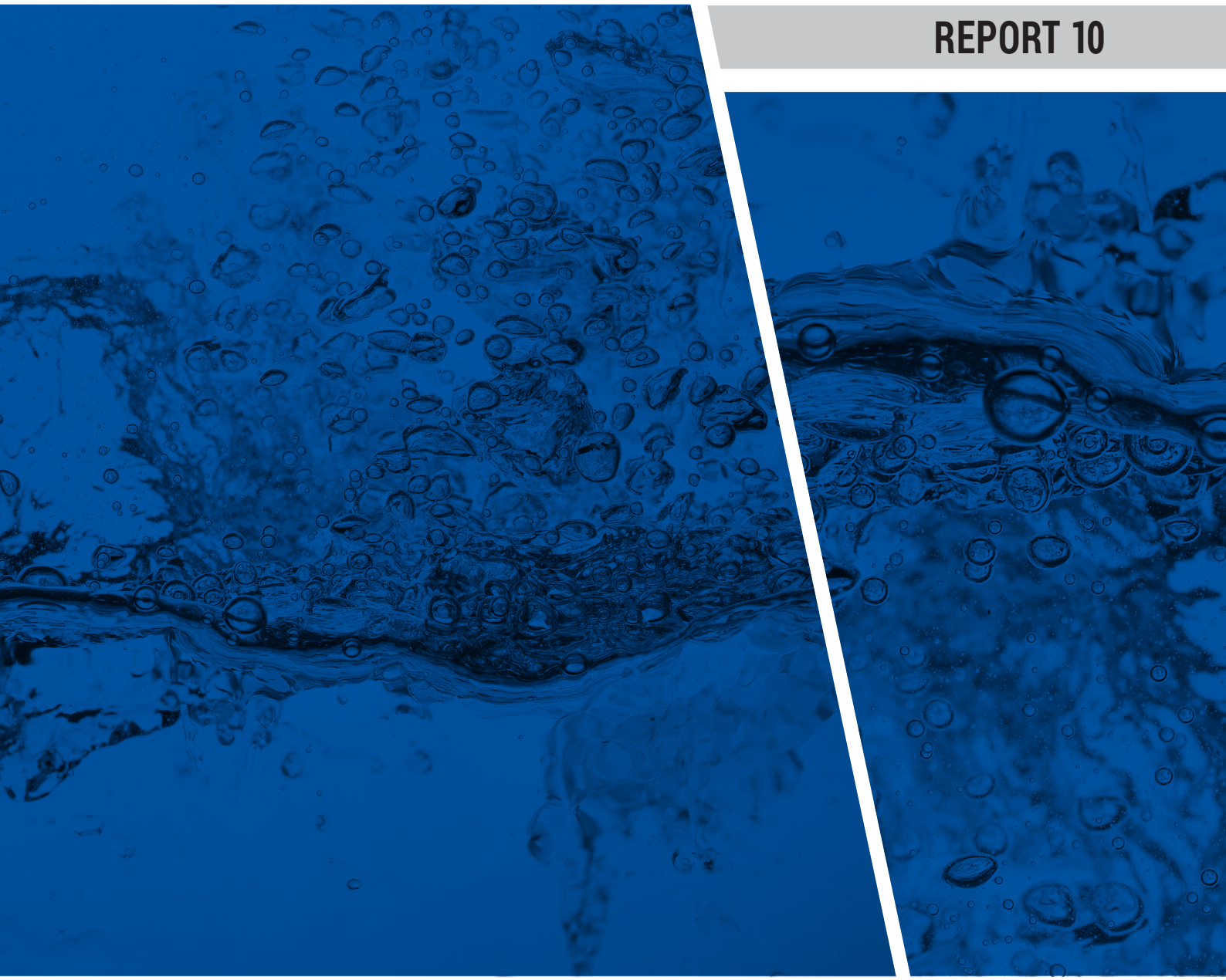
NATIONAL WASTEWATER DRUG MONITORING PROGRAM

