports will provide a regular, timely, unambiguous and detailed measure of the level of demand within a very large percentage of the Australian population for the listed commodities, and hence complement other drug data sets that are published in Australia. This report measures drug use by approximately 58 per cent of the Australian population.[4]

It is hoped that wastewater data will be used to assess and validate other available data sources to obtain a more comprehensive and accurate appreciation of drug markets nationally, and in the respective jurisdictions. Making the NWDMP data available to the public will enrich understanding and inform the national conversation in relation to trends in the demand for drugs. Because of similar collection and analysis protocols, it will also be possible to compare domestic drug use with levels of use internationally, which may stimulate further useful discussions on alternative responses. These outcomes are consistent with the aims of the National Ice Action Strategy.

In addition to broadly releasing the results of the wastewater analysis, the ACIC anticipates that the NWDMP data will be used by stakeholders to identify areas of the country where holistic policy and operational responses are appropriate. The data will also provide opportunities to formulate tailored responses appropriate to local circumstances. At this stage of the process the data becomes the foundation for delivering appropriate policy and operational responses to drug markets.

The ACIC is also considering methods of using the data as a measure of the effectiveness of supply and demand reduction initiatives in select locations around the country. The ACIC wishes to ensure the broadest possible range of stakeholders is engaged throughout the life of the NWDMP so that maximum benefit is derived from the program. Consultation will occur through existing drug forums and direct discussions with agencies.

4 This estimate is based on the Australian Bureau of Statistics estimate of the Australian population as at 30 June 2016 and catchment data supplied by the operators of the wastewater facilities and service providers.

The NWDMP is based on an established internationally recognised methodology, which has been applied to varying extents by many other nations. In the Australian context, wastewater has been identified as offering an important, unified and consistent guiding tool in developing holistic drug responses. To this end, the scope of the sampling will generate data which offers information for governments at both a state and national level to formulate appropriate responses.

RESULTS FROM THE INITIAL COLLECTION

This report constitutes a baseline assessment of national drug consumption. It contains data on usage patterns across states, territories and the nation; provides data on capital city and regional drug use; comparisons between some Australian locations and overseas countries, and where possible, comparisons with previous use in Australia.

Future reports will build on the baseline assessment and contribute further data to permit identification of changes in usage patterns and to build a comprehensive and increasingly detailed picture of national drug consumption.

Reported results reflect per capita use in all locations and are expressed in terms of both the number of doses to facilitate comparison between substances, and the weight or volume per capita of the respective substances.

RESEARCH FINDINGS

Prepared by the University of Queensland (J.O'Brien, S.Grant, J.Mueller) and University of South Australia (B.Tscharke, C.Gerber, J.White).

LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACIC	Australian Criminal Intelligence Commission
ACT	Australian Capital Territory
DASSA	Drug and Alcohol Services South Australia
LC-MS/MS	Liquid chromatography tandem mass spectrometry
LOD	Limit of detection
LOR	Limit of reporting
MDA	3,4-methylenedioxyamphetamine
MDMA	3,4-methylenedioxymethamphetamine
NSW	New South Wales
NT	Northern Territory
QA/QC	Quality assurance and quality control
QLD	Queensland
SA	South Australia
SCORE	Sewage Analysis CORe group Europe
TAS	Tasmania
VIC	Victoria
WA	Western Australia
WWA	Wastewater analysis
WWTP	Wastewater treatment plant

TERMINOLOGY

Methylamphetamine is also commonly known as methamphetamine. In this report, consistent with the preferences of the Australian Criminal Intelligence Commission, methylamphetamine is used.

MDMA is commonly known as ecstasy.

Alcohol consumption in this report refers to ethanol consumption but the more general term 'alcohol' is used throughout.

1: EXECUTIVE SUMMARY

Wastewater analysis has become the standard for measuring population-scale use of a range of different chemical compounds. The underlying concepts involved in wastewater analysis are well established in Australia and have been applied to a wide range of licit and illicit drugs. Estimates of drug usage in a population can be back-calculated from measured concentrations of drug metabolites (excreted into the sewer system after consumption) in wastewater samples. Spatial and temporal trends in drug use have been reported using this approach for several sites located primarily in South Australia and Queensland since 2009. The National Wastewater Drug Monitoring Program (NWDMP) for the Australian Criminal Intelligence Commission (ACIC) aims to expand the monitoring of substances of concern to all regions of Australia. The study focuses on thirteen licit and illicit drugs, including tobacco, alcohol, methylamphetamine, cocaine and MDMA (ecstasy). Trends in estimated drug consumption will be established over the three-year project. Wastewater treatment plants (WWTPs) located across capital cities and regional Australia, covering all states and territories, have been invited to participate in this program.

For this first report, wastewater samples have been collected from twenty-two WWTPs in capital cities and a further twenty-nine regional sites. These samples provide comprehensive, Australia-wide baseline data against which subsequent data can be compared to ascertain both spatial and temporal trends. Twenty-four hour composite wastewater samples were collected using time-proportional or flow-proportional autosamplers at the influent of each WWTP by plant operators. Samples were collected for up to seven consecutive days in August 2016. Concentrations of drug metabolites were determined in the wastewater using liquid chromatography-tandem mass spectrometry (LC-MS/MS) analytical methods. Drug consumption estimates for each catchment population were calculated from these measured concentrations using flow volumes and estimates of the catchment population size provided by the treatment plants, together with excretion and dose data derived from the scientific literature. To maintain treatment plant confidentiality, each site was allocated a unique code and site names are not included in this report.

Estimated drug usage across the fifty-one sites was highly variable, both between drugs and between sites. However, when the amount of drug measured in wastewater was normalised for population size and average dose consumed, alcohol and tobacco were consistently the highest consumed drugs in all states and territories. Estimated consumption of both these licit substances was generally highest at the Northern Territory sites and some sites in regional Tasmania and Queensland were substantially above the national average. Amongst the illicit drugs, methylamphetamine consumption was the highest across all regions of Australia. This trend was consistent for both capital cities and regional sites and on average, regional and capital city Australia showed comparable levels of usage. The highest methylamphetamine levels were seen at Western Australian and South Australian sites (capital city and regional), as well as at several regional sites in Queensland, Victoria and Tasmania. Comparing the latest findings of drug use with previous data for sites in Queensland and South Australia, current methylamphetamine levels have been consistently increasing and are currently at historic highs.

Amphetamine is a metabolite of methylamphetamine and measured amphetamine concentrations across the sites were consistent with the observed levels being primarily related to methylamphetamine metabolism rather than sourced from direct consumption.

Compared to methylamphetamine, estimated usage of other stimulants was generally much lower, although no consistent pattern (profile) of usage for these other drugs could be observed between states and territories. Cocaine usage in Australia is mostly centred in New South Wales across several capital city and regional sites. At sites elsewhere around the country usage was generally low. MDMA usage was similarly low across most sites with a few site-specific exceptions. Historical data for both cocaine and MDMA usage for a limited number of sites in Queensland, South Australia and Victoria did not highlight any obvious longer term trends.

Oxycodone and fentanyl, which are both pharmaceutical substances with abuse potential through diversion, had elevated consumption levels at several regional sites. It should be noted that recorded usage is predominantly derived from prescription of the substances. Regional Queensland, in particular, showed above average oxycodone use. For the other drugs included in this study, methylone, mephedrone, MDA, JWH-018 and JWH-073, concentrations were generally at or below detection levels at all participating sites.

From an international perspective, methylamphetamine levels in Australia rank high compared to countries in Europe where wastewater analysis is routinely conducted. In contrast, cocaine consumption is relatively low, while MDMA is close to the European average. Estimated tobacco consumption rates in Australia are low in comparison to parts of Europe and China. Similarly, alcohol intake is relatively low, being at the lower Mediterranean end of consumption in Europe.

2: INTRODUCTION

2.1: PREAMBLE

Wastewater analysis is a technique for delivering population-scale consumption of substances. The University of Queensland and University of South Australia have been commissioned to provide drug consumption data to ACIC for a period of three years. A total of approximately fifty wastewater treatment sites will be assessed, bimonthly in the case of capital city sites and every four months for regional sites. The aim is to acquire data on the population-scale use of substances causing potential harm, either through addiction, health risks, or criminal and anti-social behaviour. The intention is to establish baseline data of substance use across Australia, with future reports showing temporal changes over the three-year project. Compounds of concern include nicotine from tobacco, ethanol from alcohol intake, pharmaceutical opioids with abuse potential, illicit substances such as methylamphetamine, MDMA and cocaine, as well as a number of new psychoactive substances (NPS) including synthetic cannabinoids. The compounds amphetamine and MDA were measured but not included in the final report since these are also metabolites of methylamphetamine and MDMA, respectively. These substances may be included in future reports once there is greater certainty regarding the contribution from other drugs as opposed to ingested amphetamine and MDA. The report presents patterns of substance use across Australia, showing differences in levels between capital cities and regional centres within states and territories and nationally. The collective national data are placed in an international context by comparing findings with European and other studies which conducted similar wastewater analyses.

2.2: BACKGROUND

Wastewater analysis has become the standard for measuring population-scale use of a range of different chemical compounds. The European-based international collaboration, SCORE[1], uses wastewater analysis to compare illicit substance use globally. The SCORE initiative calibrates methods between different laboratories around the world once a year and has had a significant role in establishing best practice in the sampling, analytics and reporting of wastewater analysis. In Australia, methods for determining a range of illicit drugs and substances with abuse potential in wastewater have been developed and applied since 2009 (Irvine et al., 2011; Lai et al., 2011; Lai et al., 2016; Tscharke et al., 2016). Findings are being reported to health authorities, emergency services and the police.

Wastewater analysis is a tool for determining population scale of use of a particular substance, i.e. the total amount of a drug used by a whole community or population, not by individuals or individual households. This is useful for showing differences between populations (Lai et al., 2016), or, when applied over time, to show temporal trends (Tscharke, 2016). Finer demographic information such as gender, age or ethnicity cannot be ascertained by wastewater analysis, nor the administration route used (intranasal, oral, intravenous, etc.). Drug concentration is measured overall, and therefore cannot be used to distinguish occasional use by many people from heavy use by a few individuals. In the case of drugs such as methylamphetamine, different forms of the drug (‘ice’, powder) will yield the same result when measured in wastewater.

1 Established in 2010, SCORE brings together research groups working on drug analysis in sewage. European based, the initial goal of the group was to collaborate on international studies comparing drug use in participating countries <http://www.niva.no/SCORE>.

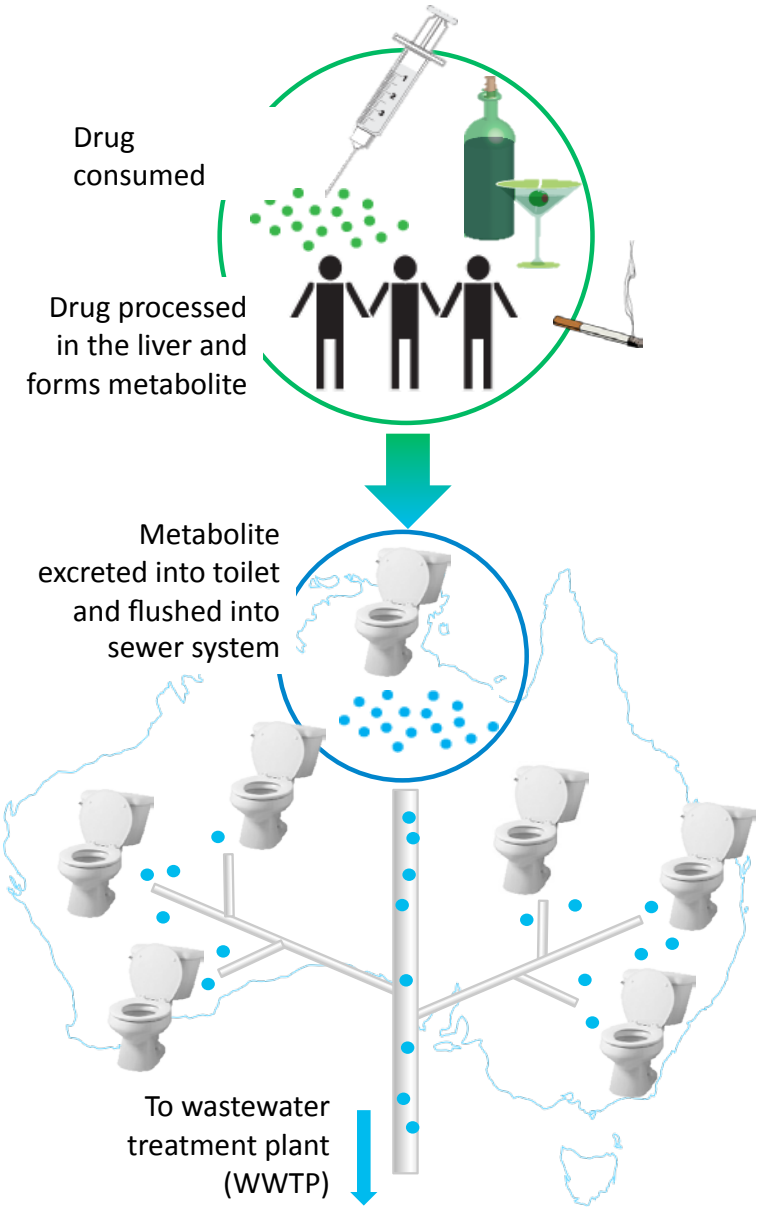
Spatial and temporal trends in Australia have been well documented and form the basis of several reports and papers published in the scientific literature (Lai et al., 2015; Lai et al., 2016; Lai et al., 2016a; Tscharke et al., 2016). A report on drug use in Adelaide has been compiled for the Drug and Alcohol Services of South Australia (DASSA) every two months since 2011, while in Western Australia the levels of methylamphetamine in city and regional areas have been monitored bimonthly for two years for the Western Australia Police. In Queensland, samples have been collected, archived and analysed from two regional centres, one since 2009 and the other since 2010. The concept has subsequently been expanded to a number of sites across Australia where sampling has occurred on an intermittent basis. In recent years, the number of target substances has increased to reflect concerns about population health and wellbeing. The list includes alcohol, tobacco, pharmaceutical opioids with abuse potential, the stimulants methylamphetamine, MDMA and cocaine, as well as a number of new psychoactive substances and (in previous studies) cannabis. Overall, the underlying concepts involved in wastewater analysis are well established in Australia and have been applied to a wide range of licit and illicit drugs.

The current report for the ACIC aims to expand the monitoring of substances of concern to all regions of Australia. Samples have been collected from all capital cities and a range of regional sites across all states and territories. These samples provide comprehensive, Australia-wide baseline data against which data collected in the subsequent three years of this project can be compared to ascertain both spatial and temporal trends. Capital city sites have been asked to participate for the duration of the project and will be sampled every two months. Sampling at regional sites will take place every four months and these sites may change on an annual basis to increase the spatial coverage of the program.

3: METHODS

The method underlying wastewater based monitoring of drug use in a given population is based on the principle that any given compound that is consumed (irrespective of whether it is swallowed, inhaled/smoked or injected) will subsequently be excreted (either in the chemical form it is consumed and/or in a chemically modified form that is referred to as a metabolite). The excreted compound or metabolite will eventually arrive in the sewer system (Figure 1). The drugs and their metabolites of interest in this study are given in Table 1, together with their known excretion factors (i.e. the amount of metabolite excreted per amount of compound consumed) and assumed standard doses (i.e. the average amount of compound consumed in one go, e.g. in one cigarette).

Figure 1: Schematic of the transport of drugs from consumed chemical to metabolised waste product being delivered to the sewer system.



Collectively, waste products in the sewer system arrive at a wastewater treatment plant (WWTP) where wastewater samples are collected over a defined sampling period. Measuring the amount of target compound in the wastewater stream allows for a back-calculation factor to be applied to determine the amount of drug that was used over the collection period (Figure 2). The method is non-invasive and is done on a population-scale level, so individuals are not targeted and privacy is respected.

Table 1: The metabolites measured in the wastewater samples for each drug included in this project (13 chemicals), together with the metabolite's excretion factor and the standard dose of each drug typically consumed, are given in the table. See Appendix 1 for literature sources of excretion factors and standard doses.

Drug consumed	Metabolite measured at WWTP	#Excretion factor	^Standard dose consumed
Tobacco (nicotine)	Cotinine* Hydroxycotinine*	0.74 combined	1.25 mg nicotine
Alcohol (ethanol)	Ethyl sulphate	0.00012	10 g ethanol
Methylamphetamine	methylamphetamine	0.39	30 mg methylamphetamine
□ Amphetamine	□ Amphetamine	0.394	30 mg amphetamine
MDMA	MDMA	0.225	100 mg MDMA
MDA	MDA	No reliable data	No reliable data
Cocaine	Benzoylecognine	0.35	100 mg Cocaine
Oxycodone	Noroxycodone	0.22	20 mg oxycodone
Fentanyl	Norfentanyl	0.3	0.2 mg fentanyl
Methylone	Methylone	No reliable data	No reliable data
Mephedrone	Mephedrone	No reliable data	No reliable data
JWH - 018	JWH - 018	No reliable data	No reliable data
JWH - 073	JWH - 073	No reliable data	No reliable data

* metabolites combined for calculations

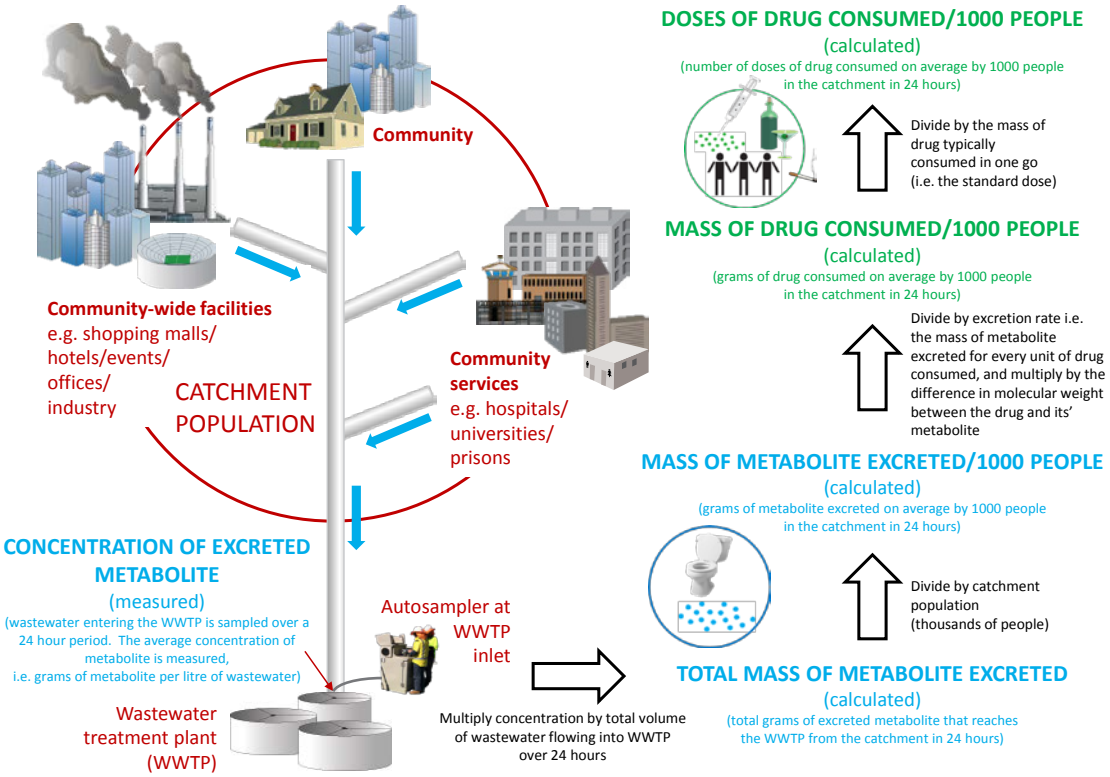
to convert "mg consumed / 1000 people / day" back to "mg excreted / 1000 people / day", multiply by the excretion factor

^ to convert "doses / 1000 people / day" back to "mg excreted / 1000 people / day", divide by the standard dose and then multiply by the excretion factor

□ amphetamine is a metabolite of methylamphetamine consumption. Amphetamine results have not been reported as the major source of amphetamine detected in wastewater was attributed to amphetamine excretion from methylamphetamine consumption.