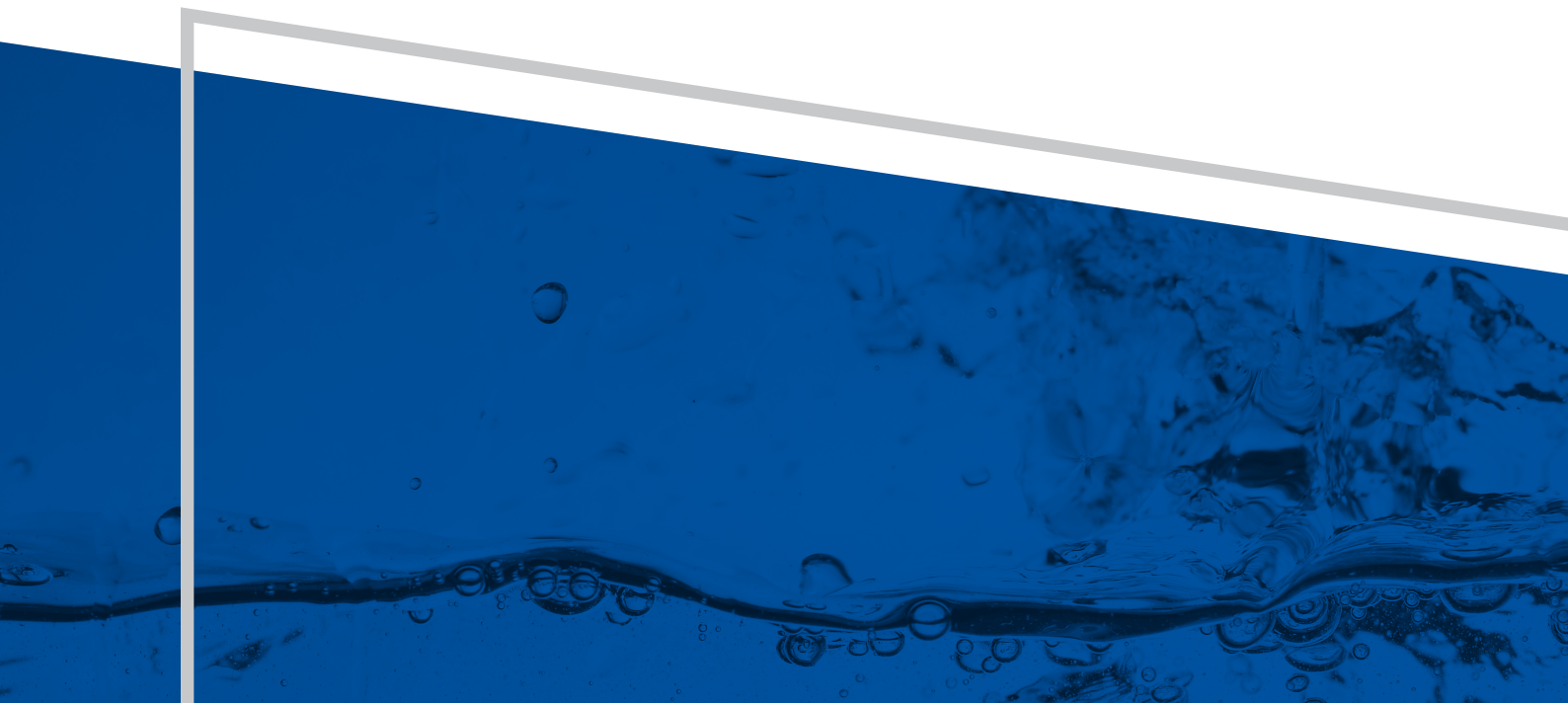
REPORT 10



AUSTRALIAN CRIMINAL INTELLIGENCE COMMISSION

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

University of South Australia



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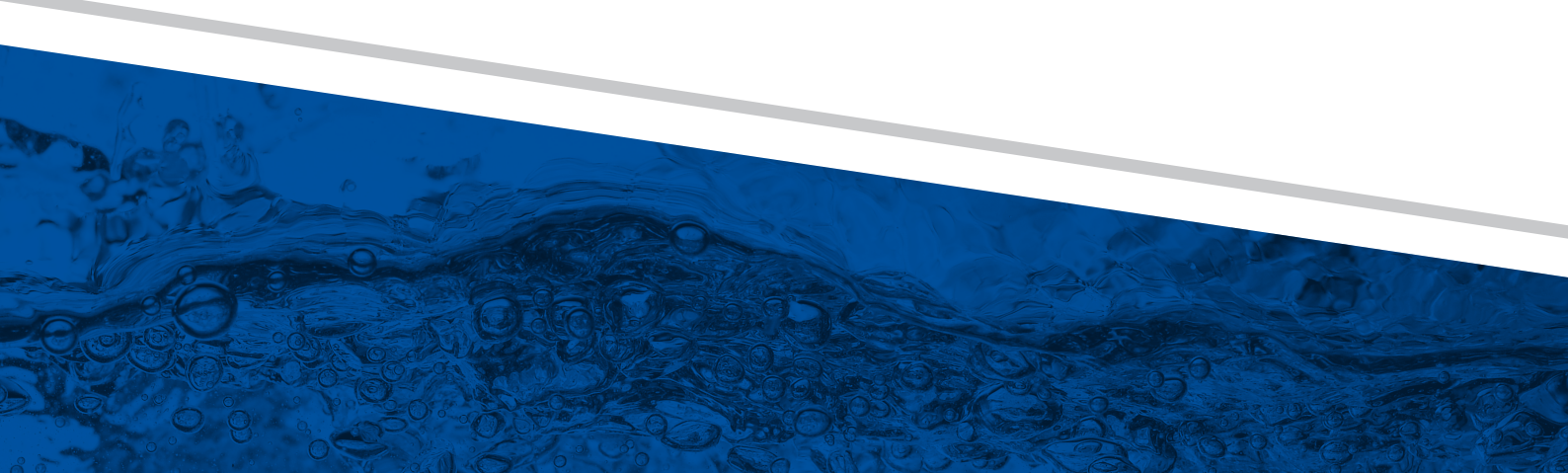


CEO FOREWORD

The Australian Criminal Intelligence Commission (ACIC) has a responsibility to provide information and intelligence on criminal activity to support the Government in creating a safer Australia. Much of the harm that Australians suffer at the hands of organised crime is due to illicit drugs. Serious and organised crime groups profit from the importation, manufacture, trafficking and sale of drugs that cause harm to the community.

The National Wastewater Drug Monitoring Program represents world best practice in its field. Wastewater analysis is a tool to measure and interpret drug use within populations, providing a measure of one important aspect of national health—the demand for a range of licit and illicit drugs. Illicit drugs and licit drugs with abuse potential are inherently harmful. Reliable drug consumption data are a useful indicator of the level of harm experienced by the community, because logically the level of harm to the community is a function of the quantity of the substance that is consumed. Understanding drug consumption at a population level supports the effective allocation of resources to priority areas. It also allows monitoring of the progress of demand, supply and harm reduction strategies.

The National Wastewater Drug Monitoring Program is an Australian Government initiative. The ACIC has received an additional $4.8 million over four years as part of its annual appropriation to continue delivery of this important program. This report is the first in a series of 12 reports that will be released publicly until early 2024. The ACIC will continue to provide an objective evidence base concerning illicit and licit drug use, and to work with partners to exploit the data by informing local and national response options and monitoring the effectiveness of responses.

TOWARDS AN INNOVATIVE FUTURE

The most pleasing aspect of the program is its increasing flexibility and ongoing evolution. The future of wastewater analysis is linked to ongoing collaboration between the ACIC and a growing list of partners in the public and private sectors and academic institutions. This was demonstrated earlier this year when the ACIC funded a wastewater analysis ‘proof of concept’ project, which successfully detected for the first time in Australia the SARS-CoV-2 (COVID-19) virus in wastewater in a number of geographic locations. The project also demonstrated the application of the technique to strategic sites and major assets. This work is ongoing. Daily analysis at several key sites for the past several months will soon permit the ACIC to report in a timely manner to law enforcement and policy departments on the impact on illicit drug markets of the COVID-19 crisis and the national response.

At the same time, new technology developed and tested by one of the ACIC’s university partners using funding from confiscated proceeds of crime has raised the prospect of significantly improved coverage of drug use in remote and regional sites in Australia.

The ACIC is now routinely engaging with academic institutions and the private and public sectors to merge our respective data holdings and answer key questions concerning the size of illicit markets, the characteristics of particular locations which exhibit high levels of use of some drugs and the nature and extent of drug-related harms suffered by the community.

TRENDS IDENTIFIED DURING THIS REPORTING PERIOD

This National Wastewater Drug Monitoring Program report is the tenth in a series of public reports that present program findings. The program provides statistically valid datasets of drug use and distribution patterns across a large number of sites in capital cities and regional Australia. In December 2019, 53 wastewater sites were monitored nationally. Based on 2016 Census data, these sites covered approximately 43 per cent of the Australian population. The number and diversity of regional sites provides unique drug data that facilitates analysis of drug trends outside of the capital cities and informs local responses to the different circumstances that apply in each location. The fact that, with the exception of cocaine and heroin, the per capita consumption of all drugs tested by the program is higher in regional sites than in the capital cities makes the search for bespoke data to inform regional responses an ongoing priority for the program.

Of the drugs measured by the program with available dose data, alcohol and nicotine continue to be the most consumed substances, and methylamphetamine the most consumed illicit drug. Of note in this report are the increases since August 2019 in consumption of nicotine, methylamphetamine, cocaine, MDMA, fentanyl, cannabis (capital city) and alcohol (regional). Consumption of heroin and oxycodone decreased. Importantly, the data in Report 10 (to February 2020) leaves the ACIC very well placed to assess in Report 11 the impact of the COVID-19 crisis from sampling periods in April and June 2020.

STRATEGIC TRENDS

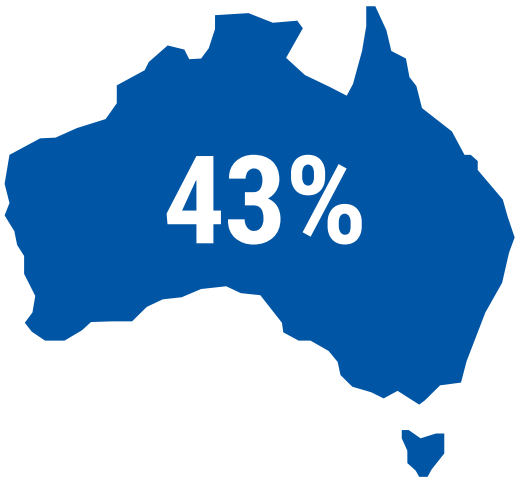
Section 5 of the Report provides updated 2019 data from the Sewage Core Group Europe (SCORE), which now extends to Europe, North America, South Africa, Oceania and Turkey. All of the contributing countries must sample and analyse wastewater in accordance with exacting and consistent criteria, so the results are directly comparable. The results confirm the strong preference in world terms by Australian illicit drug users for illicit stimulants (methylamphetamine, MDMA and cocaine) and the domination of our domestic stimulant market by methylamphetamine.