Wastewater consists of highly complex mixtures which derive from toilets, bathrooms, kitchen and laundry appliances, as well as all other domestic, industrial or commercial plumbed structures. To obtain an estimate of drug use, representative samples are collected over a given period (typically 24 hours) using autosamplers that collect time or flow proportional samples. Wastewater treatment plant operators provide assistance with collecting the samples from the influent autosampler (where the wastewater enters the treatment plants). Pertinent information on the volume of wastewater entering the WWTP (flow volume) that is associated with a given sample is also collected by local operators. It should be noted that rain events may, for example, cause an increase in the volume of wastewater that enters a treatment plant but providing that the flow volume is available for each sampling period, this will not affect the overall estimate of the amount of drugs that has been used by the population that contributed to this wastewater. Details of the calculation method are given in Section 3.6.

Figure 2: Schematic of the population catchment area and methodology employed to convert measured concentration of substances in wastewater to mass loads or doses consumed per day per normalised population.



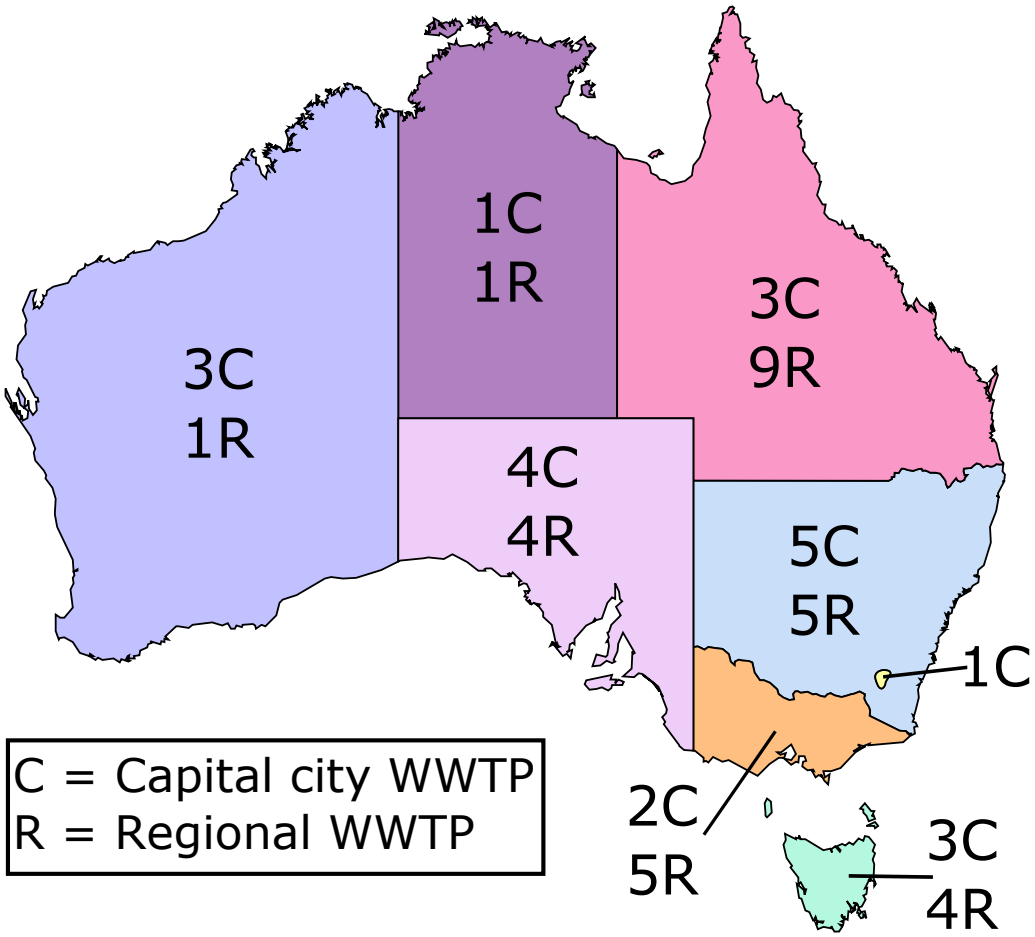
Collected wastewater samples were analysed at the University of South Australia and the University of Queensland laboratories. The steps routinely performed in our laboratories are based on filtration of the samples followed by an enrichment/concentration step where the concentrated sample is injected, or (for chemicals with sufficiently high concentrations) direct injection of samples into the analytical instruments. The instrumental analysis consists of chromatographic separation and subsequent compound specific detection. A summary of the extraction and analytical methods is given in Sections 3.3 and 3.4.

3.1: PARTICIPATING WASTEWATER TREATMENT PLANTS (WWTPS)

Fifty-one WWTPs across Australia participated in this study (Figure 3). Of these, 22 sites were located in capital cities and a further 29 were regional sites covering a wide range of catchment population sizes. Sites were selected by the Australian Criminal Intelligence Commission. Summary details for the sites, including the number of sampling days and type of autosampler are provided in Appendix 2.

To maintain the confidentiality of the participating sites, all sites were allocated a unique code to de-identify their results. Site codes only are presented in the results sections.

Figure 3: Participating WWTPs, showing the split between capital city and regional plants by state and territory. The colours in this figure are used in the remainder of the report to identify results relating to individual states and territories.



3.2: SAMPLE COLLECTION AND PREPARATION

Composite samples were collected by treatment plant staff daily on seven consecutive days from Monday to Sunday, or where seven days was not feasible, across as many consecutive days as possible. Samples were stored at 4°C or were frozen prior to transport to Adelaide or Brisbane, respectively. Further details of the sampling protocol and relevant quality controls are included in Irvine et al. (2011), Lai et al. (2011), Lai et al. (2015), Tscharke et al. (2016).

3.3: SOLID PHASE EXTRACTION (SPE) ANALYSIS

Each sample was individually filtered prior to further processing at the University of South Australia. A portion of each filtered sample was spiked with isotopically labelled (deuterated) internal standards (e.g. benzoylecgonine D3, etc.). The samples were concentrated and cleaned by SPE and the extract was analysed by liquid chromatography-tandem mass spectrometry (LC-MS/MS). The purpose of the isotopically labelled (deuterated) standard was to serve as quality control for instrument performance and target analyte recovery, while SPE was used to concentrate the analyte and simplify the sample mixture in terms of the range of chemicals present. Further analytical details are given in Chen et al. (2013).

For these analyses, two samples (of the possible seven) in the sampling week were targeted for analysis and are reported below. This applies to the following drugs: cocaine, MDMA, oxycodone, fentanyl, methylone, mephedrone, JWH-018 and JWH-073.

3.4: DIRECT INJECTION ANALYSIS

The direct injection analytical method used at the University of Queensland has been previously reported in detail (Lai et al., 2011; Lai et al., 2015) and validated through an inter-laboratory comparison (SCORE, 2015). Briefly, wastewater samples were filtered through 0.2 µm regenerated cellulose filters, transferred (1 mL) to an amber vial, and spiked with corresponding mass-labelled standards. Chemical residue concentrations in the samples were measured using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Chromatographic separation of the analytes was performed on an analytical column with gradient mobile phases. Identification and quantification of each analyte was performed using two transitions of the multiple-reaction monitoring of the MS. Chemical concentrations were quantified using a compensation for ion suppressions of the analytes during instrumental analyses based upon the amounts of corresponding mass-labelled standards in the samples. Quality assurance and quality control (QA/QC) samples and blanks were analysed with each batch to monitor analytical performance. All samples collected were analysed using direct injection and alcohol, tobacco, methylamphetamine, amphetamine and MDA were quantified using this approach.

3.5: QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

To ensure consistency between sample collection at the various participating WWTPs, analysis and interpretation of data, rigorous QA and QC measures were implemented. The first of these involved both laboratories participating in an interlaboratory comparison where replicate samples were analysed by both laboratories. Secondly, sampling packs including pre-cleaned and labelled bottles as well as detailed sampling instructions and questionnaires were sent to all participating WWTPs to ensure consistency between sample collection, prevention of contamination and for optimal sampling to be utilised at each site. Upon arrival of samples at the laboratories, samples were registered into a database and processed for analysis as soon as practical. Blanks were run with each batch of samples in addition to multiple QA/QC samples including spiked QA/QC samples.

Drug-specific limits of detection (LOD) and limits of reporting (LOR) are given in Table 3, Appendix 1. See Section 3.7 for the approach to estimate per capita drug consumption when a measured drug concentration in a wastewater sample is below the LOD or LOR.

3.6: CALCULATIONS

The concentration of each compound or metabolite in the wastewater samples analysed by the direct injection method were quantified using a calibration curve of the ratio between signal response for the unlabelled authentic drug standard and deuterated analogue. In all other cases, the concentrations were determined by a standard addition method using the reference standard/deuterated standard ratio.

The wastewater concentration data was used in conjunction with plant-specific details for flow volume (ML) and the number of people in the catchment (catchment population; thousands of people), as well as drug-specific details such as the excretion rate and standard dose (Equation 1). Excretion factors and standard doses used in this report are given in Table 1. When the unchanged drug was used for the calculation (i.e. not a metabolite), the molecular weight ratio of drug to metabolite was taken as 1. An overview of the calculations steps represented by Equation 1 is illustrated in Figure 2.

Equation 1: Calculation used to estimate the number of doses of a target drug per 1 000 people per day.

$$Doses\ per\ day\ per\ 1000\ people = \frac{\left(\frac{\left[Analyte\ (\frac{mg}{ML})\right] \times\ Flow\ volume\ (ML)}{Catchment\ population\ in\ 1000's}\right) \times \left(\frac{Mw\ ratio}{Excretion\ factor}\right)}{Standard\ dose\ (mg)}$$

Mw ratio = molecular weight ratio of a drug to its metabolite. [Analyte] = concentration of the target drug or metabolite in the wastewater sample. Flow volumes and catchment population estimates were provided by treatment plant managers or state water management authorities. Units are given in brackets.

Some plant-specific details (i.e. catchment population size) used in Equation 1 are summarised in Table 4, Appendix 2 (data are categorised according to size ranges to maintain confidentiality of the sites). For the purposes of generating graphs, population estimates were either supplied by the Australian Bureau of Statistics (ABS) or by wastewater management staff (using a range of different calculation methods). Some treatment plant area catchment maps were used in conjunction with ABS population growth estimates to arrive at population numbers. When the 2016 population Census data are released by the ABS later in 2017, accurate catchment population numbers will be determined using catchment maps provided by individual WWTPs combined with the number of people residing in that area from the Census data. We will also use the updated Census data to refine other parameters, where relevant. Once accurate parameters are available, estimated drug consumption will be updated for all participating WWTPs using Equation 1 and the revised data will be reported in future reports. Refined flow estimates, excretion factors and standard doses will also be updated as new information comes to light.

A number of factors may influence the accuracy of the result obtained from Equation 1. In terms of errors, site specific variables range from inherent errors/bias within the treatment plant flow meters, autosamplers or storage, to analytical variability and uncertainties in population estimates. The sources of potential uncertainties in the data presented in this report are explained in further detail in Appendix 3.

3.7: PRESENTATION OF DATA AND INTERPRETATION OF GRAPHS

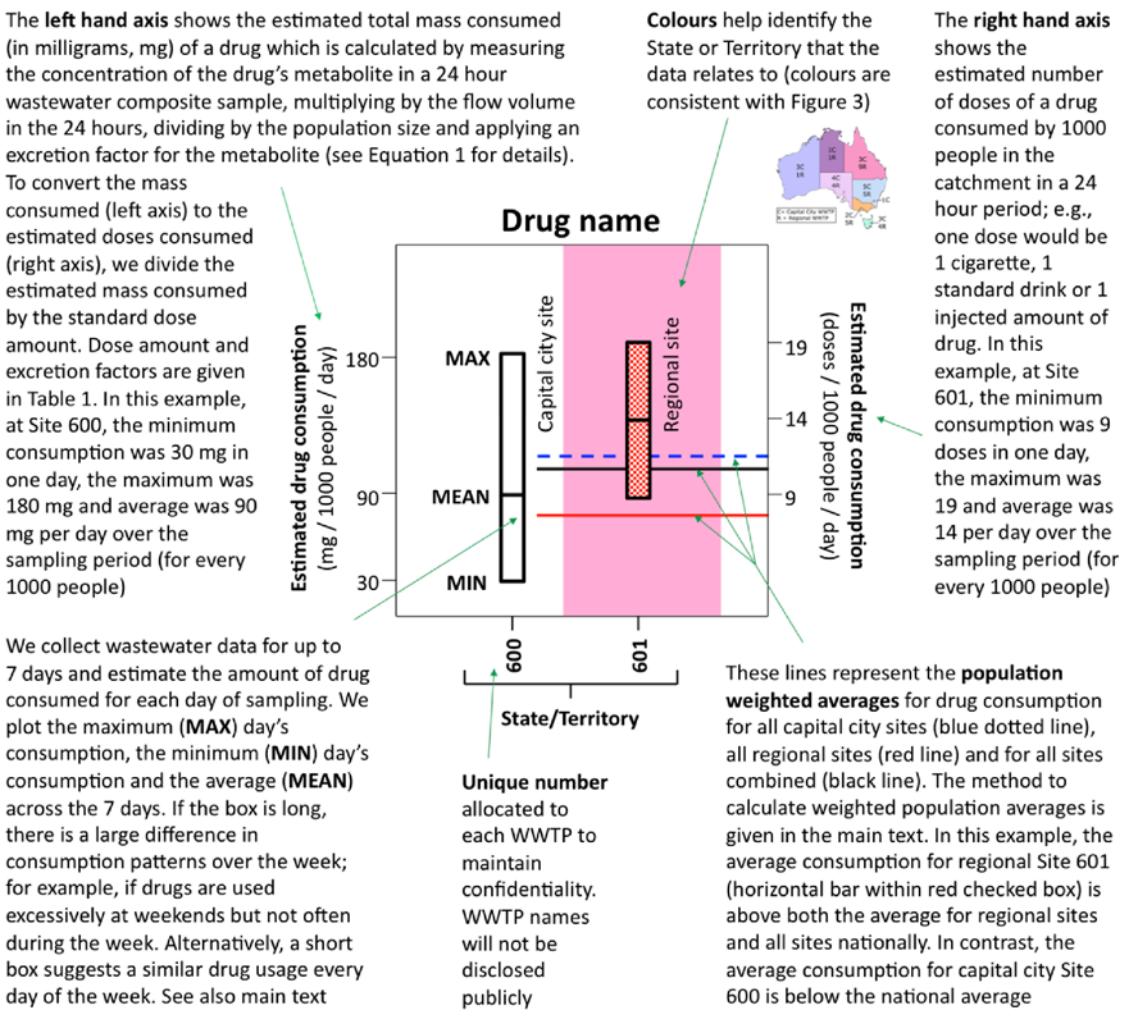
Reported averages: All averages for state/territory or Australia-wide drug consumption data are presented throughout this report as population weighted averages. The number of people in the catchment population is used as the weighting for the respective drug consumption data for that population. For example, to calculate the population weighted average of capital city methylamphetamine consumption, the methylamphetamine

consumption data for each WWTP was multiplied by the respective population number, all data were then summed and divided by the total population across all capital city sites. Reported average values are therefore not skewed towards usage data from small, non-representative populations.

Per capita consumption: The per capita consumption estimates presented in this report are calculated using the total estimated catchment population (which includes children). For example, per capita alcohol consumption has previously been reported by the ABS based on population numbers for people aged 15 and over. The consumption values presented in the current report will be under-estimated compared to those determined for an adult-only population. For consistency, data from other studies included in this report were recalculated where necessary using estimated total population.

Graphical presentation of data: An overview of how the data is presented in the graphs for the individual sites is given in Figure 4. This includes information on interpreting the consumption data presented on the vertical axes in all graphs in this report; in some graphs, the values plotted in the graph can be read as either mass of drug consumed (left axis) or doses of drug consumed (right axis).

Figure 4: Explanation of the graphical representation of data for individual sites. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).



Instrumental method limits of detection and limits of reporting: For wastewater samples that hold very low quantities of particular drugs, the limit of detection (LOD) is determined analytically as the lowest concentration of that drug that can be distinguished in the sample (using the methods described above). A drug may be present at a concentration below the LOD, but we cannot detect it. The limit of reporting (LOR) is a concentration (higher than the LOD), above which we have high confidence that the concentration measured on the analytical instrument is accurate. Above the LOD but below the LOR there may be some uncertainty as to the actual concentration. To be conservative (a drug may be present but there is uncertainty as to its concentration) and in line with current practise, for back calculations to estimate per capita consumption, a concentration below the LOD is included at a value of LOD. A concentration above the LOD but below LOR, is included at the midpoint between the LOD and LOR (i.e. (LOD + LOR)/2).

Weekly pattern of drug use: The pattern of drug use over the sampling week for the sites in this report cannot be elucidated from the data presented in the current report. We present only maximum, minimum and average (for the individual sites) (Figure 4) and only average (or population weighted average, see above) values for all other graphs. Furthermore, for cocaine, MDMA, oxycodone, fentanyl, methylone, mephedrone, JWH-018 and JWH-073 only two samples per site were analysed therefore the max, min and average should be interpreted accordingly. In future reports, all samples will be analysed for these drugs. Consistent patterns of drug use in Australia from previous wastewater-based epidemiology studies indicate that some illicit drugs such as cocaine, MDMA, mephedrone and methylone, have high variation in weekly consumption rates, with higher consumption on weekends. Other drugs such as methylamphetamine, oxycodone and fentanyl appear to have lower daily variation suggesting that their consumption is consistent throughout the week (Lai et al., 2015; Tscharke et al., 2016).

4: RESULTS

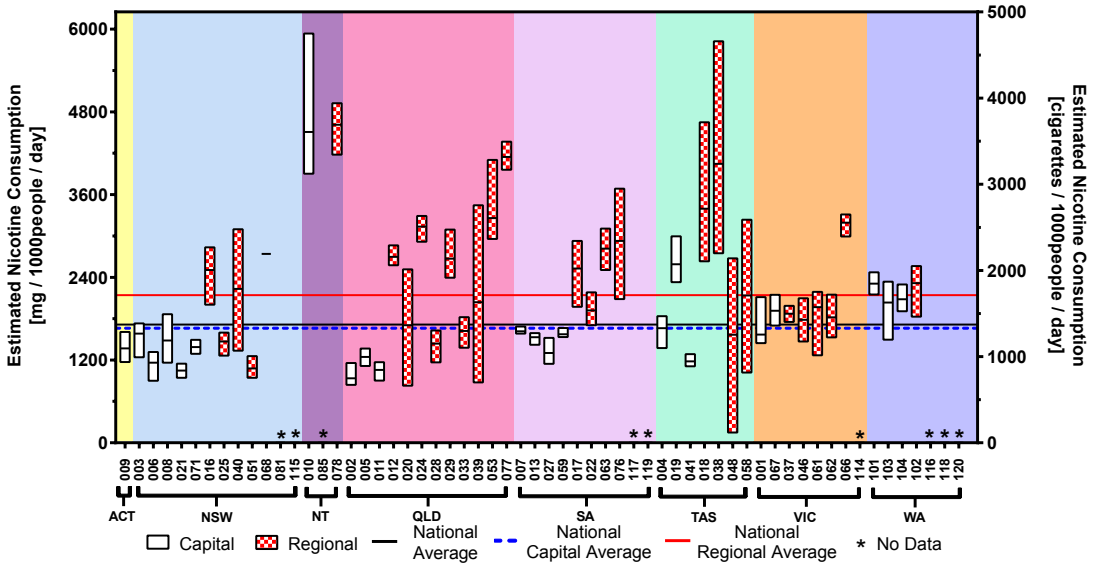
In the following sections estimated drug consumption data are presented in several different ways to allow comparisons of drug use at the individual site level (Section 4.1), between states and territories (Section 4.2), within each state and territory (Section 4.3), and at an international level (Section 4.4). We recommend exercising caution when comparing results between individual sites as population estimates for some catchments have not been refined and estimated consumption may be affected by inaccuracies in population figures provided by plants or managing agencies. On release of the 2016 Census data, updated catchment populations will be determined and included in future reports. The uncertainties in individual population estimates have less impact when data are averaged, for example when broader comparisons at the state/territory or international level are undertaken.

4.1: INDIVIDUAL SITE COMPARISON OF DRUG USE

4.1.1: TOBACCO AND ALCOHOL

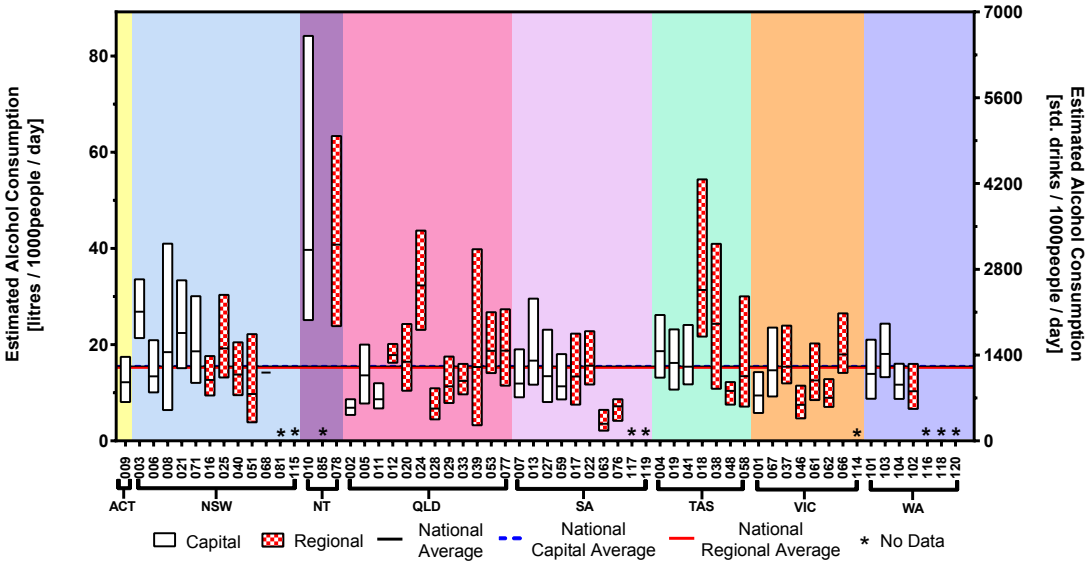
Tobacco consumption was estimated by measuring two nicotine metabolites. The method does not distinguish between nicotine intake from tobacco or electronic cigarettes and nicotine replacement therapies such as patches and gums. Estimated tobacco consumption varied significantly between sites and the participating Northern Territory capital city site had the highest per capita consumption estimate in the nation. However, as only one capital site was analysed for the Northern Territory, this may not be indicative of tobacco use across the entire Northern Territory capital city. Per capita consumption of tobacco in both the Northern Territory sites and at some sites in regional Tasmania and Queensland were substantially above the national average and more generally, regional sites on average had higher consumption levels (red horizontal line, Figure 5) than capital city precincts (dotted blue line, Figure 5).

Figure 5: Estimated tobacco consumption in mass of nicotine consumed per day (left axis) and number of cigarettes per day (right axis) per thousand people. The number of collection days varied from 1–7.



Alcohol was measured using a specific metabolite of ethanol. The Northern Territory showed the highest average per capita consumption estimates of all the participating sites, with a wide range in alcohol consumption from a minimum of 2 000 standard drinks per 1 000 people per day to 6 600 per 1 000 people per day maximum, across the sampling period (right axis, Figure 6). Compared to tobacco, the difference between average alcohol consumption in regional Australia and capital cities was marginal (Figure 6).

Figure 6: Estimated alcohol consumption in volume consumed per day (left axis) and standard drinks per day (right axis) per thousand people. The number of collection days varied from 1–7.



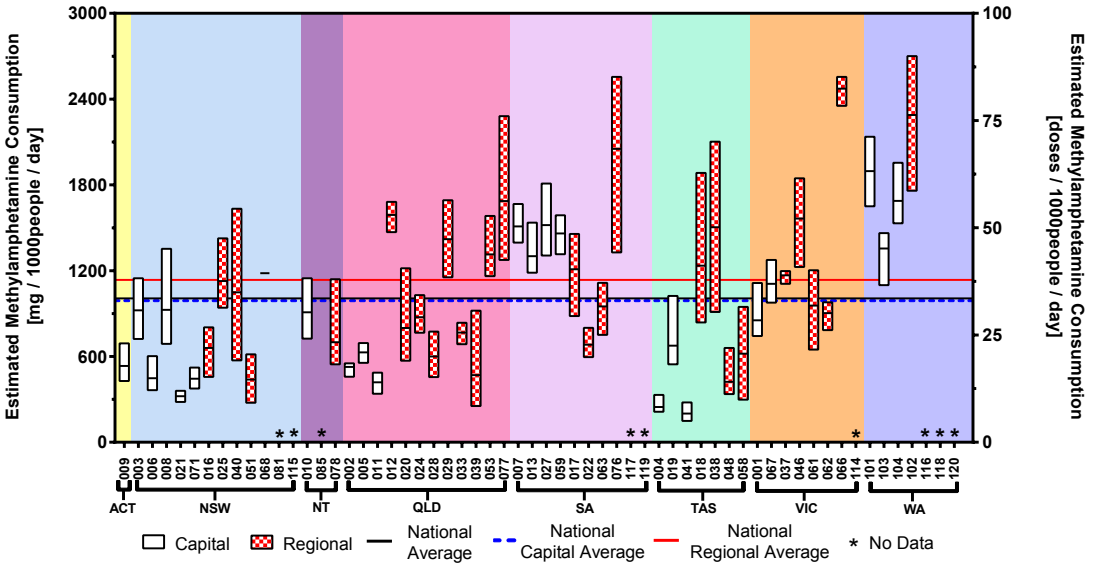
4.1.2: STIMULANTS

The relative estimated consumption levels across the participating sites for three stimulants, methylamphetamine, cocaine and MDMA, are described in more detail below.

4.1.2.1: METHYLAMPHETAMINE

Estimated mass loads of methylamphetamine were high compared to other substances of abuse. The normalised mass load in regional Western Australia was the highest (Figure 7). However, it should be recognised that the current information relates to only one participating regional site in the state.

Figure 7: Estimated methylamphetamine consumption in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 1–7.

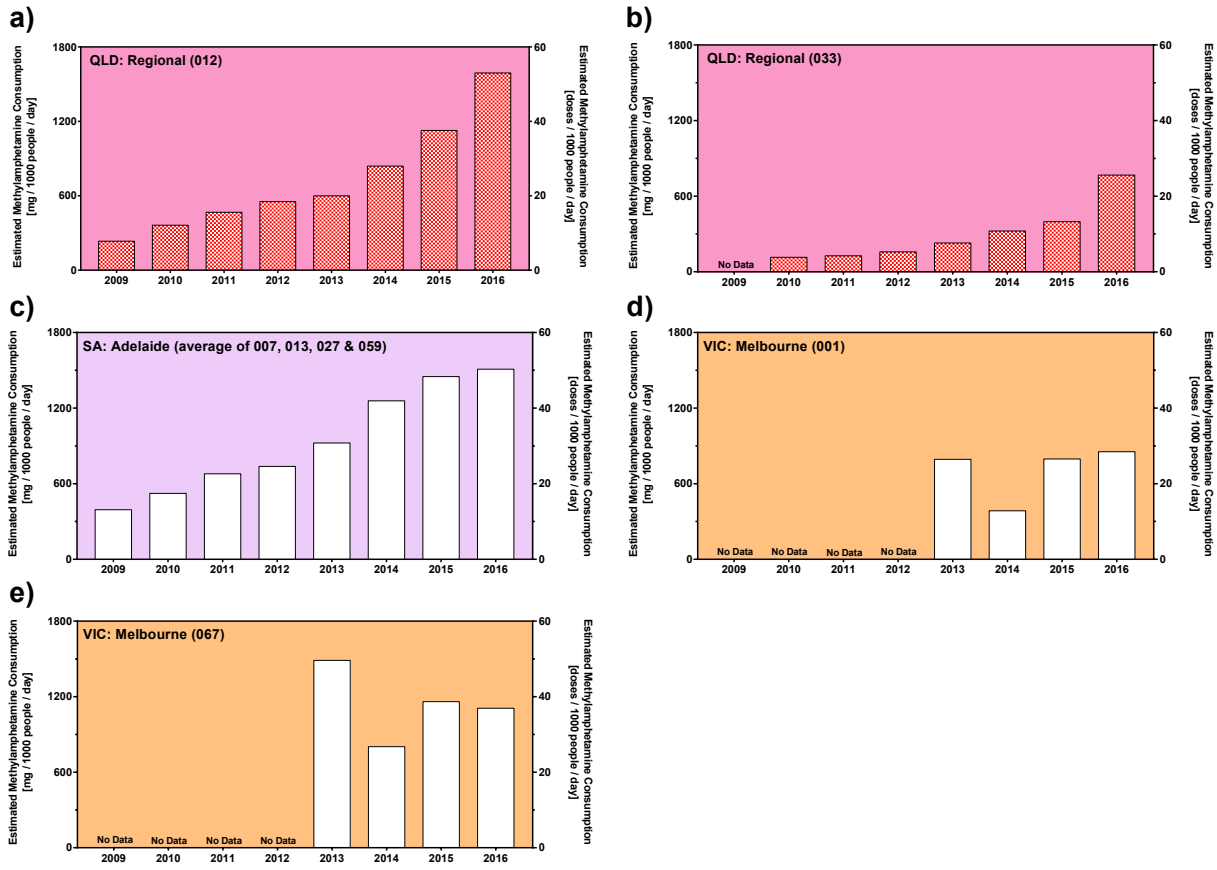


On a national scale, regional and capital city Australia showed comparable levels of methylamphetamine consumption. However, there was high variability between sites across all state and territories, with some state capital city areas having higher average load consumed of the drug, notably South Australia, while in others the regional areas showed higher levels. In terms of capital city populations, levels of methylamphetamine were consistently above the national average in Western Australia and South Australia, and below average in Tasmania and the Australian Capital Territory.

Large differences were apparent when comparing the various regional sites on a state or territory and national level. In New South Wales, Site 21 had a consistently low usage in the state. Site 66 had the highest levels in Victoria, Site 76 was the highest in South Australia, while in Tasmania, Sites 18 and 38 were well above the state average. In some states, the difference in mass loads between regional sites was more than threefold (South Australia, Tasmania, Victoria).

Levels of methylamphetamine have been monitored for several years at some sites in South Australia and Queensland, as well as intermittently in Victoria (Figure 8). Comparing the latest findings of drug use with previous data for sites in Queensland and the weighted averaged South Australia capital city region, current methylamphetamine levels have been consistently increasing and are at historic highs. The data obtained in Victoria did not show the same increase in trend observed in South Australia and Queensland but is based on a much smaller data set with infrequent sampling and is thus less reliable.

Figure 8: Site-specific yearly data for a)-b) Queensland and d)-e) Victoria, and c) population weighted average annual consumption of methylamphetamine in Adelaide (data courtesy of DASSA).



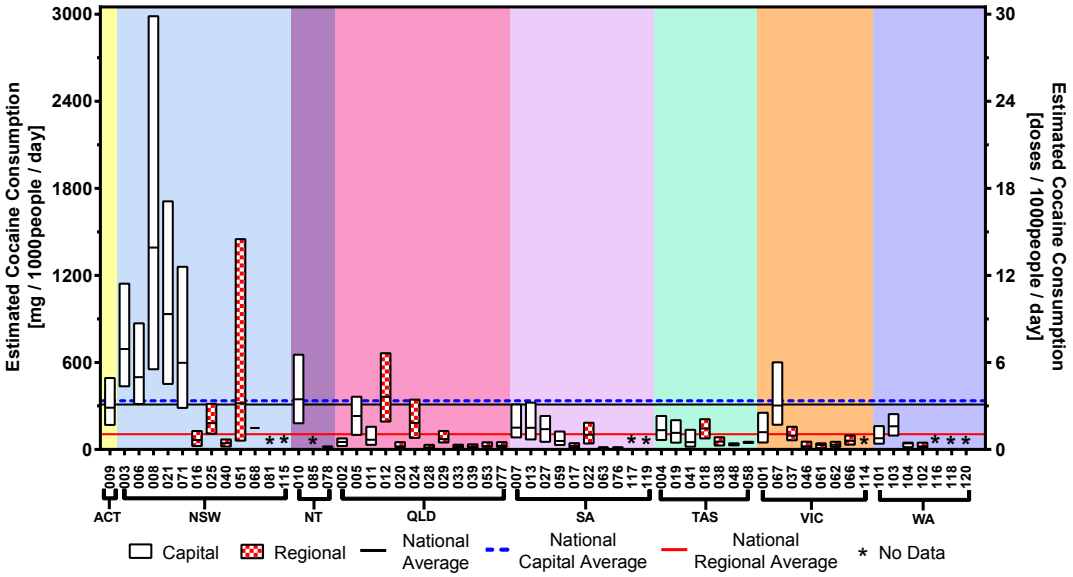
4.1.2.2: AMPHETAMINE

The concentration of amphetamine observed in the samples strongly correlated with the methylamphetamine concentrations, with approximately seven times higher methylamphetamine measured than amphetamine (R^2 = 0.77) (see Figure 27, Appendix 4) which is consistent with the reported amphetamine excretion range following methylamphetamine consumption (Gracia-Lor et al 2016). Therefore we assume the levels of amphetamine we measured are predominantly metabolites of methylamphetamine. It is possible that some of the amphetamine measured could be a result of amphetamine consumption but due to the much higher methylamphetamine consumption and excretion profile, this cannot be confirmed by our data.

4.1.2.3: COCAINE

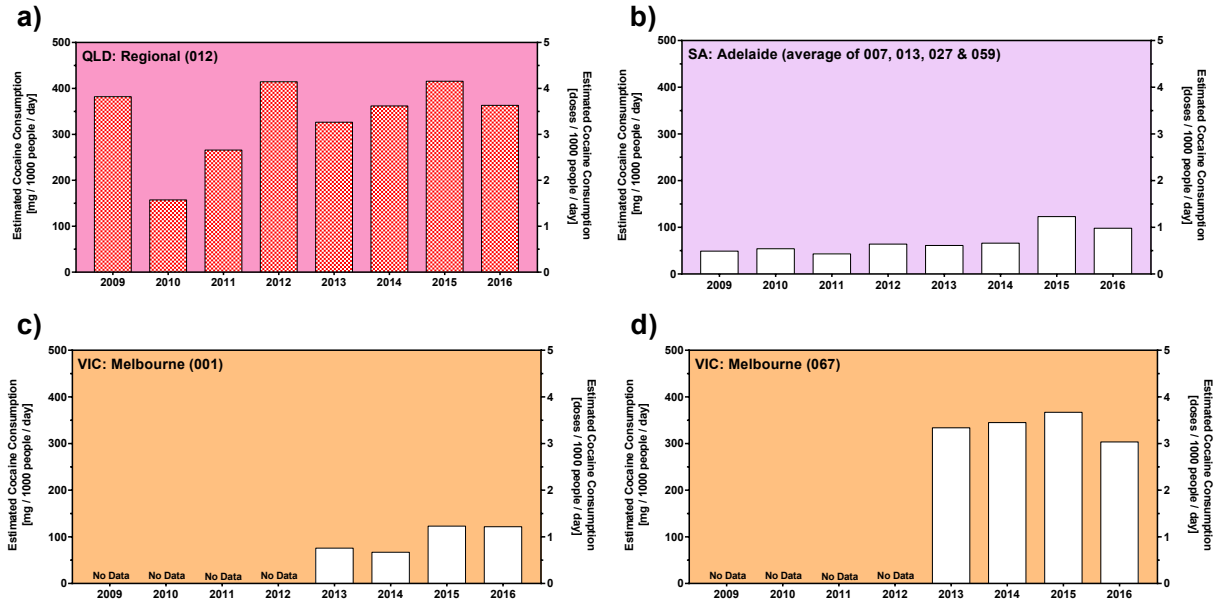
Cocaine was measured using a specific metabolite (i.e. benzoylecgonine). From a national perspective, capital city areas on average had higher cocaine use than regional centres (Figure 9). However, some regional areas such as Site 12 in Queensland and Sites 21 and 51 in New South Wales showed use well above average. In contrast, many other sites in regional Australia showed very little evidence of cocaine use. Capital city New South Wales consumed cocaine well above the national average, with Site 8 particularly prominent. Sites 10 in the Northern Territory and 67 in Victoria had the highest capital city levels of cocaine in those regions, while other capital city sites were below average. On average, cocaine consumption in Australia was noticeably lower than methylamphetamine levels.