Of concern is the overall trend that has persisted since the program commenced in August 2016 of a consistent, albeit not constant, increase in the consumption of methylamphetamine, which underlines the resilience of this market and the need for an ongoing and robust multi-faceted national response. On a positive note, overall consumption of fentanyl and oxycodone has decreased considerably since December 2018, and it is worth noting that policy and regulatory measures continue to be introduced to reduce the harms caused by the non-medical use of these substances.

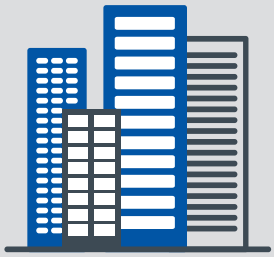
I would like to acknowledge the valuable support and expertise of the Universities of Queensland and South Australia, which undertook the data collection and analysis which underpins this report, and the Australian Criminal Intelligence Commission officers who contributed to the project.

Michael Phelan APM
Chief Executive Officer
Australian Criminal Intelligence Commission

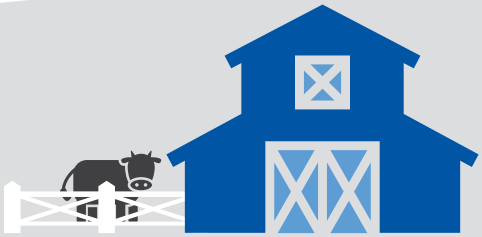
SNAPSHOT



The December 2019 collection covers around **43 per cent** of Australia's population—about **10 million Australians.**



Capital city **cocaine** and **heroin** average consumption exceeded regional consumption.



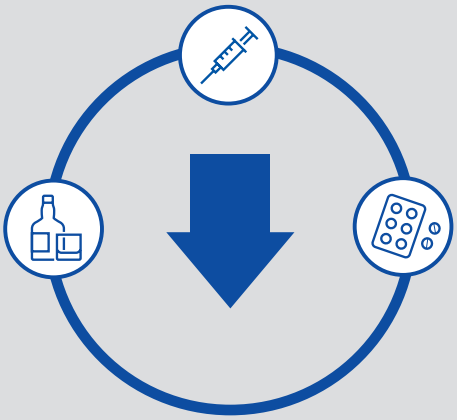
Regional **nicotine, alcohol, methylamphetamine, MDMA, MDA, oxycodone, fentanyl** and **cannabis** average consumption exceeded capital city consumption.

SCORE INTERNATIONAL COMPARISONS

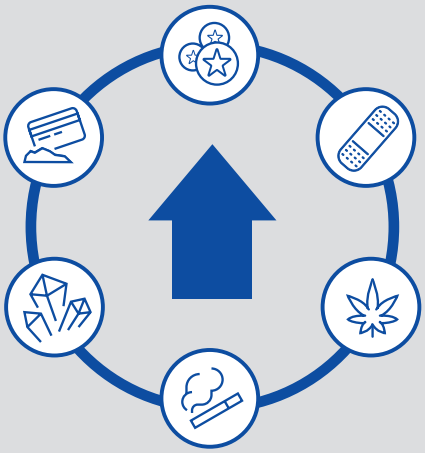
Of the 30 countries with comparable stimulant data, **Australia ranks third** for **methylamphetamine** and **MDMA**, with relatively **low cocaine consumption**.

Stimulant consumption in Australia continues to be primarily **driven by methylamphetamine** use.

Between August 2019 and December 2019, the population-weighted average capital city consumption of:

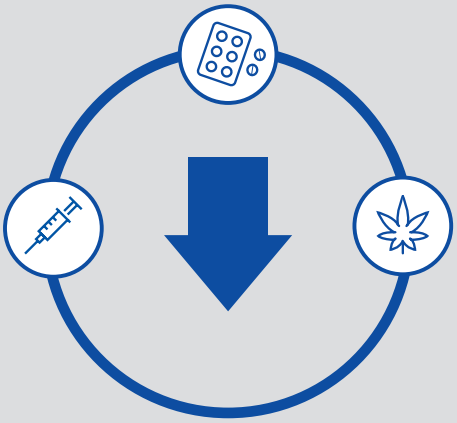


alcohol, heroin and oxycodone **decreased**

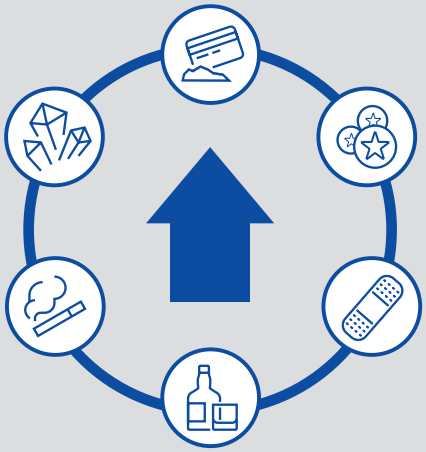


nicotine, methylamphetamine, cocaine, MDMA, fentanyl and cannabis **increased**

Between August 2019 and December 2019, the population-weighted average regional consumption of:



heroin, oxycodone and cannabis **decreased**



alcohol, nicotine, methylamphetamine, cocaine, MDMA and fentanyl **increased**

INTRODUCTION

This is the tenth in a series of National Wastewater Drug Monitoring Program reports to be publicly released by the Australian Criminal Intelligence Commission, and the first of twelve reports to be delivered under new budgetary arrangements that will see reports delivered until the early months of 2024. The program provides a measure, rather than an estimate, of the consumption of a number of illicit drugs, as well as licit drugs including nicotine, alcohol and some pharmaceuticals. It gives us valuable insight into the trends and emerging issues in drug consumption across Australia and can identify new sources of threat.

The program aims to deliver on the recommendations of the *2015 Final Report* of the *National Ice Taskforce*. In 2016 the Australian Criminal Intelligence Commission received funding under the *Proceeds of Crime Act 2002* to deliver the National Wastewater Drug Monitoring Program over three years. Since then, additional funding in the Australian Criminal Intelligence Commission's annual budgetary appropriation has allowed for the extension of the program for an additional four years.

The tenth report presents data on Australia's drug consumption for 13 substances and includes data for October and December 2019 and February 2020. Longitudinal data captured by the program increases our understanding of drug use in Australia nationally, in specific regions and over time. Findings presented in the reports provide law enforcement, policy, regulatory and health agencies with additional, objective data on the use of methylamphetamine and other drugs. These data create opportunities to shape the response to the demand and supply sides of the illicit drug market, particularly in high-use areas, and inform harm reduction strategies. They permit priorities to be set and modified in a manner that is consistent with constantly evolving drug markets.

IMPLEMENTATION

The Australian Criminal Intelligence Commission has contracted the University of Queensland, and through it the University of South Australia, to deliver the program. Relationships have been built between the universities and the operators of wastewater facilities across Australia to permit the collection and analysis of samples.

In this report, wastewater analysis from the National Wastewater Drug Monitoring Program measured the presence[1] of the following substances:

- methylamphetamine
- amphetamine
- cocaine
- 3,4-methylenedioxymethylamphetamine (MDMA)
- 3,4-methylenedioxyamphetamine (MDA)
- heroin
- cannabis
- mephedrone
- methylone
- oxycodone
- fentanyl
- nicotine
- alcohol.