Figure 9: Estimate cocaine consumption in mass consumed per day per thousand people (left axis) and doses per day (right axis). The number of collection days varied from 1–7.



Historically, cocaine consumption has been low compared to methylamphetamine. Estimated methylamphetamine use in Queensland and Victoria have generally been higher than in South Australia. However, use in a number of catchment areas in South Australia has been increasing, which is evident from the weighted capital city average (Figure 10).

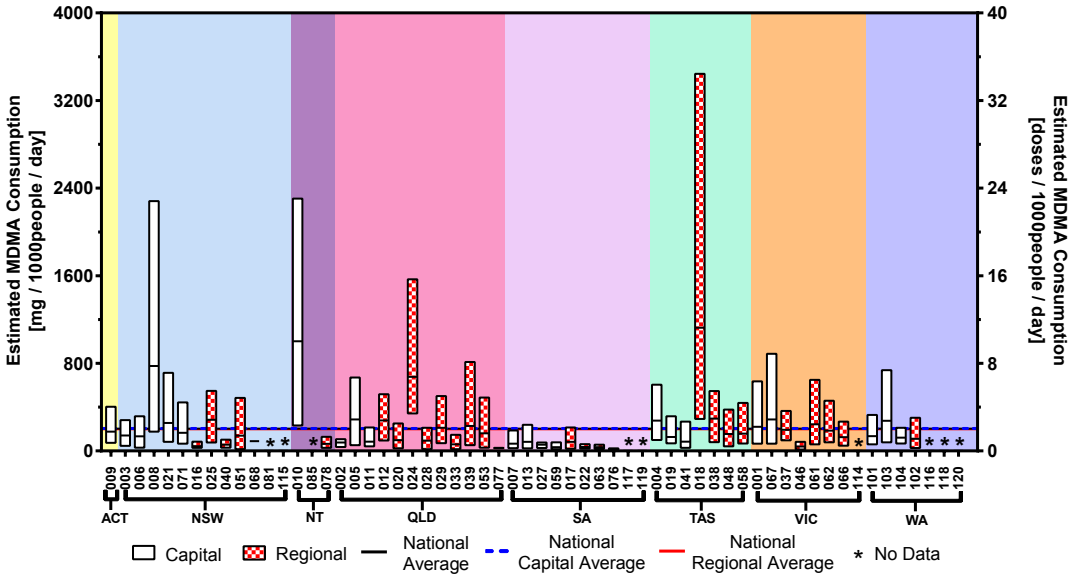
Figure 10: Site-specific yearly data for a) Queensland and c)–d) Victoria, and b) population weighted average annual consumption of cocaine in Adelaide (data courtesy of DASSA).



4.1.2.4: MDMA (3,4-METHYLENEDIOXYMETHYLAMPHETAMINE)

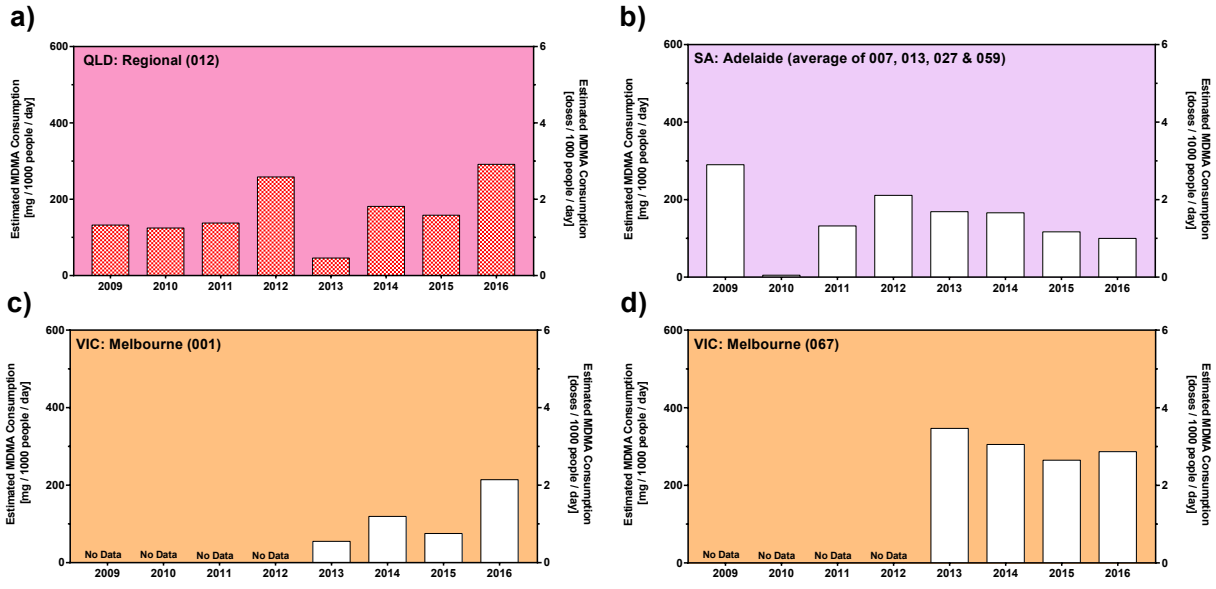
Levels of MDMA were consistently low across the country (Figure 11) compared to methylamphetamine. A few exceptions were capital city Site 8 in New South Wales and Site 10 in the Northern Territory, and regional Sites 18 and 24 in Tasmania and Queensland, respectively. Regional and capital city average MDMA consumption were almost identical.

Figure 11: Estimated MDMA consumption in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 1–7.



When comparing historic levels of MDMA consumption as measured in three regions, we observed a slow decline in South Australia between 2012 and 2016, whereas at the other sites with extended data sets in Queensland and Victoria there were no obvious longer term trends observable (Figure 12).

Figure 12: Site-specific yearly data for a) Queensland and c)–d) Victoria, and b) population weighted average annual consumption of MDMA in Adelaide (data courtesy of DASSA).

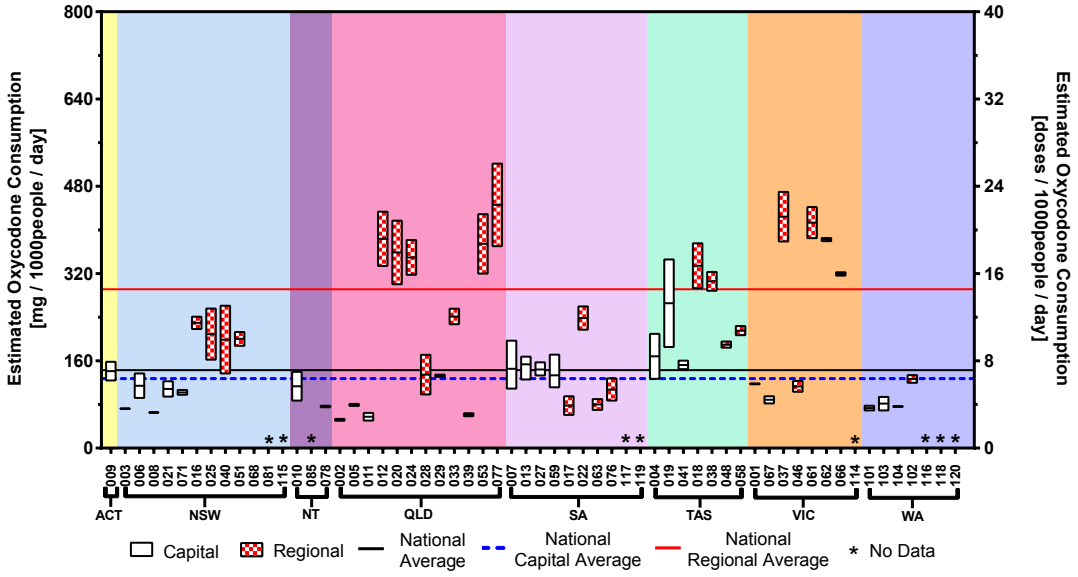


4.1.3: PHARMACEUTICAL OPIOIDS

Oxycodone and fentanyl are pharmaceutical substances with abuse potential. The metabolism and excretion of both compounds are well characterised. The major metabolite of each compound was measured to estimate drug consumption.

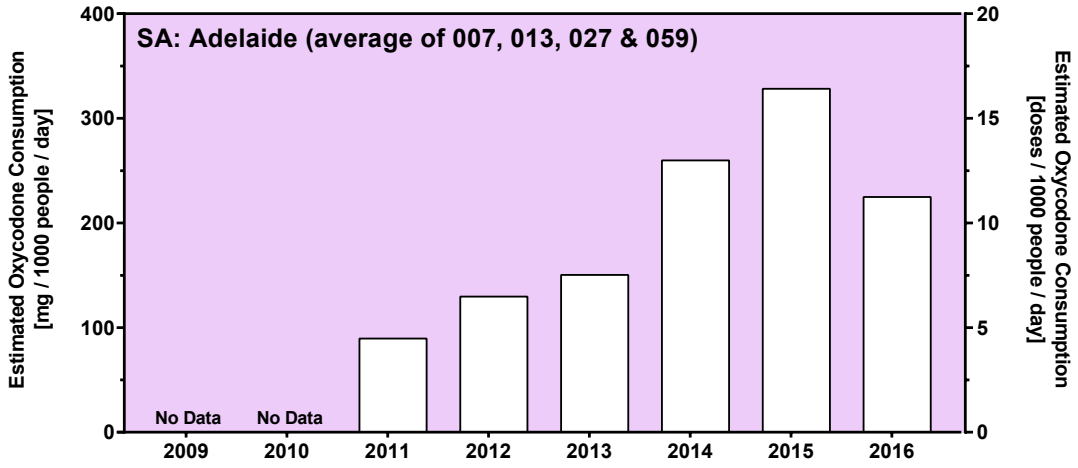
Oxycodone use in numerous regional sites was well above capital city levels which resulted in the average regional consumption being almost double the capital city national average (Figure 13). Regional Queensland, in particular, showed above average oxycodone use.

Figure 13: Estimated oxycodone consumption in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 1–7.



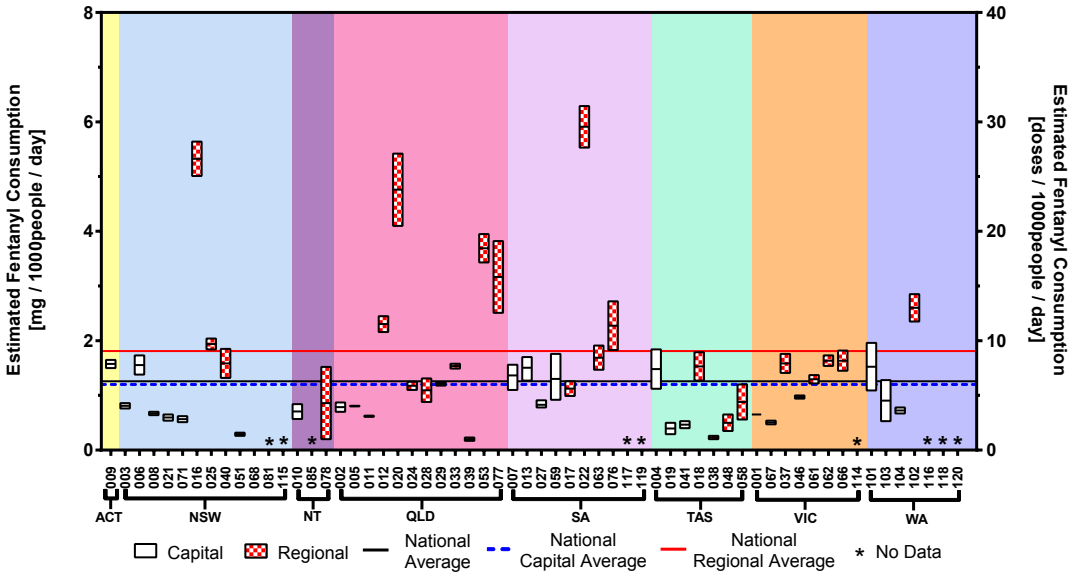
Bimonthly data for oxycodone have been collected in the Adelaide region over the past six years. The historical annual cumulative results show that use of the substance reached a peak in 2015 and has recently declined (Figure 14).

Figure 14: Population weighted average annual consumption of oxycodone in Adelaide (data courtesy of DASSA).



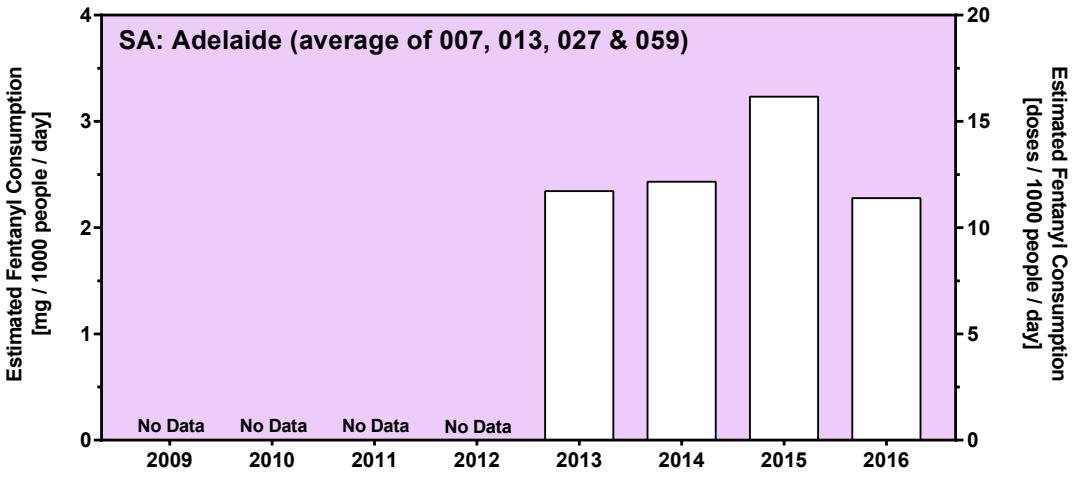
Similar to oxycodone, fentanyl levels were high in certain regional centres, notably parts of New South Wales, Queensland and South Australia (Figure 15). On average, regional consumption was higher than capital city areas. However, large variations were evident when comparing sites across Australia.

Figure 15: Estimated fentanyl consumption in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 1–7.



The temporal trend for fentanyl over a six-year period in Adelaide shows relatively constant consumption levels, except for a spike in 2015 (Figure 16).

Figure 16: Population weighted average estimated annual consumption of fentanyl in Adelaide (data courtesy of DASSA).



4.1.4: NEW PSYCHOACTIVE SUBSTANCES

A number of other substances were included in the study. Methylone and mephedrone are two psychoactive substances for which limited information is available on the metabolism and excretion of these compounds. The parent compound was therefore measured, although it is probable that a significant proportion of the ingested drug is converted into different metabolites. In this collection, only a few sites showed evidence of methylone and mephedrone use. Since these were mostly below quantification levels, sites that showed the presence of the two compounds are qualitatively listed in Table 2.

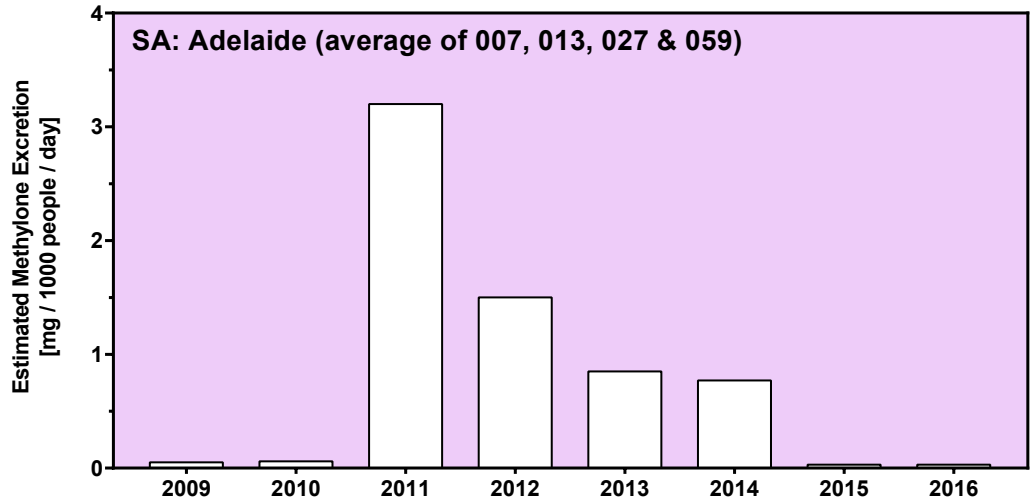
Table 2: The number and code of sites per State and Territory where mephedrone and methylone were detected.

	NUMBER OF DETECTIONS		SITES DETECTED	
STATE	MEPHEDRONE	METHYLONE	MEPHEDRONE	METHYLONE
NT	0	1		010
ACT	0	2		009
NSW	3	16	003, 008, 071	003, 006, 008, 016, 021, 025, 040, 071
QLD	1	24	002	002, 005, 011, 012, 020, 024, 028, 029, 033, 039, 053, 077
SA	2	0	027, 059	
TAS	3	13	018, 038, 058	019, 004, 041, 018, 038, 048, 058
VIC	0	0		
WA	0	2		103, 102
Total	9	58	9	31

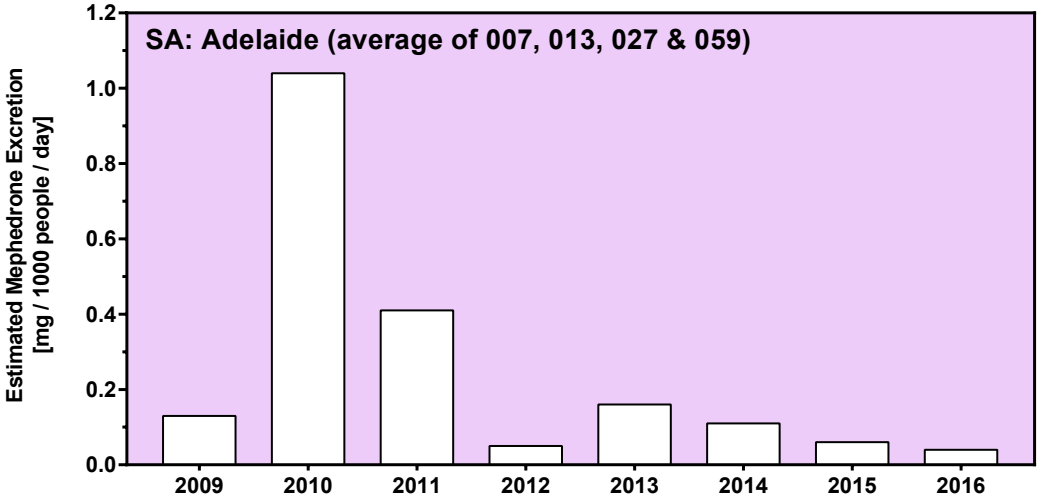
Both methylone and mephedrone have been detected historically in South Australia (Figure 17). The South Australia data suggests that levels of consumption of both these drugs have been declining over the last six years.