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

The Australian Criminal Intelligence Commission continues to review the appropriateness of monitored substances and sampling sites with its partners, stakeholders and the universities.

Both contracted universities monitor wastewater across Australia, covering all state and territory capital cities and a range of regional cities and towns. In December 2019, 53 wastewater treatment plants participated nationally. Sites were selected to permit the Australian Criminal Intelligence Commission to provide data on major population areas, sites of actual or potential concern from a drug use perspective, and sites where the treatment plant operators have established relationships with the two universities.

The breakdown of sites by jurisdiction for December 2019 is as follows:

Participation from all states and territories is vital to informing our understanding of the national picture of drug use and demand. In the event that one or more states and territories decides not to participate in the national program in the future, the Australian Criminal Intelligence Commission will identify replacement sites from participating states and territories to ensure that the largest possible segment of the national population is sampled. Accordingly, the location of sites within and between states and territories may change over the life of the program.

REPORTING

National Wastewater Drug Monitoring Program reports are completed three times a year and made public. In accordance with current wastewater analysis conventions, the terms of the contract, and to protect the integrity of the program, the exact locations of wastewater treatment plants sampled are not publicly released by the Australian Criminal Intelligence Commission. Stakeholders in law enforcement, health and other relevant policy agencies are provided with classified information identifying actual sampling locations to inform appropriate responses.

Reported results reflect per capita use in all locations and, with the exception of MDA and cannabis (for which reliable dose figures are not available), are expressed in terms of both the number of doses and the weight or volume consumed per capita of the respective substances, to facilitate comparison between substances. Work is under way to determine a reliable dose figure for cannabis.

EXPLOITATION OF THE NATIONAL WASTEWATER DRUG MONITORING PROGRAM DATA

The National Wastewater Drug Monitoring Program is based on a well-established and internationally recognised methodology. The Australian Criminal Intelligence Commission considers that National Wastewater Drug Monitoring Program data provide an important basis for the development of empirically informed government and private sector policy and decision making. The reports provide regular, timely, unambiguous and detailed measures of the level of demand for the listed substances in the Australian population, complementing other drug datasets published in Australia. The tenth National Wastewater Drug Monitoring Program report measures the drug use of approximately 43 per cent of the Australian population.[2]

Wastewater data are also particularly useful for identifying differences in levels of drug consumption in capital city and regional areas of Australia. The data reinforce the different dynamics that apply to both capital city and regional markets and also illustrate drug preference variation that exists both within and between states and territories. Understanding these preferences is important in the development and delivery of national responses and in tailoring responses to suit the specific needs of individual jurisdictions. The number and diversity of regional sites that participate in the program permits confident assessments to be made of drug trends outside of the capital cities and facilitates local responses to the different circumstances that apply in each location. This is important because a number of other sources of drug data in Australia either have very limited regional coverage, or are confined to capital cities.

Wastewater data are used with other available data sources to develop a comprehensive and accurate understanding of drug markets nationally and in the states and territories. Wastewater analysis data collected by the National Wastewater Drug Monitoring Program has been used to estimate the quantity and value of methylamphetamine, cocaine, MDMA and heroin consumed annually in Australia; to explore the relationship between drug consumption and different types of crime; and to assess the impact of law enforcement and health initiatives aimed at reducing drug supply and demand. A number of partners are using wastewater data as the basis of their operational decision making.

2 The December 2019 population estimate is based on the Australian Bureau of Statistics 2016 Census data and catchment data supplied by the operators of the wastewater facilities and service providers.

In collaboration with partners, the program is assisting to develop novel sampling techniques which will allow for the monitoring of drug consumption at additional sites, including sites that are not treatment plants. Early indications are that the new sampling techniques are viable in an Australian context and will extend the utility of the existing national program. Work continues on the practical application of this sampling strategy.

The Australian Criminal Intelligence Commission engages with academic institutions, industry and public sector agencies to identify further data applications. Opportunities identified include informing responses in high risk areas; measuring drug use in specific local areas; estimating the size of discrete illicit markets; and exploring options for monitoring the effectiveness of existing demand, supply and harm reduction initiatives. Advantages of the National Wastewater Drug Monitoring Program are that the data are collected on an ongoing basis, are reported regularly, and the program is sufficiently flexible to allow for focusing collection activity in different geographic locations and at more regular intervals in response to identified need. Increasingly, the program's data is being triangulated with other data sources in order to generate a more granular appreciation of drug markets.

A STRATEGIC PERSPECTIVE

One of the priorities of the first three years of the National Wastewater Drug Monitoring Program was to ensure that it was appropriately established and recognised for its contribution to national thinking and decision making in relation to drug policy and responses. This has been achieved—internationally the program is recognised as world best practice. Moreover, with the passage of three years, sufficient data has now been collected to permit a range of stakeholders to commence longitudinal analysis of consumption trends. The data is also being used by third parties for a range of applications that were not anticipated at the commencement of the program.

The data has proven itself to be amenable to analysis from a variety of perspectives. A summary of some of this analysis is provided below.

CAPITAL CITY V REGIONAL COMPARISON

Consumption of most drugs since August 2016 has been higher per capita in regional sites, with the exception of cocaine and heroin. For illicit drugs and drugs with abuse potential, this has implications for response options and how we understand drug supply routes.

DRUG CONSUMPTION TRENDS

The data show that consumption of the three major illicit stimulants (methylamphetamine, cocaine and MDMA) has increased in capital city and regional sites, albeit not consistently, since August 2016. There has been a significant increase in the consumption of MDMA since April 2018. This is consistent with comparable international data, reported in Section 5 of this report, collated by the Sewage Core Group Europe (SCORE) 2019. SCORE data confirm that methylamphetamine continues to dominate Australia's illicit stimulant landscape.

Heroin use since August 2016 has declined considerably in regional sites but has increased slightly in some capital cities. There has been a decline in the consumption of oxycodone and fentanyl in the capital cities and regional sites since December 2018. Work continues with industry and regulators to determine if the decrease relates solely to the legitimate market for these substances, or also the illicit market.

Cannabis consumption has declined since August 2018 in the capital cities and regional sites.

POLICY AND OPERATIONAL CONSIDERATIONS

It is evident that a multi-dimensional approach that targets supply, demand and harm reduction is critical to addressing drug use in Australia. Drug consumption estimates derived from wastewater data, when used in combination with other data—such as seizure, arrest, price, purity, health and availability data—provide insight into related markets and the potential impact of supply, demand and harm reduction strategies.

Wastewater data are an important part of the suite of datasets available to increase our understanding of drug consumption, demand and supply in Australia. Making data from the program publicly available assists to enrich understanding and inform the national conversation on drug trends and related demand. This tenth report of the National Wastewater Drug Monitoring Program builds on national drug consumption data contained in preceding reports to identify temporal drug use trends across states, territories and the nation. It provides data on capital city and regional drug use and, where possible, comparisons with previous levels of use in sites across Australia and internationally. This, and future reports, continue to build and shape understanding on trends and changes in patterns of use, creating an increasingly detailed picture of drug consumption in Australia.

RESEARCH FINDINGS

Prepared by the University of Queensland (B Tscharke, J O'Brien, T Reeks, G Elisei, J Lin, S Grant, J Mueller, K Thomas) and University of South Australia (M Ghetia, R Bade, J Chen, L Nguyen, 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
LOQ	Limit of quantification
MDA	3,4-methylenedioxyamphetamine
MDMA	3,4-methylenedioxymethylamphetamine
NPS	New psychoactive substances
NSW	New South Wales
NT	Northern Territory
NWDMP	National Wastewater Drug Monitoring Program
Qld	Queensland
SA	South Australia
SPE	Solid phase extraction
Tas	Tasmania
THC	Tetrahydrocannabinol
THC-COOH	11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH), metabolite of THC
Vic	Victoria
WA	Western Australia
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.