Figure 17: Population weighted average estimated annual consumption of a) methylone and b) mephedrone in Adelaide (data courtesy of DASSA).

a)



b)



Detection methods for measuring the cannabinoids JWH-018 and JWH-073 were also included in this study but neither compound was detected in any of the samples. MDA had overall low detection frequency using direct injection methods and, as a metabolite of MDMA, we assume that most low levels detected originated from MDMA consumption. This will be addressed further in subsequent reports using SPE for extraction of samples.

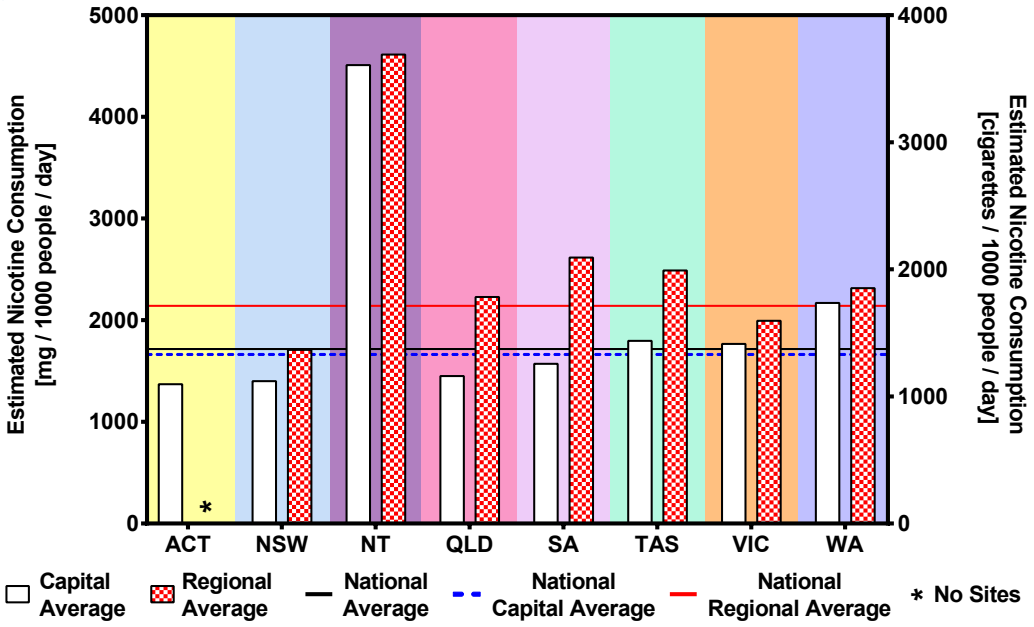
4.2: STATE AND TERRITORY COMPARISON OF DRUG USE

4.2.1: TOBACCO AND ALCOHOL

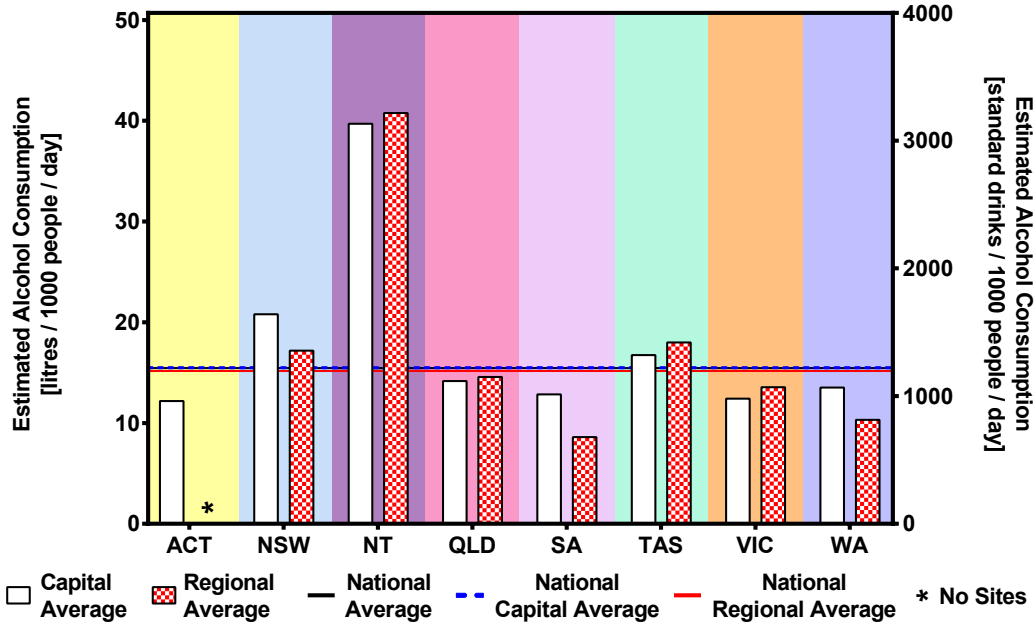
For all states and territories, we found a consistent trend of higher average tobacco consumption in samples collected from regional sites when compared to the capital cities (Figure 18a). For alcohol, the difference within each state or territory was less pronounced (Figure 18b). The consumption of alcohol and tobacco in the Northern Territory was noticeably higher than the national averages for these substances, although only a single Northern Territory capital site was included in the study and care should be taken when interpreting the result.

Figure 18: Estimated average consumption of a) tobacco and b) alcohol for capital city sites and regional sites by state/territory. A standard drink is 10.0 g or 12.5 mL and 1 cigarette contains 1.25 mg of nicotine.

a)



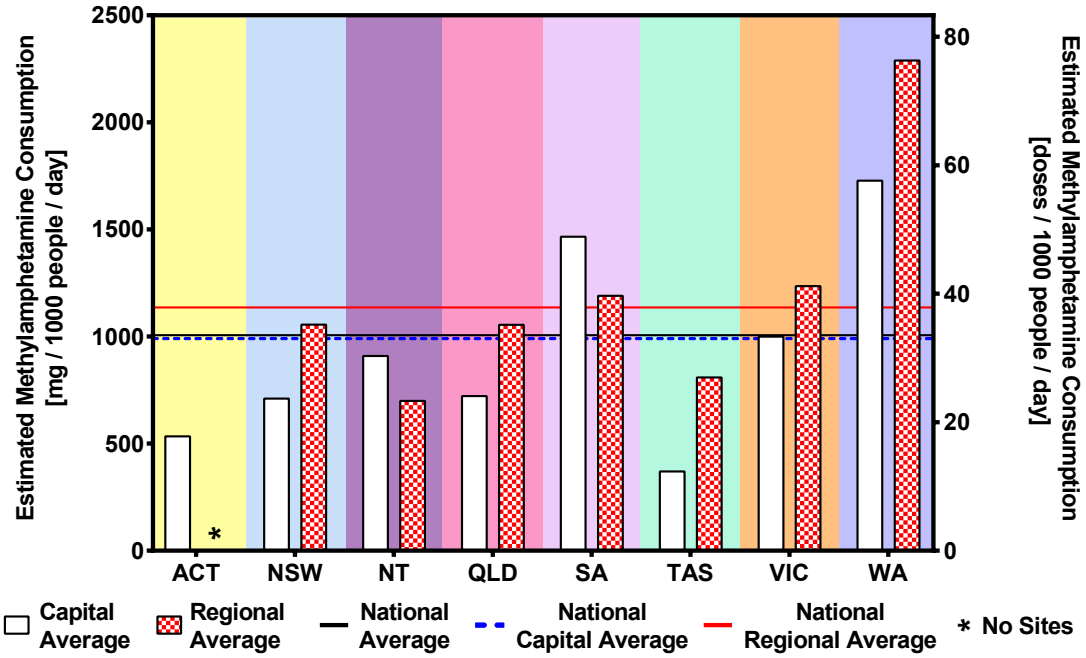
b)



4.2.2: ILLICIT DRUGS

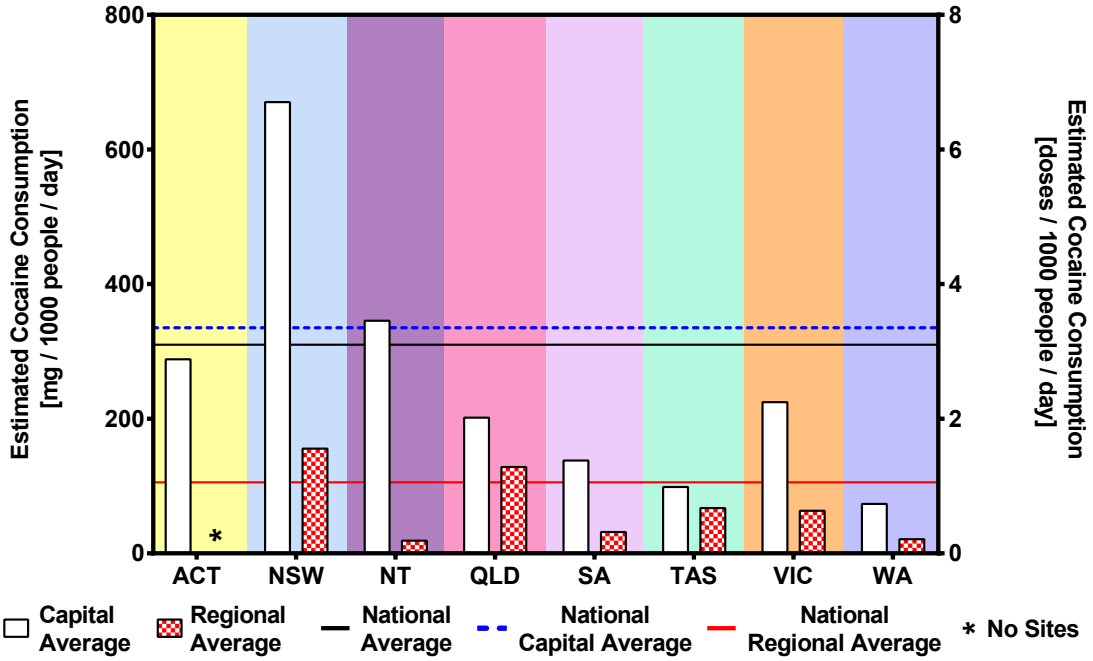
Western Australia had the highest levels of methylamphetamine, with levels in both capital city and regional areas above the respective national averages (Figure 19). It should be noted though that only one regional site was included in the Western Australia collection. Except in South Australia and Northern Territory, regional areas had higher levels of methylamphetamine use than capital sites. The capital city sites in the Australian Capital Territory and Tasmania were the regions with lowest methylamphetamine levels nationwide.

Figure 19: Estimated average consumption of methylamphetamine for capital city sites and regional sites by state/territory.



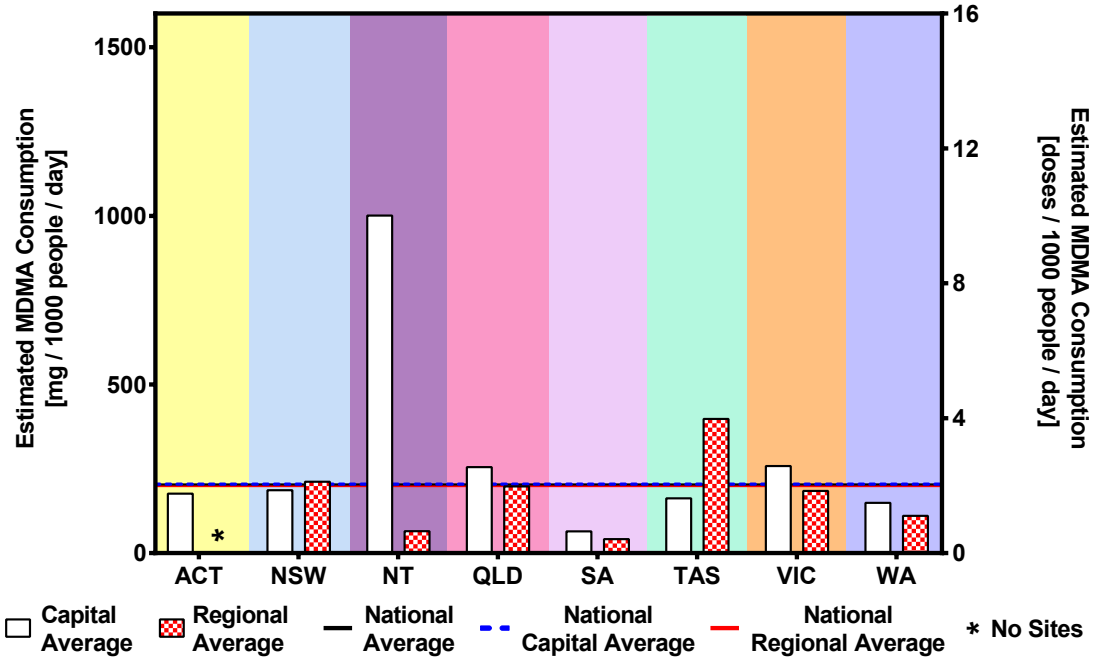
Cocaine consumption in capital city sites in New South Wales dominated the national landscape, being almost double the next highest region in terms of doses consumed per day. The Australian Capital Territory and the capital Northern Territory site showed substantially higher cocaine consumption compared to other states, with Western Australia well below the average (Figure 20). The drug's use was consistently higher in capital city areas compared to regional areas, the Northern Territory having the lowest regional consumption of all participating regions.

Figure 20: Estimated average consumption of cocaine for capital city sites and regional sites by state/territory.



In regions with representative sampling data, the capital city site in the Northern Territory ranked highest in terms of estimated MDMA consumption (Figure 21). In contrast, MDMA use in regional Northern Territory and South Australia was well below other regional areas. The Northern Territory was also the only state or territory with substantially higher MDMA use in the capital city than in the regional areas.

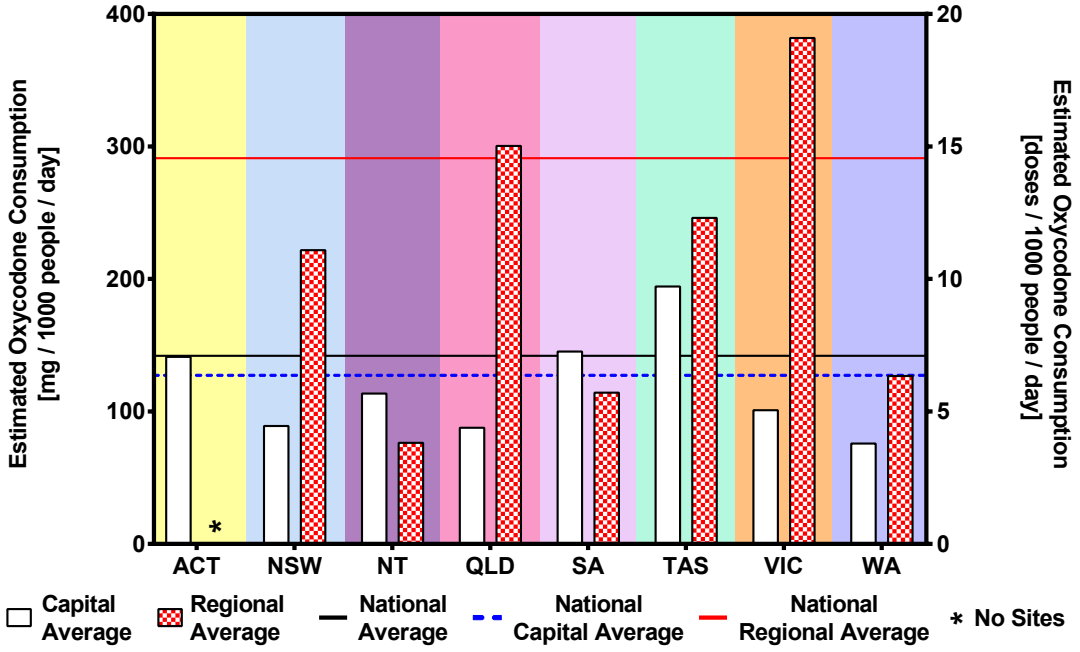
Figure 21: Estimated average consumption of MDMA for capital city sites and regional sites by state/territory.



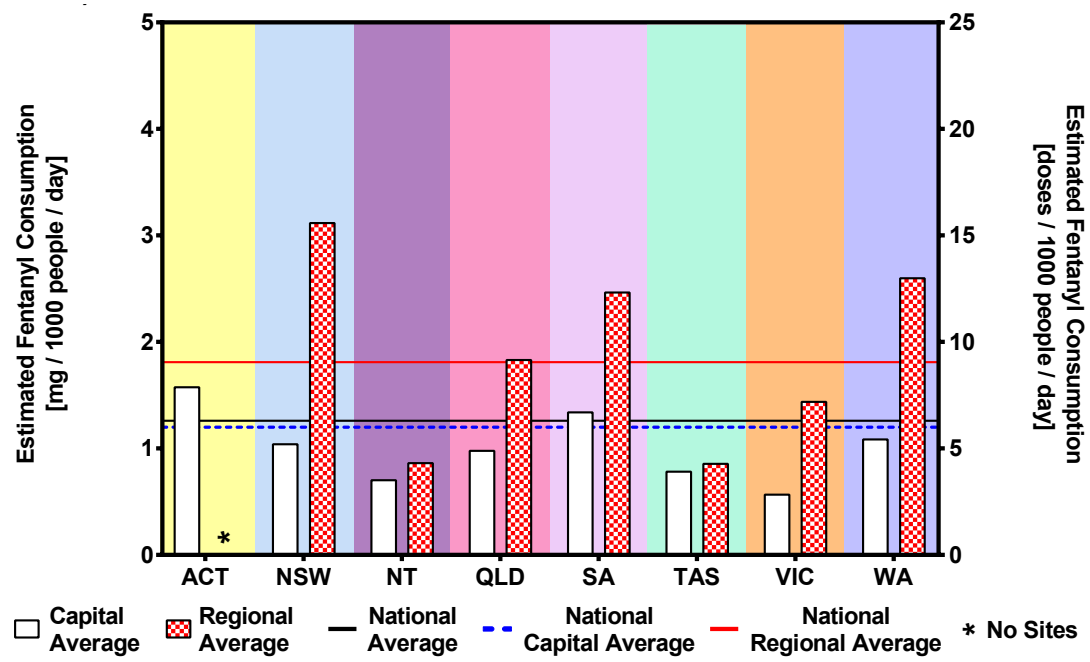
Comparing pharmaceutical opioids, average oxycodone and fentanyl use was substantially higher in regional areas of a number of states (Figure 22).