Nicotine consumption has replaced tobacco consumption in this report as the target metabolites may also be derived from nicotine replacement products, such as gums and patches.

THC and THC-COOH: Tetrahydrocannabinol is the main psychoactive compound in cannabis and is referred to as THC throughout this report. Cannabis consumption levels have been calculated from the THC metabolite, 11-Nor-9-carboxy-Δ9-tetrahydrocannabinol (THC-COOH).

1: EXECUTIVE SUMMARY

The National Wastewater Drug Monitoring Program (NWDMP) for the Australian Criminal Intelligence Commission (ACIC) monitors selected substances of concern in most populated regions of Australia. Estimates of drug usage in a population were back-calculated from measured concentrations of drug metabolites (excreted into the sewer system after consumption) in wastewater samples. The current version of the NWDMP focuses on thirteen licit and illicit drugs, including nicotine, alcohol, methylamphetamine, cocaine and MDMA (ecstasy), with cannabis included from Report 6. Trends in estimated drug consumption are being established over the life of the program. 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 tenth report, wastewater samples were collected during weeks of October and December 2019, as well as February 2020. Twenty-four-hour composite influent wastewater samples were collected using time or flow-proportional autosamplers at each WWTP by plant operators. Samples were collected for up to seven consecutive days. Concentrations of drug metabolites were determined in the wastewater using liquid chromatography-tandem mass spectrometric (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 by evaluating census data vs. catchment maps, together with excretion and dose data obtained from the scientific literature.

A total of 18 WWTPs in capital cities and a further 35 regional sites participated in the program for the December 2019 period, covering a population of 10 million Australians. To maintain treatment plant confidentiality, each site was allocated a unique code and site names are not included in this report. Site codes stay assigned to each WWTP throughout the course of the program. Data from this report equates to coverage of approximately 48 per cent of Australia's population for October 2019 and February 2020 (capital city sites only), and 43 per cent for December 2019. A total of 4,914 individual daily samples have been collected and analysed since the beginning of the program, with new results from 629 additional samples added in this report. The collected samples provide comprehensive, Australia-wide baseline data against which subsequent results can continue to be compared to ascertain both spatial and temporal trends.

The estimation of drug use across 53 sites provided a snapshot of the scale of use over a week in December 2019, which was compared with historical data included in previous reports. The December 2019 dataset was used for this purpose as it was more comprehensive, including capital city and regional sites. After normalising the amount of drug measured in wastewater for population size and average dose consumed, alcohol and nicotine remained consistently the highest consumed drugs in all states and territories. Cannabis will be included in the comparison once better estimates of a typical dose are available. The consumption of nicotine was substantially higher in regional areas compared to capital cities. In the case of alcohol, the difference between regional and capital city use was also considerable. Sites in New South Wales, Queensland, Tasmania and the Northern Territory had the highest levels of nicotine. Alcohol consumption was more consistent across regional parts of the country, with notable exceptions in South Australia and Western Australia where use was substantially lower. Tasmania had the highest capital city consumption of alcohol. For the most part, levels of nicotine and alcohol have remained relatively steady since the start of the program in 2016, despite short-term fluctuations. South Australia and Western Australia were some of the exceptions, with declining longer-term alcohol consumption rates.

When expressed as doses per day, methylamphetamine had the highest doses of the illicit drugs included in the report, both in capital cities and regional sites. Regional dose levels were on average higher than in the capital cities, particularly sites in New South Wales, Queensland, Tasmania and Western Australia. The trend over the life of the program shows a rise in methylamphetamine use in almost every part of the country. South Australia has managed to contain their capital city levels at nearly half the historical highs, but even there, current use is higher than when the program started in 2016. Short-term comparisons show that December 2019 values were generally above August results included in the previous report.

Amphetamine is a metabolite of methylamphetamine. Measured amphetamine concentrations across the sites were mostly consistent with the observed levels being related to methylamphetamine metabolism rather than a consequence of direct amphetamine consumption.

Compared to methylamphetamine, the estimated usage of other stimulants was generally much lower. Cocaine consumption in Australia remains mostly centred in New South Wales, particularly the capital city. The overall trend over the life of the program shows increases in many states and territories. Consumption of cocaine was lowest in regional Northern Territory, South Australia, Tasmania and Western Australia. Regional use of the drug was generally less than in capital cities. MDMA usage was relatively low across most sites but tended to be higher in regional locations. Consumption levels over the span of the program have been increasing in many parts of Australia, with capital city New South Wales, the Northern Territory and Tasmania amongst the highest MDMA users. MDA use was relatively low, with no consistent pattern being evident. One site in Queensland had very high levels for the second time in two years.

Oxycodone and fentanyl are prescription pharmaceutical opioids with abuse potential. Oxycodone had elevated consumption levels at several sites, noticeably across regional parts of Australia and in particular regional centres in Victoria. Western Australia generally had relatively low oxycodone consumption across the state. Over the course of the program, oxycodone consumption increased to 2018, but has largely returned to initial levels across most parts of the country. Fentanyl use was also more prevalent in regional parts of the country, but not to the extent of oxycodone. Similar to oxycodone, consumption of the drug appeared to peak in late 2018. Levels of heroin varied widely, with minimal amounts detected in the Northern Territory and many regional areas of other states. The highest levels were recorded in capital city sites in Victoria and Western Australia, although capital city New South Wales shows an increased consumption rate over the program.

The cannabis metabolite, 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH), a specific marker for cannabis consumption, is excreted in extremely small amounts. This may be a cause of variability in back-calculated results, so a cautious approach is needed when making comparisons. Nevertheless, cannabis consumption in New South Wales, Tasmania, regional South Australia and the Northern Territory were highest in the nation. Use was relatively low in capital city New South Wales, Queensland and Victoria compared to other parts of the country. A feature of national cannabis consumption was the elevated regional average compared to capital cities. No obvious temporal trends were apparent over the relative short period of cannabis reporting.

For the other drugs included in the NWDMP, methylone and mephedrone concentrations were generally at or below detection levels at most participating sites. The detection frequency of mephedrone has been on the rise, particularly in Australian capital cities.

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 were commissioned to provide drug consumption data to the ACIC, for an initial three-year program from 2016 to 2019, including nine public reports. The two universities have been re-commissioned to provide data for a further four years from 2019 to 2023, commencing with this tenth public report. Wastewater treatment sites have been assessed, bimonthly in the case of capital city sites and every four months for regional sites. The aim has been to acquire data on the population-scale use of substances that cause potential harm, either through addiction, health risks, or criminal and anti-social behaviour. The intention is to build on the baseline data of substance use across Australia to establish trends. This latest NWDMP report compares consumption data from previous reports with results obtained subsequently from October and December 2019, as well as February 2020.