Figure 22: Estimated average consumption of a) oxycodone and b) fentanyl for capital city sites and regional sites by state/territory.

a)



b)



Some drugs such as the cannabinoids were not detected at all, while for methylone and mephedrone, excretion rates are not yet fully understood and therefore conversion factors for the purposes of the figure could not be applied. Nevertheless, these compounds were detected at very low levels compared to substances included in Figure 18 to Figure 22.

4.3: DRUG PROFILE FOR EACH STATE AND TERRITORY

To compare usage of drugs of different types within the same region (for example, within a state or territory), drug consumption should be reported as the number of doses consumed. When the amount of drug measured in wastewater was normalised for population size and average dose consumed (conversion factors listed in Table 1), alcohol and tobacco were consistently the highest consumed drugs in all states and territories. For example, the national average consumption of alcohol and tobacco per 1 000 people per day is 1 200 standard drinks or 1 400 cigarettes per 1 000 people per day, respectively (Figure 5 and Figure 6), whereas for methylamphetamine, the national average consumption is closer to 35 doses per 1 000 people per day (Figure 7). Amongst the illicit drugs, methylamphetamine consumption was the highest across all regions of Australia (Figure 23). This trend was consistent for both capital cities and regional sites. Based on the usage profiles for the other drugs commonly detected in this study (cocaine, MDMA, oxycodone and fentanyl), no other consistent patterns of usage within the different states and territories were observed; for example, the second highest drug consumed was fentanyl in the Australian Capital Territory, New South Wales regional, South Australia regional and Western Australia regional sites, MDMA in the Northern Territory capital city and oxycodone in Queensland, Tasmania and Victoria regional sites (Figure 23).

Figure 23(a): Profile of average drug consumption by state or territory. Consumption is shown as the number of doses per 1 000 people per day to allow comparison of drugs of different types within the same region (state or territory).

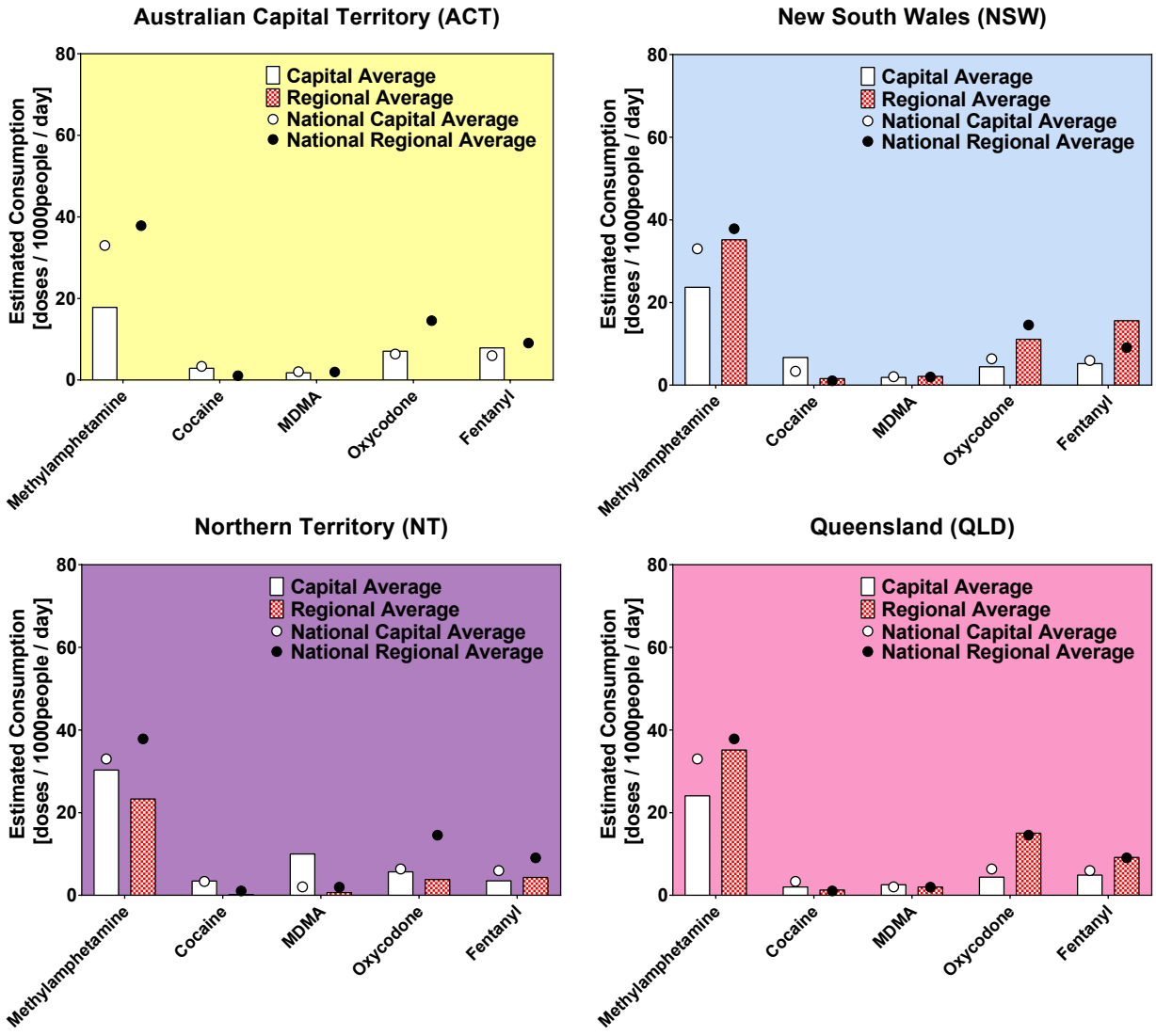
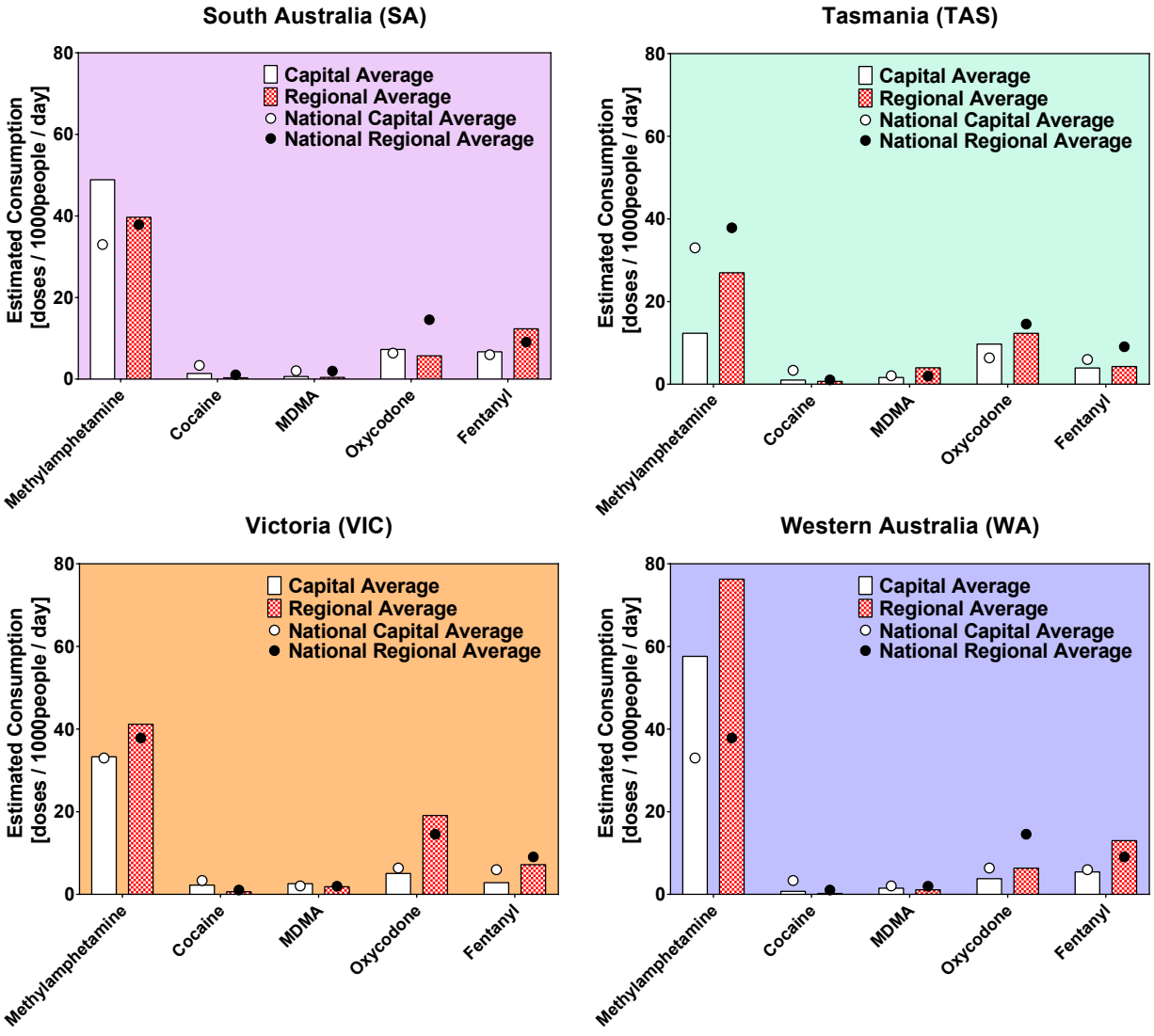


Figure 23(b): Profile of average drug consumption by state or territory. Consumption is shown as the number of doses per 1 000 people per day to allow comparison of drugs of different types within the same region (state or territory).

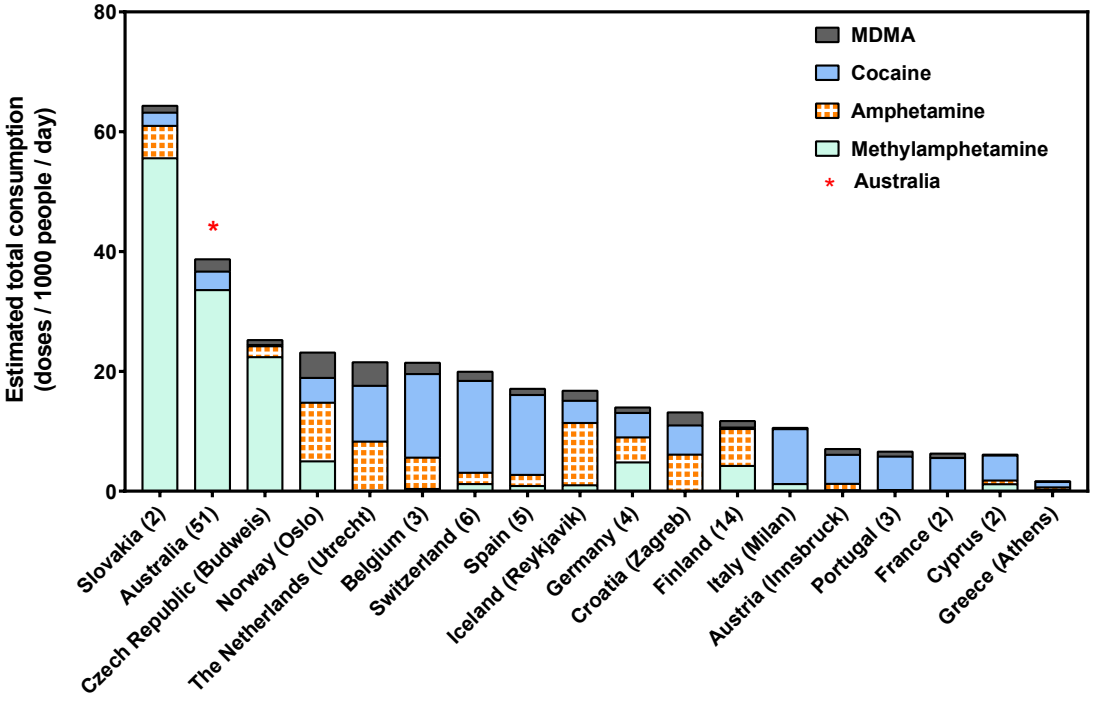


4.4: INTERNATIONAL COMPARISON OF DRUG USE

4.4.1: STIMULANT USE

When comparing stimulant use in Australia with international levels, it should be recognised that cultures have different drug preferences and availability of drugs may differ between countries. Throughout many parts of Europe amphetamine is more commonly used than methylamphetamine, while the opposite is true in Australia. Therefore, to make international comparisons, the four common stimulants were added together and expressed as doses per day per normalised population (Figure 24). Latest international data for Europe were used as reported by SCORE (2017).

Figure 24: The total amount of stimulant consumed (as doses per 1 000 people per day) by a country as a population weighted average of the number of reported sites (given in brackets after country name).



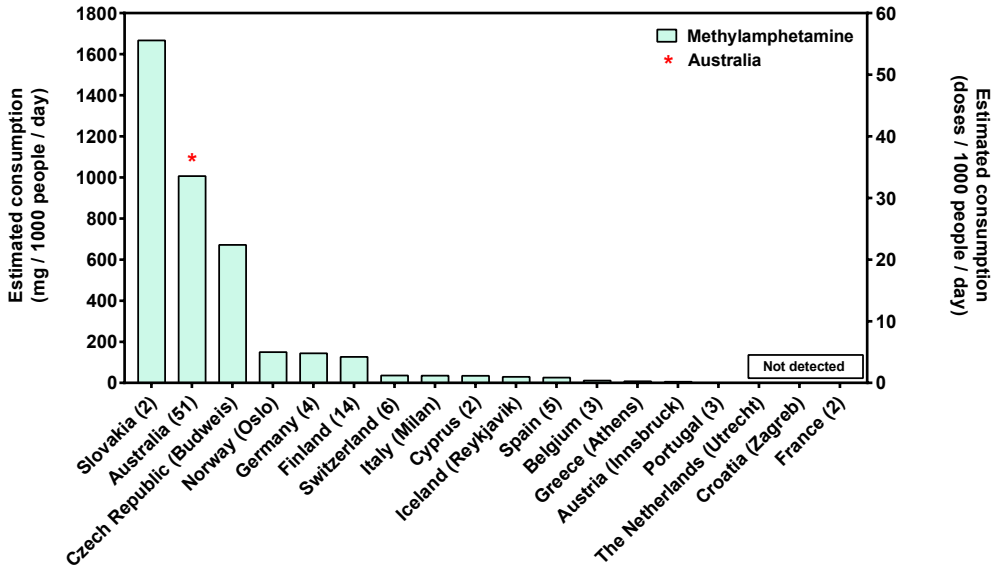
Note: the European estimates are based on data of a few WWTPs per country only and, therefore, may not represent the national per capita consumption for a given analyte in a given country. The number of reported cities is given in brackets after country name. European data are from SCORE (2017) and various excretion factors applied are reported in Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia.

Of the European countries with comparable reported data for the four common stimulants considered, Australia has the second highest total estimated consumption. As discussed above, the amphetamine detected in this study is expected to be mainly a methylamphetamine metabolite and so no Australian usage is reflected in Figure 24.

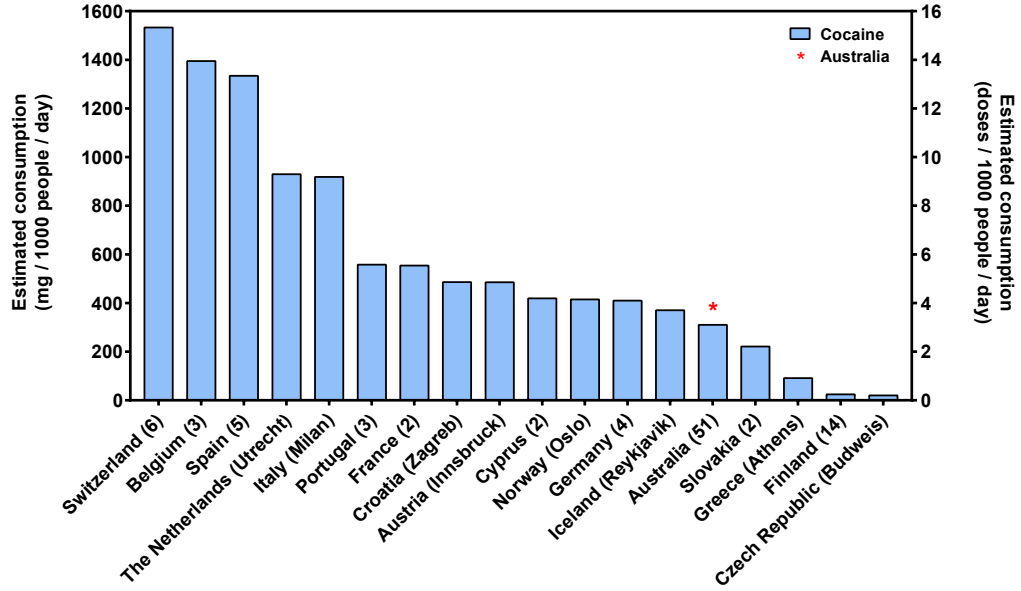
Comparing these drugs individually between Australia and other countries, Australia's ranking in Figure 24 is driven by its high methylamphetamine consumption (Figure 25a). Methylamphetamine levels are the second highest compared to the other reported countries. It is worth noting that the other countries in the world with reasonably high methylamphetamine use, in Asia and parts of the United States, are not represented here. Compared to European drug usage patterns, Australian cocaine consumption is relatively lower, while MDMA is at median levels (Figure 25b-c).

Figure 25: National population weighted average consumption for cities in Europe and Australia for a) methylamphetamine, b) cocaine and c) MDMA consumed on a per capita basis.