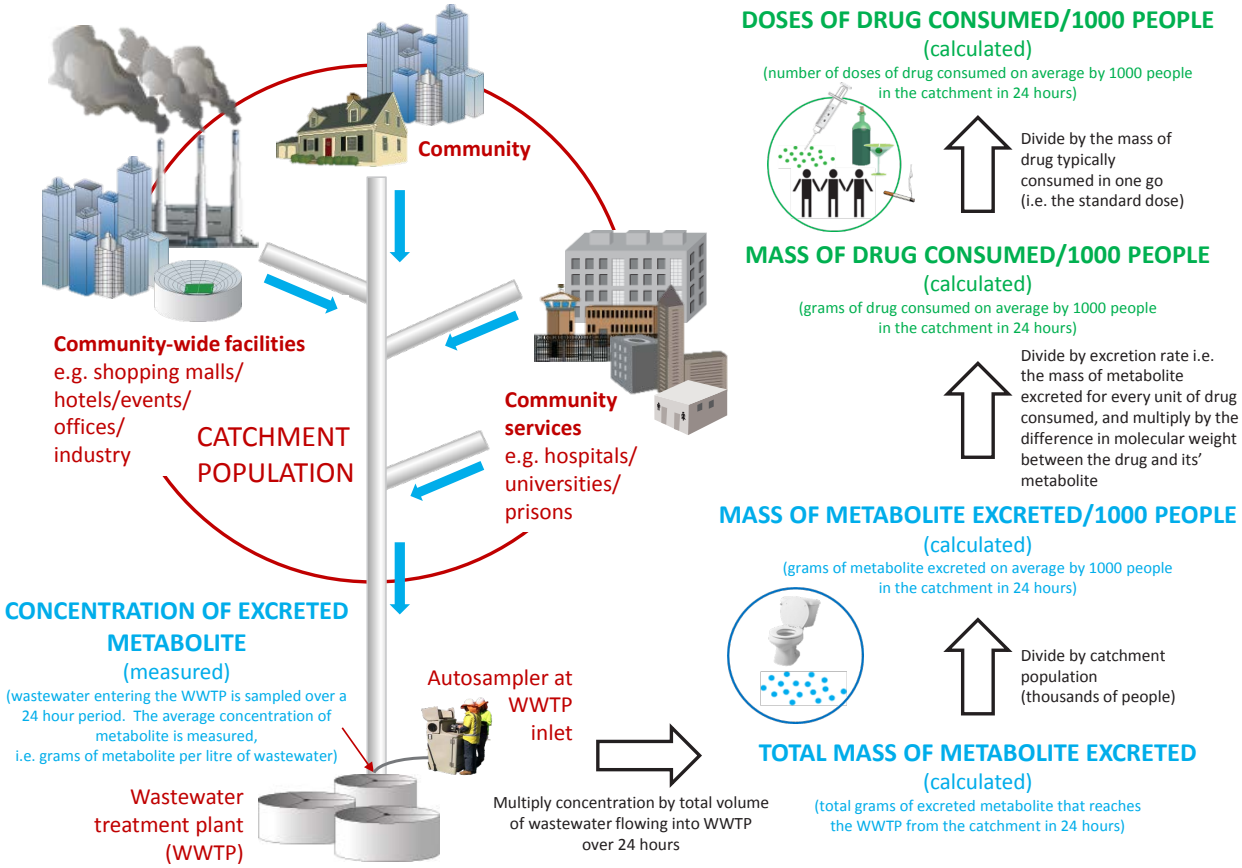
Compounds of concern include nicotine from nicotine intake (cigarettes, gum, patches, e-cigarettes, etc.), ethanol from alcohol intake, pharmaceutical opioids with abuse potential, illicit substances such as methylamphetamine, MDMA, cocaine and heroin, as well as a number of new psychoactive substances (NPS). Amphetamine and MDA were not included in the initial reports. Amphetamine is a by-product of methylamphetamine pyrolysis and is also one of its metabolites. Amphetamine can also be used as an illicit drug. However, we found the levels of amphetamine corresponded largely with the expected values from the excretion of methylamphetamine. Similarly, MDA is a metabolite of MDMA but can also be used as an illicit drug. However, since the proportion of MDA derived from MDMA is known, the difference between measured MDA and MDMA metabolite has been included in subsequent reports, including this one. The amount of MDA was calculated by subtracting 1.65 mg of MDA for every 100 mg of MDMA consumed (Pizarro et al. 2002; Khan & Nicell 2011) and is expressed in units of mg excreted per day per 1,000 people. Cannabis was measured by its urinary metabolite, THC-COOH. The report presents patterns of substance use across Australia, showing differences in levels between capital cities and regional centres, within and between states and territories, and nationally. Cannabis results are expressed only as mg consumed per day per 1,000 people and will also be expressed as dose per day per 1,000 people when better estimates of a typical dose become available.

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. This may be either in the chemical form it was 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. The drugs and their metabolites of interest were included in the first NWDMP report (available at www.acic.gov.au), as well as an in-depth description of the methodologies involved.[3] Collectively, waste products in the sewer system arrive at a WWTP where wastewater samples are collected over a defined sampling period. Measuring the amount of a 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 1). The method is non-invasive and is done on a population-scale level, so individuals are not targeted, and privacy is respected.

3 Information in relation to heroin appears in Report 3.

Figure 1: 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.



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 aid with collecting the samples from the influent autosampler (where the wastewater enters the treatment plants). Details of the calculation methods are given in Report 1. From the August 2018 collection period, operators collected a second daily influent sample with sodium metabisulphite (0.5% m/v) as preservative to allow for the detection of the cannabis metabolite.

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 Report 1. An updated excretion table including THC-COOH and dose can be found in Appendix 1. Methods to extract and analyse the cannabis metabolite are outlined in Tscharke et al. (2016).

3.1 PARTICIPATING WASTEWATER TREATMENT PLANTS (WWTPS)

Fifty-three WWTPs across Australia participated in the NWDMP for the December 2019 collection period (Figure 2). Of these, 18 sites were located in capital cities and a further 35 were regional sites, covering a wide range of catchment population sizes. Sites were selected by the Australian Criminal Intelligence Commission. The number of participating sites for this report and a complete list of participating sites, number of samples and relative catchment sizes are listed in Table 1 and Appendix 2. To maintain the confidentiality of the participating sites, all sites were allocated a unique code to de-identify their results. Only site codes are presented in the results sections.

Figure 2: Participating WWTPs in December 2019 showing the number of capital city and regional plants by state and territory. The colours in this figure are matched with others in the remainder of the report to identify results relating to individual states and territories.

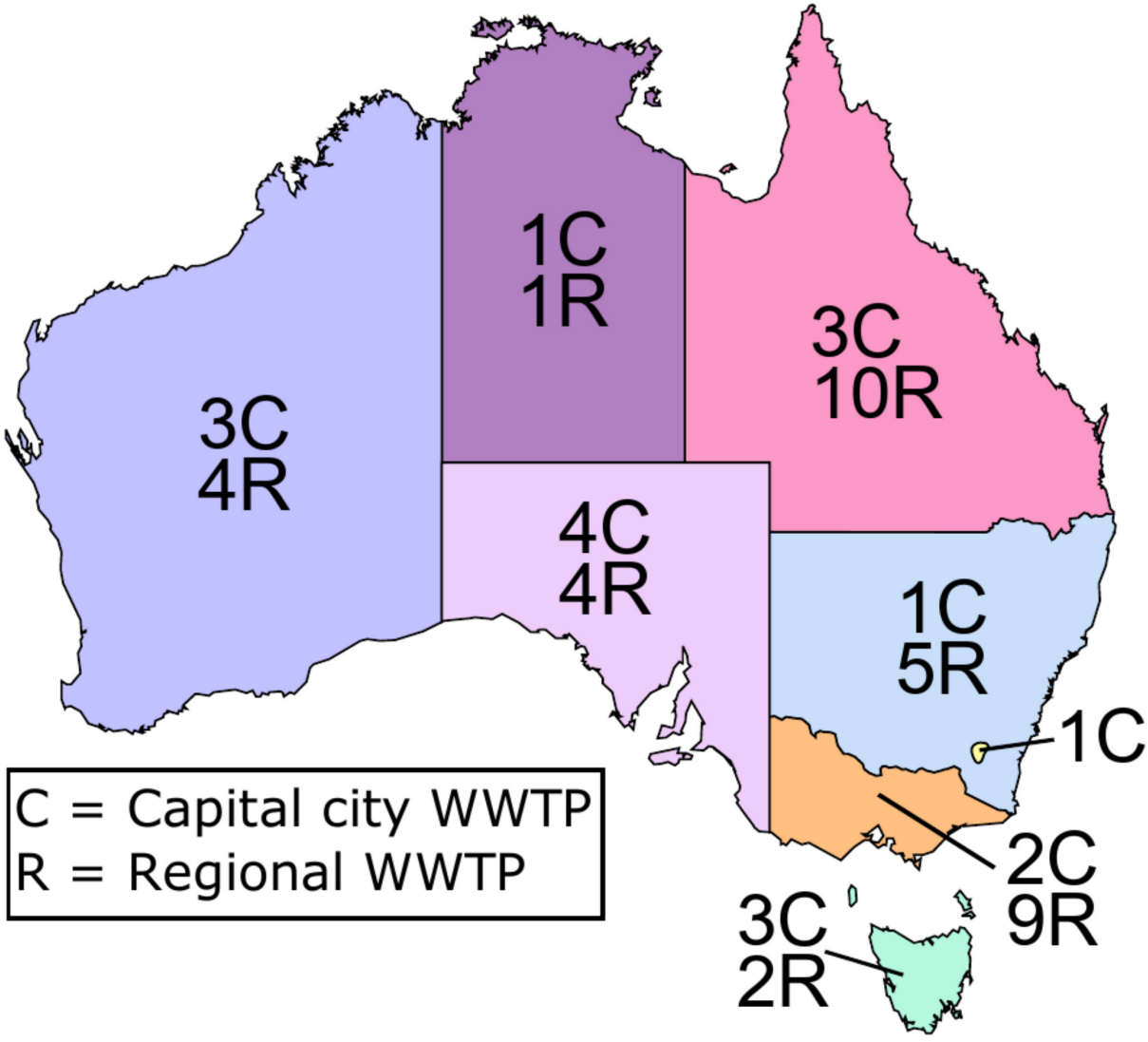


Table 1: Number of participating WWTPs for the periods covered in this report. Every second collection period aims to collect data from both regional (R) and capital city (C) sites, while the in-between collection period aims to collect data from capital city sites only.

State/territory	Oct 2019 Capital	Dec 2019 Capital	Dec 2019 Regional	Feb 2020 Capital
ACT	1	1	0	1
NSW	3	1	5	3
NT	1	1	1	1
Qld	3	3	10	3
SA	4	4	4	4
Tas	3	3	2	3
Vic	2	2	9	2
WA	3	3	4	3
Sites	**20**	**18**	**35**	**20**
Population (millions) C & R	**11.2**	**8.2**	**1.8**	**11.2**
% of Australian Population	**47.9**	**35.2**	**7.7**	**47.9**
Total population (millions)	**11.2**	**10.0**		**11.2**
% of Australian population	**47.9**	**42.9**		**47.9**

Estimates have been rounded to the nearest 0.1 million. Census 2016 population used (23,401,892) for population percentage estimates.

3.2 SAMPLE COLLECTION AND PREPARATION

Daily composite samples were collected by treatment plant staff on seven consecutive days, or where seven days was not feasible, across as many consecutive days as possible. Regional sites in South Australia have only been providing weekend samples since April 2018, which should be considered when interpreting historical results where number of sampling days was five—see Appendix 3, Report 6. Furthermore, small revisions may be made to historical data when more accurate data become available, for example, updated flow measurements supplied by wastewater treatment authorities. Samples were stored at 4°C or were frozen prior to transport to South Australia or Queensland. 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) and Bade et al. (2019). All other descriptions of calculations, extractions and analytical methods are outlined in Report 1 (available at www.acic.gov.au). Methods to detect and analyse THC-COOH are outlined in Tscharke et al. (2016).

3.3 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 Australian Bureau of Statistics (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 3. 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). For the specific case of MDA, the amount of MDA excreted following MDA consumption is not known, and therefore this drug can only be expressed as how much drug was excreted into the sewer network, e.g. the mg excreted per 1,000 people per day. For cannabis, the approximate dosage is not well defined, and results are expressed as mg consumed per 1,000 people per day.

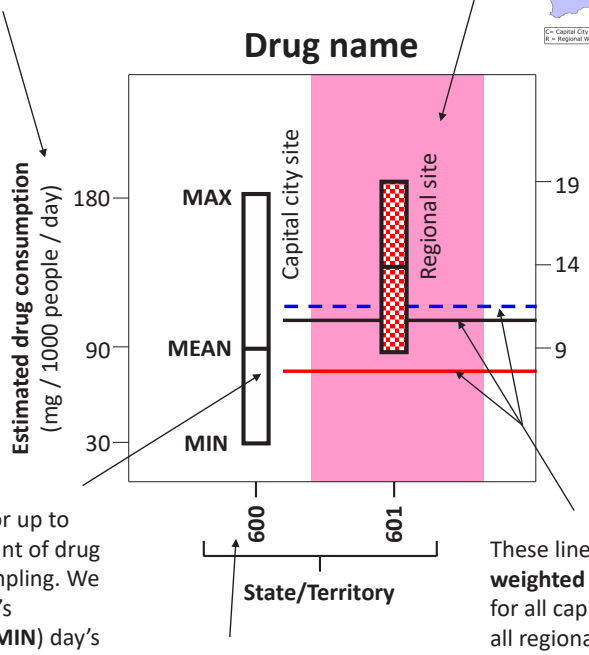
Figure 3: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

The **left hand axis** shows the estimated total mass consumed (in milligrams, mg) of a drug which is calculated by measuring the concentration of the drug's metabolite in a 24 hour wastewater composite sample, multiplying by the flow volume in the 24 hours, dividing by the population size and applying an excretion factor for the metabolite (see Equation 1, Report 1 for details).

To convert the mass consumed (left axis) to the estimated doses consumed (right axis), we divide the estimated mass consumed by the standard dose amount. Dose amount and excretion factors are given in Appendix 1 of Report 4. In this example, at Site 600, the minimum consumption was 30 mg in one day, the maximum was 180 mg and average was 90 mg per day over the sampling period (for every 1,000 people).

We collect wastewater data for up to 7 days and estimate the amount of drug consumed for each day of sampling. We plot the maximum (**MAX**) day's consumption, the minimum (**MIN**) day's consumption and the average (**MEAN**) across the 7 days. If the box is long, there is a large difference in consumption patterns over the week; for example, if drugs are used excessively at weekends but not often during the week. Alternatively, a short box suggests a similar drug usage every day of the week. See also main text.

Colours help identify the State or Territory that the data relates to (colours are consistent between Figures).