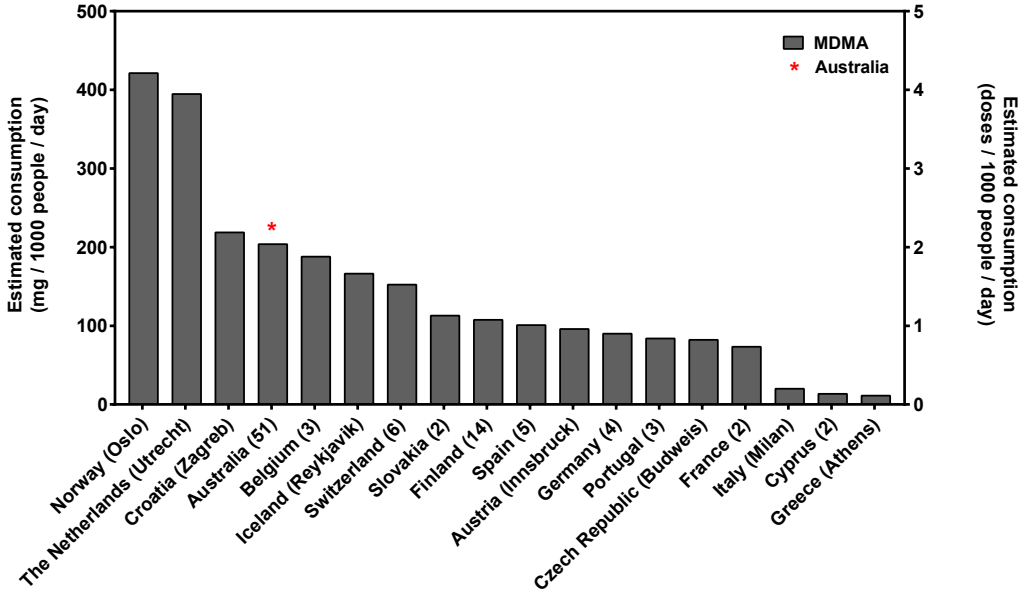
a) Methylamphetamine



b) Cocaine



C) MDMA



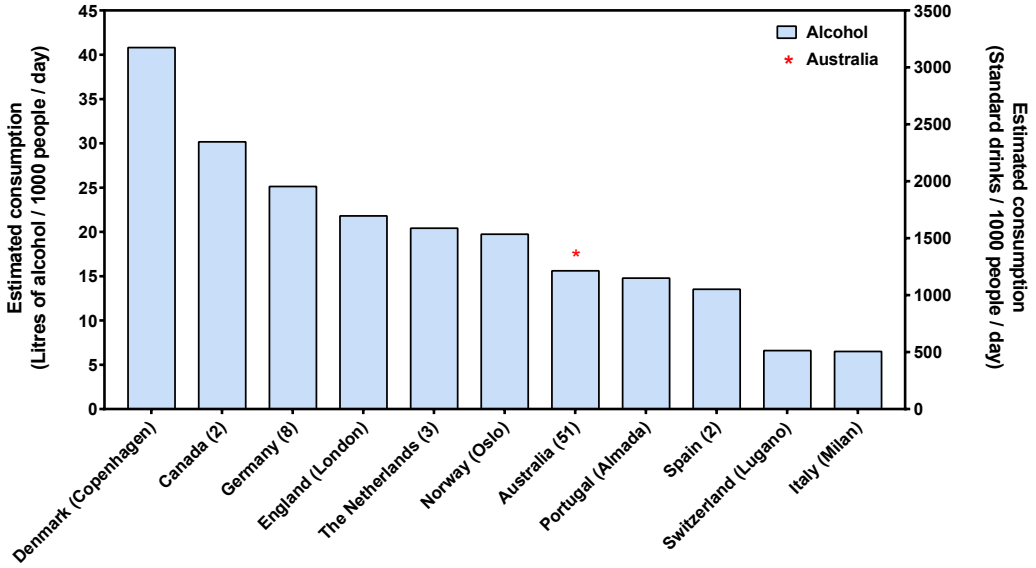
Note: the European estimates are based on data of a few WWTPs per country only and, therefore, may not represent the national per capita consumption for a given analyte in a given country. The number of reported cities is given in brackets after country name. European data are from SCORE (2017) and various excretion factors applied are reported in Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia.

4.4.2: ALCOHOL AND TOBACCO USE

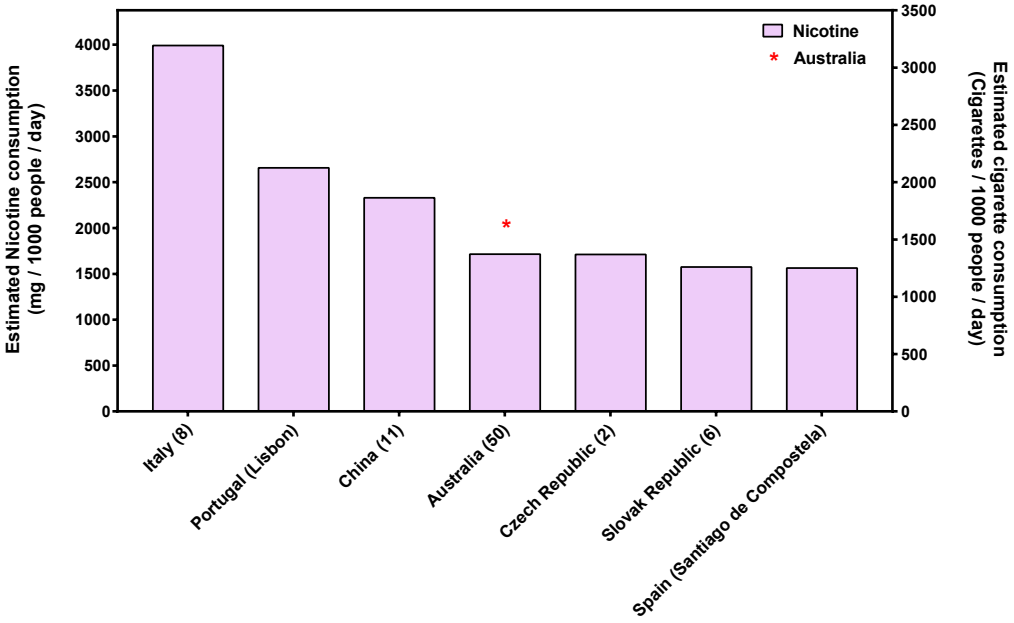
Similar international comparisons can be made for alcohol and tobacco usage between Australia and other countries (Figure 26). International data have been recalculated on a consistent basis to the Australian data (i.e. based on total population rather than adult population) and converted excreted to consumed values using the excretion factors and standard doses in Table 1). Australian average consumption of alcohol (approximately 1 200 standard drinks per 1 000 people per day, i.e. on average just over 1 standard drink per person per day) and tobacco (approximately 1 400 cigarettes per 1 000 people per day, i.e. just over 1 cigarette per person per day) sit within the mid to low range of the available consumption rates reported by other countries.

Figure 26: National population weighted average consumption of a) alcohol for cities in Australia, Europe and Canada and b) tobacco for cities in Australia, China and Europe on a per capita basis.

a) Alcohol consumption



b) Tobacco consumption



Note: the non-Australian estimates are based on limited data of WWTPs per country and therefore may not represent the national per capita consumption for a given analyte in a given country. The number of reported sites is given in brackets after country name. Non-Australian alcohol data are from samples collected in 2015 (Ryu et al., 2016). Non-Australian tobacco data are from 2011 (Portugal), 2012 (Italy), 2014 (Czech Republic, Slovak Republic), average of 2012-2014 (Spain) and 2015 (China) (Lopes et al., 2014, Rodriguez-Alvarez et al., 2014, Castiglioni et al., 2015, Mackulak et al., 2015, Wang et al., 2016). Excretion factors that were applied are reported in Appendix 1. The number of reported sites is given in brackets after country name.

5: ACKNOWLEDGEMENTS

The project team sincerely thanks the numerous WWTP operators involved in sample collection and WWTP management agencies for providing flow volumes and other site information. The cooperation of the plants and management agencies is critical to the ongoing success of this project.

The University of South Australia would like to thank our funding partners, the Drug and Alcohol Services South Australia, for their permission to use historical and current data from South Australia as well as Western Australia Police for permission to use August Western Australia data. We would also like to acknowledge the efforts of other team members at University of South Australia, including Maulik Ghetia and Frankie Lam for assistance in analytical operations.

The University of Queensland thanks Geoff Eaglesham and Soumini Vijayasarathy for their contributions to the analytical work for this study. We also thank the members of the Emerging Environmental Health Risks research group at QAEHS (incorporating the former Entox) for assistance with preparing and shipping over 1 000 sampling bottles to the various plants, and those members, past and present, who helped establish this field at the university.

We also would like to acknowledge the wider wastewater-based epidemiology field which includes addiction specialists, analytical chemists, environmental engineers, forensic scientists, pharmacologists, policy advisors and sewer engineers for their ongoing contributions to knowledge, willingness to share both methodology and data, critical review and for advancing wastewater analysis research.

6: REFERENCES

Castiglioni, S., I. Senta, A. Borsotti, E. Davoli and E. Zuccato (2015). "A novel approach for monitoring tobacco use in local communities by wastewater analysis." Tob Control **24**(1): 38-42. DOI: 10.1136/tobaccocontrol-2014-051553.

Chen, C., C. Kostakis, R. J. Irvine, P. D. Felgate and J. M. White (2013). "Evaluation of pre-analysis loss of dependent drugs in wastewater: stability and binding assessments." Drug Test Anal **5**(8): 716-721. DOI: 10.1002/dta.1428.

Gracia-Lor, E., E. Zuccato and S. Castiglioni (2016). "Refining correction factors for back-calculation of illicit drug use." Sci Total Environ **573**: 1648-1659. DOI: 10.1016/j.scitotenv.2016.09.179.

Irvine, R. J., C. Kostakis, P. D. Felgate, E. J. Jaehne, C. Chen and J. M. White (2011). "Population drug use in Australia: a wastewater analysis." Forensic Sci Int **210**(1-3): 69-73. DOI: 10.1016/j.forsciint.2011.01.037.

Khan, U. and J. A. Nicell (2012). "Sewer epidemiology mass balances for assessing the illicit use of methamphetamine, amphetamine and tetrahydrocannabinol." Sci Total Environ **421-422**: 144-162. DOI: 10.1016/j.scitotenv.2012.01.020.

Lai, F. Y., S. Anuj, R. Bruno, S. Carter, C. Gartner, W. Hall, K. P. Kirkbride, J. F. Mueller, J. W. O'Brien, J. Prichard, P. K. Thai and C. Ort (2015). "Systematic and Day-to-Day Effects of Chemical-Derived Population Estimates on Wastewater-Based Drug Epidemiology." Environ Sci Technol **49**(2): 999-1008. DOI: 10.1021/es503474d.

Lai, F. Y., J. O'Brien, R. Bruno, W. Hall, J. Prichard, P. Kirkbride, C. Gartner, P. Thai, S. Carter, B. Lloyd, L. Burns and J. Mueller (2016). "Spatial variations in the consumption of illicit stimulant drugs across Australia: A nationwide application of wastewater-based epidemiology." Sci Total Environ **568**: 810-818. DOI: 10.1016/j.scitotenv.2016.05.207.

Lai, F. Y., J. O'Brien, P. K. Thai, W. D. Hall and J. Mueller (2016a). "Trends in methamphetamine residues in wastewater in metropolitan and regional cities in south-east Queensland, 2009-2015." Med J Aust **204**(4): 151-152.

Lai, F. Y., C. Ort, C. Gartner, S. Carter, J. Prichard, P. Kirkbride, R. Bruno, W. Hall, G. Eaglesham and J. F. Mueller (2011). "Refining the estimation of illicit drug consumptions from wastewater analysis: Co-analysis of prescription pharmaceuticals and uncertainty assessment." Water Research **45**(15): 4437-4448. DOI: <http://dx.doi.org/10.1016/j.watres.2011.05.042>.

Lalovic, B., E. Kharasch, C. Hoffer, L. Risler, L. Y. Liu-Chen and D. D. Shen (2006). "Pharmacokinetics and pharmacodynamics of oral oxycodone in healthy human subjects: role of circulating active metabolites." Clin Pharmacol Ther **79**(5): 461-479. DOI: 10.1016/j.clpt.2006.01.009.

Lopes, A., N. Silva, M. R. Bronze, J. Ferreira and J. Morais (2014). "Analysis of cocaine and nicotine metabolites in wastewater by liquid chromatography-tandem mass spectrometry. Cross abuse index patterns on a major community." Sci Total Environ **487**: 673-680. DOI: 10.1016/j.scitotenv.2013.10.042.

Mackulak, T., L. Birosova, R. Grabic, J. Skubak and I. Bodik (2015). "National monitoring of nicotine use in Czech and Slovak Republic based on wastewater analysis." Environ Sci Pollut Res Int **22**(18): 14000-14006. DOI: 10.1007/s11356-015-4648-7.

McCall, A. K., R. Bade, J. Kinyua, F. Y. Lai, P. K. Thai, A. Covaci, L. Bijlsma, A. L. van Nuijs and C. Ort (2016). "Critical review on the stability of illicit drugs in sewers and wastewater samples." Water Res **88**: 933-947. DOI: 10.1016/j.watres.2015.10.040.

Rodriguez-Alvarez, T., R. Rodil, M. Rico, R. Cela and J. B. Quintana (2014). "Assessment of local tobacco consumption by liquid chromatography-tandem mass spectrometry sewage analysis of nicotine and its metabolites, cotinine and trans-3'-hydroxycotinine, after enzymatic deconjugation." Anal Chem **86**(20): 10274-10281. DOI: 10.1021/ac503330c.

Rossi, S. (2016). Australian Medicines Handbook, (internet). Adelaide, Australia, Australian Medicines Handbook, Pty. Ltd.

Ryu, Y., D. Barcelo, L. P. Barron, L. Bijlsma, S. Castiglioni, P. de Voogt, E. Emke, F. Hernandez, F. Y. Lai, A. Lopes, M. L. de Alda, N. Mastroianni, K. Munro, J. O'Brien, C. Ort, B. G. Plosz, M. J. Reid, V. Yargeau and K. V. Thomas (2016). "Comparative measurement and quantitative risk assessment of alcohol consumption through wastewater-based epidemiology: An international study in 20 cities." Sci Total Environ **565**: 977-983. DOI: 10.1016/j.scitotenv.2016.04.138.

SCORE (2015). Interlaboratorium Tests (2011-2015), Sewage analysis CORe group Europe (SCORE). (Available at: <http://score-costeu/monitoring/interlab/>).

SCORE (2017). Wastewater monitoring data 2011-2016 Sewage analysis CORe group Europe. COST Action ES1307, EMCDDA. (Available at: <http://score-cost.eu/monitoring2016/>).

Tscharke, B. J., C. Chen, J. P. Gerber and J. M. White (2016). "Temporal trends in drug use in Adelaide, South Australia by wastewater analysis." Sci Total Environ **565**: 384-391. DOI: 10.1016/j.scitotenv.2016.04.183.

Wang, D. G., Q. Q. Dong, J. Du, S. Yang, Y. J. Zhang, G. S. Na, S. G. Ferguson, Z. Wang and T. Zheng (2016). "Using Monte Carlo simulation to assess variability and uncertainty of tobacco consumption in a city by sewage epidemiology." BMJ Open **6**(2): e010583. DOI: 10.1136/bmjopen-2015-010583.

Zuccato, E., C. Chiabrando, S. Castiglioni, R. Bagnati and R. Fanelli (2008). "Estimating community drug abuse by wastewater analysis." Environ Health Perspect **116**(8): 1027-1032. DOI: 10.1289/ehp.11022.

7: APPENDICES

APPENDIX 1: DRUG-SPECIFIC PARAMETERS FOR ANALYTICAL REPORTING AND USAGE CALCULATIONS

Table 3: Analyte levels of detection, levels of reporting, highest detection, excretion factors and standard doses from the literature.

ANALYTE	LEVEL OF DETECTION (LOD) [NG/L]	LEVEL OF REPORTING (LOR) [NG/L]	HIGHEST DETECTION [NG/L]	EXCRETION FACTOR	STANDARD DOSE (MG)
Amphetamine	50	150	430	0.394[a]	30[b]
Cocaine	17	50	1100	0.075[b]	100[b]
Cotinine	33	100	7100	0.3[c]	1.25[c]
Norfentanyl	0.1	0.1	6	0.3[d]	0.2[d]
JWH-018	1	14	<LOD	n.a.	n.a.
JWH-073	10	20	<LOQ	n.a.	n.a.
MDA	67	200	360	n.a.	n.a.
MDMA	33	100	1500	0.225[b]	100[b]
Mephedrone	0.4	0.8	0.8	n.a.	n.a
Methylamphetamine	33	100	5400	0.39[g]	30[b]
Methylone	0.01	0.1	1.7	n.a.	n.a.
Hydroxycotinine	17	50	9100	0.44[c]	1.25[c]
Noroxycodone	0.1	1	440	0.22[f]	20[d]
Ethyl Sulfate	167	500	62000	0.00012[e]	10g[e]
Benzoylecgonine	33	100	2600	0.35[g]	100[b]

n.a. = data not available; a = (Khan et al., 2012) ; b = (Zuccato et al., 2008); c = (Castiglioni et al., 2015); d = (Rossi, 2016), e = (Ryu et al., 2016); f = (Lalovic et al., 2006); g = (Lai et al., 2011)

APPENDIX 2: FURTHER INFORMATION ON WWTPs

Table 4: WWTPs' sampling details and catchment population size (categorised by <30, 30-150 and >150 thousand people).

SITE IDENTIFIER	NUMBER OF SAMPLING DAYS	SAMPLING MODE (FLOW OR TIME PROPORTIONAL)	FREQUENCY (TIME OR VOLUME)	CAPITAL CITY OR REGIONAL	CATCHMENT POPULATION CATEGORY (THOUSANDS OF PEOPLE)
ACT: 009	7	Flow	2 ML	Capital	>150
NSW: 003	7	Time	60 min	Capital	>150
NSW: 006	7	Time	60 min	Capital	>150
NSW: 008	6	Time	60 min	Capital	>150
NSW: 021	7	Time	60 min	Capital	30 to 150
NSW: 071	7	Time	60 min	Capital	>150
NSW: 016	5	Time	60 min	Regional	30 to 150
NSW: 025	7	Time	15 min	Regional	>150
NSW: 040	7	Time	15 min	Regional	<30
NSW: 051	7	Time	15 min	Regional	<30
NSW: 068	1	Time	60 min	Regional	>150
NT: 010	7	Time	15 min	Capital	30 to 150
NT: 078	7	Time	15 min	Regional	<30
QLD: 002	7	Time	15 min	Capital	>150
QLD: 005	7	Time	15 min	Capital	>150
QLD: 011	7	Time	15 min	Capital	>150
QLD: 012	5	Time	60 min	Regional	>150
QLD: 020	7	Time	60 min	Regional	<30
QLD: 024	7	Time	60 min	Regional	30 to 150
QLD: 028	7	Time	15 min	Regional	30 to 150
QLD: 029	7	Flow	160 kL	Regional	30 to 150
QLD: 033	7	Flow	10 kL	Regional	30 to 150
QLD: 039	7	Time	10 min	Regional	<30
QLD: 053	7	Time	60 min	Regional	<30
QLD: 077	7	Time	continuous	Regional	<30

SITE IDENTIFIER	NUMBER OF SAMPLING DAYS	SAMPLING MODE (FLOW OR TIME PROPORTIONAL)	FREQUENCY (TIME OR VOLUME)	CAPITAL CITY OR REGIONAL	CATCHMENT POPULATION CATEGORY (THOUSANDS OF PEOPLE)
SA: 007	5	Time	n.a.	Capital	>150
SA: 013	5	Flow	340 kL	Capital	>150
SA: 027	5	Time	n.a.	Capital	30 to 150
SA: 059	5	Flow	500 kL	Capital	30 to 150
SA: 017	5	Time	15 min	Regional	<30
SA: 022	5	Time	15 min	Regional	<30
SA: 063	5	Flow	50 kL	Regional	<30
SA: 076	5	Flow	n.a.	Regional	<30
TAS: 004	7	Time	15 min	Capital	30 to 150
TAS: 019	7	Time	49 min	Capital	30 to 150
TAS: 041	7	Flow	n.a.	Capital	30 to 150
TAS: 018	7	Time	15 min	Regional	<30
TAS: 038	7	Time	60 min	Regional	<30
TAS: 048	7	Flow	180 kL	Regional	<30
TAS: 058	7	n.a.	n.a.	Regional	<30
VIC: 001	7	Flow	8 ML	Capital	>150
VIC: 067	7	Flow	60 min average	Capital	>150
VIC: 037	7	Time	60 min	Regional	>150
VIC: 046	7	Time	60 min	Regional	30 to 150
VIC: 061	7	Time	15 min	Regional	30 to 150
VIC: 066	6	Time	60 min	Regional	30 to 150
VIC: 062	7	Flow	53 kL	Regional	30 to 150
WA: 101	7	n.a.	n.a.	Capital	>150
WA: 103	7	n.a.	n.a.	Capital	>150
WA: 104	7	n.a.	n.a.	Capital	>150
WA: 102	7	Time	60 min	Regional	30 to 150

n.a. – data not provided by treatment plant

APPENDIX 3: UNCERTAINTIES RELATED TO WASTEWATER ANALYSIS

Most drugs are metabolised in the body and many are cleared through the kidneys in water soluble form. Either the unchanged drug or its metabolite may be excreted and enter the sewer system. There it contributes to the total effluent which reaches a treatment plant. Therefore, the amount of drug can be measured as a concentration expressed as mass of drug per volume of wastewater entering the treatment plant. When the daily flow rate is known, i.e. the total amount of water flowing into the plant on any given day, the absolute amount of drug excreted per day can be derived. Combining the measured amount with the clearance rate and population served by a treatment plant, the daily mass load per plant can be calculated and expressed per number of inhabitants (or more usually, per thousand inhabitants). When a typical dose can be defined, the figure can be reported as doses per day per thousand people according to the calculation provided in the Methods section (repeated here for convenience) (Equation 1).

Equation 1*: The calculation used to return the number of doses of a target drug per 1 000 people per day. Mw ratio = molecular weight ratio, or difference in mass between the metabolite and the parent drug. The Mw ratio is 1 when the parent drug is also the measured metabolite. [Analyte] = concentration of the target analyte in the wastewater sample. Daily flow volume in megalitres.*

A number of factors may influence the accuracy of the result obtained from Equation 1. In terms of errors, site specific variables range from inherent errors/bias within the treatment plant flow meters, autosamplers or storage, to analytical variability and uncertainties in population estimates.

One of the largest uncertainties involves the population estimate of the area being served by the treatment plant. Plants have a maximum design capacity, so the proportional maximum flow can be used to gauge the contributing population. More commonly, population is based on census data for the surrounding community. The ABS suggests on an annual basis the growth in population in specific areas. Therefore, based on census figures, the population in a post code area can be determined to some degree of accuracy. However, uncertainty still exists regarding the number of people residing in a post code area over a 24 hour interval, considering work, travelling, etc. Another method is based on the number of waste connection points in a particular catchment. Each connection point is assigned a number of people and the overall population is derived by multiplying the connection points by the population factor.

Depending on the residence time of an excreted drug metabolite in the sewer system, some decomposition may occur in the aerobic environment. The same applies between sample collection and analysis. This would include storage in a 24-hour autosampler at the treatment plant, transportation time, refrigeration and presence of a preservative. Nevertheless, most of the drugs included in this report have been shown to be relatively stable within the sewer network and under appropriate storage conditions (Chen et al., 2013; McCall et al., 2016).

Most Australian capital city sites employ separate household and industrial sewer systems from stormwater. However, some in-and exfiltration due to porosity, damage to pipes, corrosion, tidal flow, etc. cannot be avoided and may affect the levels of drug measured entering the treatment plant.

Excretion rate of the drug is also a potential confounding factor. Some individuals metabolise a drug faster than others, and so the clearance rate, or even the proportion of drug excreted may vary significantly. Co-ingestion of alcohol or other drugs may similarly affect the metabolism of a drug. However, on a population scale, it is not unreasonable to expect that differences may average out and the mean remain relatively constant.

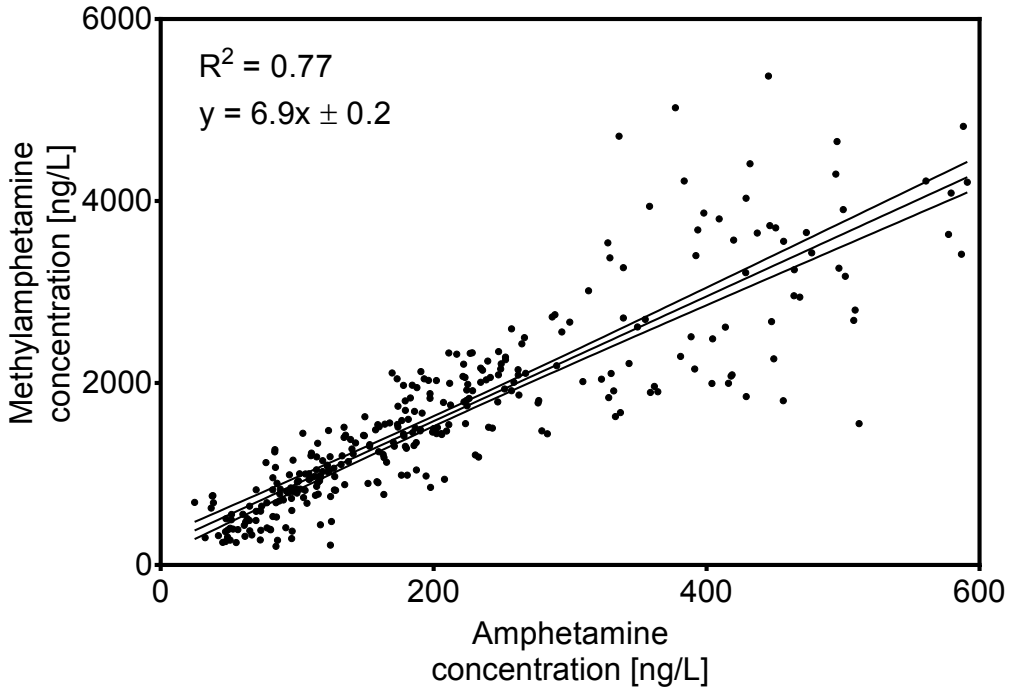
When the excretion rate of a drug metabolite is known, the dose size is a useful parameter to include in Equation 1. Expressed as doses per day per population, a better comparison of drug use can be made. Drugs that are metabolised extensively and cleared from the body as a number of derivatives will contribute only a small proportion of the total measured mass load in a sewer system (mg metabolite per day per population). Similarly, very potent drugs will be administered in low doses and so the measured mass load of parent drug per day per population may be a relatively insignificant figure. However, taking dose into account, the overall use of different drugs can be compared and therefore the risk of associated social harm. From a policing perspective, seizing a small weight amount of a drug may appear to be of little relevance, but if the dose size is small (consider e.g. NBOMe-type stimulants or fentanyl analogues), the seized amount may represent a large number of doses. Unfortunately, dose sizes vary from region to region, and may be higher or lower, depending on the purity and consumption habits. For the purpose of this report, doses were based on averages and are stated for each drug (refer to Table 1).

Errors/variation within the extraction and analysis methods is usually less than 10%, but in rare instances, background interference may cause signal strength. This is corrected for using internal standards, which are deuterated analogues of the target compounds. Some groups suggest the error/variation of the final estimate, including all possible sources of error, can be of the order of 20-30%. A conservative estimate for the uncertainty of each measurement might be ±25%.

When reporting the levels of a drug which is excreted in unchanged from, there remains the potential for discarded (dumped) parent drug being measured. If significant, such events will be observed as a spike in levels on a specific occasion. With regular monitoring and when influent stream from multiple plants are investigated, unusual spikes on a particular day or at a plant due to dumping will become apparent and can be noted.

APPENDIX 4: CORRELATION BETWEEN AMPHETAMINE AND METHYLAMPHETAMINE

Figure 27: Correlation between amphetamine and methylamphetamine levels in samples across the 51 sites.



CONCLUSIONS

CONCLUSIONS

Wastewater analysis conducted in the latter half of 2016 shows that alcohol and tobacco consumption was the highest of all substances tested in all states and territories. Of the remaining substances, methylamphetamine consumption was highest, indicating that demand for the drug remains resilient. There were some indications, which will be closely monitored in future reports, that methylamphetamine use continues to increase. Use of the pharmaceutical opioids oxycodone and fentanyl is significant, particularly in regional areas, which provides potential for diversion to illicit markets. Results for the four new psychoactive substances support the assessment that this is a niche market, which remains small in comparison with traditional illicit drug markets.

Results for specific substances are summarised below:

METHYLAMPHETAMINE

In all jurisdictions, methylamphetamine consumption far exceeds the consumption of the other illicit stimulants and the consumption (both licit and illicit) of oxycodone and fentanyl.[1] In Western Australia, methylamphetamine consumption in both capital city and regional locations is higher than all other jurisdictions and far exceeds the national average.

Wastewater analysis in Queensland and South Australia for at least the last five years has shown a consistent pattern of methylamphetamine consumption exceeding the consumption of other illicit stimulants. Historical data is available in two Queensland regional sites since 2010. This data shows that in those locations methylamphetamine consumption has increased every year and in recent years, at an increasing rate. Similar data is also available for four capital city sites in South Australia and results from these sites also show continuous increases in methylamphetamine consumption each year. Available data since 2013 from two capital city sites in Victoria shows that methylamphetamine consumption has been relatively constant in the respective catchment areas.

The above results are consistent with other publicly available data reported by the ACIC. For example, both the number and weight of amphetamine-type stimulants (ATS excluding MDMA) detections at the Australian border in 2014–15 are the highest on record. The number of ATS (excluding MDMA) detections increased 47 per cent from 2013–14 to 2014–15, with the weight detected almost doubling. The number and weight of national ATS seizures increased in 2014–15 and are the highest on record. Amphetamines[2] have accounted for the greatest proportion of national ATS arrests over the last decade, with the number of national amphetamines arrests continuing to increase since 2009–10.

1 Throughout this report, all comparisons of the consumption of different drugs are based on doses rather than the weight of the respective substances.
2 Amphetamines include amphetamine, methylamphetamine, dexamphetamine and amphetamines not elsewhere classified.

Results from the Drug Use Monitoring in Australia (DUMA) program[3] indicate that in 2014–15, 50.4 per cent of detainees self-reported recent[4] methylamphetamine use, an increase from the 48.9 per cent reported in 2013–14. The proportion of detainees testing positive via urinalysis for amphetamines[5] increased from 35.8 per cent in 2013–14 to 40.9 per cent in 2014–15, the highest percentage reported in the last decade. This increase in amphetamines use is largely due to an increase in the proportion of detainees testing positive for methylamphetamine, from 33.0 per cent in 2013–14 to 38.7 per cent in 2014–15. The proportion of detainees testing positive for methylamphetamine continues to be higher than the proportion testing positive for MDMA, heroin, cocaine, benzodiazepines and opiates (excluding heroin).

AMPHETAMINE

In this report the major source of amphetamine detected in the wastewater was methylamphetamine consumption.

COCAINE

Cocaine consumption in capital city locations is higher than consumption in regional locations in all jurisdictions. Cocaine use is highest in New South Wales by some margin, with consumption in the capital city sites in New South Wales and the Northern Territory being above the national average. That said, in a number of jurisdictions (Queensland and Tasmania) there is little difference between cocaine consumption in capital city and regional locations.

Historical data for cocaine is available for one Queensland regional site since 2009. This data shows that, although use in the location is high in national terms, consumption levels within that site have remained relatively stable over the period. Average cocaine use in four capital city sites in South Australia has increased a little over the same period, but consumption is far less than in the Queensland regional site. Cocaine consumption measured at two capital city sites in Victoria since 2013 has not changed significantly.

Other publicly available data reported by the ACIC indicates that both the number and weight of cocaine detections at the Australian border increased in 2014–15. There was a record 3 236 national cocaine seizures in 2014–15, with a record 2 092 national cocaine arrests in the same reporting period.

3 The DUMA program examines drug use and offending patterns among police detainees and comprises an interviewer-assisted self-report survey and the voluntary provision of a urine sample which is subjected to urinalysis to detect licit and illicit drug use. Detainees can participate in the survey without providing a urine sample. Cases with missing data are excluded from the relevant analysis.

4 'Recent use' in the DUMA program refers to self-reported use in the 12 months prior to arrest.

5 Amphetamines in the DUMA program include results for methylamphetamine, MDMA and other amphetamines.

Results from the DUMA program indicate cocaine continues to be one of the least commonly detected drugs among detainees.
The proportion of detainees testing positive via urinalysis for cocaine decreased, from 2.2 per cent in 2013–14 to 0.8 per cent in 2014–15. Self-reported recent use of cocaine increased from 13.5 per cent in 2013–14 to 14.2 per cent in 2014–15.

3,4-METHYLENEDIOXY-METHAMPHETAMINE (MDMA)

There is a relatively high level of consumption of MDMA in a capital city location in the Northern Territory and a regional site in Tasmania, and this requires further investigation. MDMA consumption in all other jurisdictions is spread relatively evenly across capital city and regional locations.

Historical data for MDMA is available for one Queensland regional site since 2009. This data shows that there has been significant variation year on year in MDMA consumption since 2009, but that there was a significant increase in consumption in 2016 to a level which is more than double consumption levels reported in 2009. Conversely, results from an average of four capital city sites in South Australia indicates MDMA use has been decreasing since 2009 and is now less than half the consumption level reported in 2009. Results from two capital city sites in Victoria which have been monitored since 2013 show steadily increasing consumption at one site and a high, but relatively stable level of consumption at the other site.

The equivocal nature of the above results is consistent with other publicly available data reported by the ACIC. For example, the number and weight of MDMA detections at the Australian border increased in 2014–15 and are the second highest reported in the last decade. The number of national MDMA arrests has increased 186.5 per cent over the last decade, from 1 764 in 2005–06 to 5 053 in 2014–15. Results from the DUMA program indicate the proportion of detainees testing positive for MDMA via urinalysis remained relatively constant, at 1.2 per cent in 2013–14 and 1.3 per cent in 2014–15. Over the last decade the proportion of detainees testing positive to MDMA has remained low (under 2.9 per cent). The self-reported recent use of MDMA increased from 12.1 per cent in 2013–14 to 14.7 per cent in 2014–15. This is the highest level of self-reported recent use recorded since 2009–10.

3,4-METHYLENEDIOXY-AMPHETAMINE (MDA)

In this report the major source of MDA detected in the wastewater was MDMA consumption.

JWH-018

Detection methods for measuring the cannabinoid JWH-018 were also included, but failed to find the presence of the compound in sites across Australia.

JWH-073

Detection methods for measuring the cannabinoid JWH-073 were also included, but failed to find the presence of the compound in sites across Australia.

MEPHEDRONE

Mephedrone was detected nine times at a total of nine sites in New South Wales, Queensland, South Australia and Tasmania. However, the quantity of the substance was mostly below the level at which it could reliably be quantified.

Use of mephedrone has been monitored at four South Australian capital city sites since 2009. Results of this analysis show that consumption has been low relative to other illicit drugs and has declined significantly since 2010.

METHYLONE

Methylone was detected 58 times at a total of 31 sites in all states and territories except South Australia and Victoria. However, the quantity of the substance was mostly below the level at which it could reliably be quantified.

Use of methylone has been monitored at South Australian capital city sites since 2009. Analysis of the results shows that consumption declined significantly between 2011 and 2014, with negligible detections in 2015 and 2016.

OXYCODONE

Oxycodone was detected in all jurisdictions. With the exception of the Northern Territory, the consumption (both licit and illicit) of oxycodone exceeds the use of cocaine and MDMA in all jurisdictions. In regional Queensland and regional Victoria, oxycodone consumption is significantly higher than other jurisdictions and the national average.

In South Australia and the Northern Territory, oxycodone consumption in capital city locations exceeded consumption in regional locations. For all other states, oxycodone consumption in regional locations exceeded consumption in capital city locations.

The use of oxycodone has been monitored at four South Australian capital city sites since 2011. Consumption levels increased from 2011 to 2015, followed by a decrease in 2016.

FENTANYL

With the exception of the Northern Territory, the consumption (both licit and illicit) of fentanyl exceeds the use of cocaine and MDMA in all jurisdictions.

Fentanyl consumption in regional locations exceeds consumption in capital city locations in all jurisdictions. In South Australia, the Australian Capital Territory and Western Australia, fentanyl consumption exceeds oxycodone consumption, but in all other jurisdictions, oxycodone consumption exceeds fentanyl consumption.

The use of fentanyl has been monitored at four South Australian capital city sites 2013. Analysis of the results shows that fentanyl consumption has remained relatively stable during that period, although there was an increase in consumption in 2015.

TOBACCO

In the Northern Territory, tobacco consumption in both capital city and regional locations is higher than in all other jurisdictions. Tobacco consumption in regional locations exceeded consumption in capital city locations in all jurisdictions.

ALCOHOL

In the Northern Territory, alcohol consumption in both capital city and regional locations far exceeds the national average. Alcohol consumption in regional locations in the Northern Territory, Queensland, Tasmania and Victoria exceeded consumption in capital city locations.

NEXT STEPS

The data contained in the attached report provides the ACIC and partners with an opportunity to explore a range of issues including:

- shaping responses to both the demand and the supply side of the illicit drug market, in particular in high-use areas
- collaboration between the ACIC and research institutions which have access to a broader range of drug data
- shaping programs to reduce the demand for drugs and resultant harms to the community
- exploration of the link between drug trends and trends in violent and volume crime
- exploring the extent of licit and illicit oxycodone and fentanyl use (i.e. the level of diversion from the legitimate market).