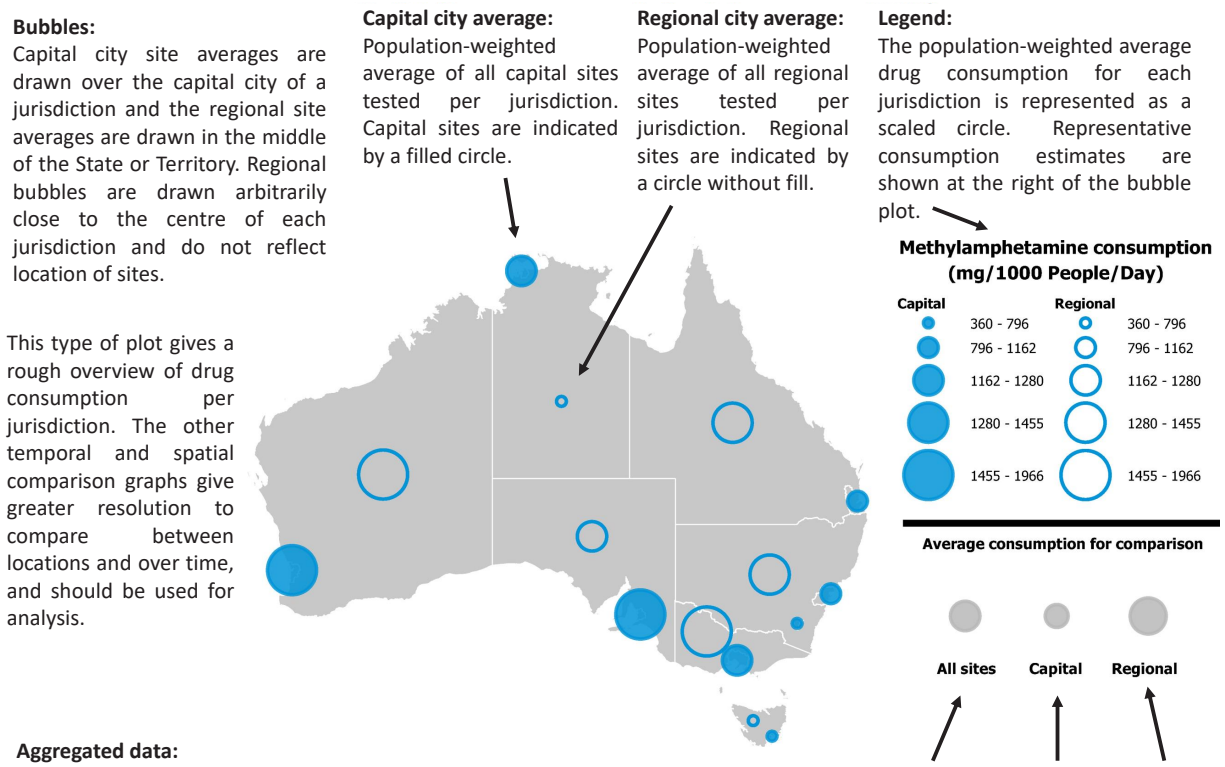


Unique number allocated to each WWTP to maintain confidentiality. WWTP names will not be disclosed publicly.

The **right hand axis** shows the estimated number of doses of a drug consumed by 1,000 people in the catchment in a 24 hour period; e.g., one dose would be 1 cigarette, 1 standard drink or 1 injected amount of drug. In this example, at Site 601, the minimum consumption was 9 doses in one day, the maximum was 19 and average was 14 per day over the sampling period (for every 1,000 people).

These lines represent the **population weighted averages** for drug consumption for all capital city sites (blue dotted line), all regional sites (red line) and for all sites combined (black line). The method to calculate weighted population averages is given in the main text. In this example, the average consumption for regional Site 601 (horizontal bar within red checked box) is above both the average for regional sites and all sites nationally. In contrast, the average consumption for capital city Site 600 is below the national average.

Figure 3 (continued): Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).



Aggregated data:
The population-weighted average drug consumption is also shown as a point of comparison for all sites, all capital, and regional sites that were tested within the timepoint. This incorporates sites from **all jurisdictions** for the timepoint under investigation. These are also represented with sizes representing the scale of use categories used for the jurisdictional averages.

Instrumental method limits of detection and limits of quantification: Since the wastewater samples contain very low quantities of particular drugs, the limit of detection (LOD) was determined analytically as the lowest concentration of that drug that could be determined in the sample (using the methods described in Report 1). A drug may be present at a concentration below the LOD. However, trace quantities may be present at undetectable levels. The limit of quantification (LOQ)[4] 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 LOQ 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 practice, for back calculations to estimate per capita consumption, a concentration below the LOD was included as a value of LOD/√2. A concentration above the LOD but below LOQ, is included at the midpoint between the LOD and LOQ (i.e. (LOD + LOQ)/2). The frequency of detection of each analyte of interest is included in Appendix 3.

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 included in the current report. This is because the starting day of the collection week did not always correspond for every plant. We present only maximum, minimum and average (for the individual sites) (e.g. Figure 3) and only population-weighted average values for all other graphs. 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.

4 LOQ is the lowest level that can be accurately measured.

Other drugs such as methylamphetamine, oxycodone and fentanyl tend to have lower daily variation suggesting that their consumption is consistent throughout the week (Lai et al. 2015, Tscharke et al. 2016).

4: RESULTS

Estimated drug consumption data are presented in several different ways in the following sections to allow comparisons of drug use at the individual site level for December 2019 (section 4.1), temporal trends for states and territories since August 2016 (section 4.2) and within each state and territory (section 4.3). December 2019 data were used for this section as it included the latest set of results for the full suite of sites included in the program. We recommend exercising caution when comparing results between sites as some plants provided samples for fewer days than others and the collection week did not correspond in all instances. A list of the detection frequency for each drug can be found in Appendix 3. This report retained the current population estimates introduced in Report 4 by integrating the specific wastewater catchment areas against the high-resolution population data released from the 2016 Census. 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. The uncertainties in population numbers may be particularly evident in smaller regional communities or sites where short-term population changes occur due to employment opportunities, tourism or festival events.

4.1 INDIVIDUAL SITE COMPARISON OF DRUG USE IN DECEMBER 2019

4.1.1 NICOTINE AND ALCOHOL

Two nicotine metabolites, cotinine and hydroxycotinine, were used to estimate the consumption of tobacco. The method cannot distinguish between nicotine intake from tobacco, electronic cigarettes and nicotine replacement therapies such as patches and gums. Therefore, the estimate is expressed as nicotine in this report. The results show that in December 2019 the consumption of nicotine was highly variable between sites across the country (Figure 4). The regional average was well above that of the capital cities (red horizontal and dotted blue lines, respectively). The Northern Territory and Tasmania had the highest overall capital city consumption. Sites in regional New South Wales, the Northern Territory, Tasmania and Queensland were above the national average.

Alcohol was measured using a specific metabolite of ethanol. The difference between the average consumption of alcohol in regional and capital city sites was substantial and in line with nicotine (Figure 5). Obvious exceptions were regional South Australian sites which all fell below the national mean. South Australia and Tasmania, and to some extent Western Australia, were regions where capital city use tended to be higher than their regional counterparts. Some capital city sites in Queensland, South Australia, Victoria and Western Australia had levels lower than the national average. Differences in use between days of the week was generally wide and in agreement with other wastewater studies, both in Australia and internationally, which have shown higher consumption of alcohol over weekend periods.

The relative consumption levels can be represented in a pictorial way by showing the relative scale of use of nicotine (Figure 6) and alcohol (Figure 7) as capital city or regional ‘bubbles’ for each state and territory.

Figure 4: Estimated nicotine consumption for December 2019 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 5-7.

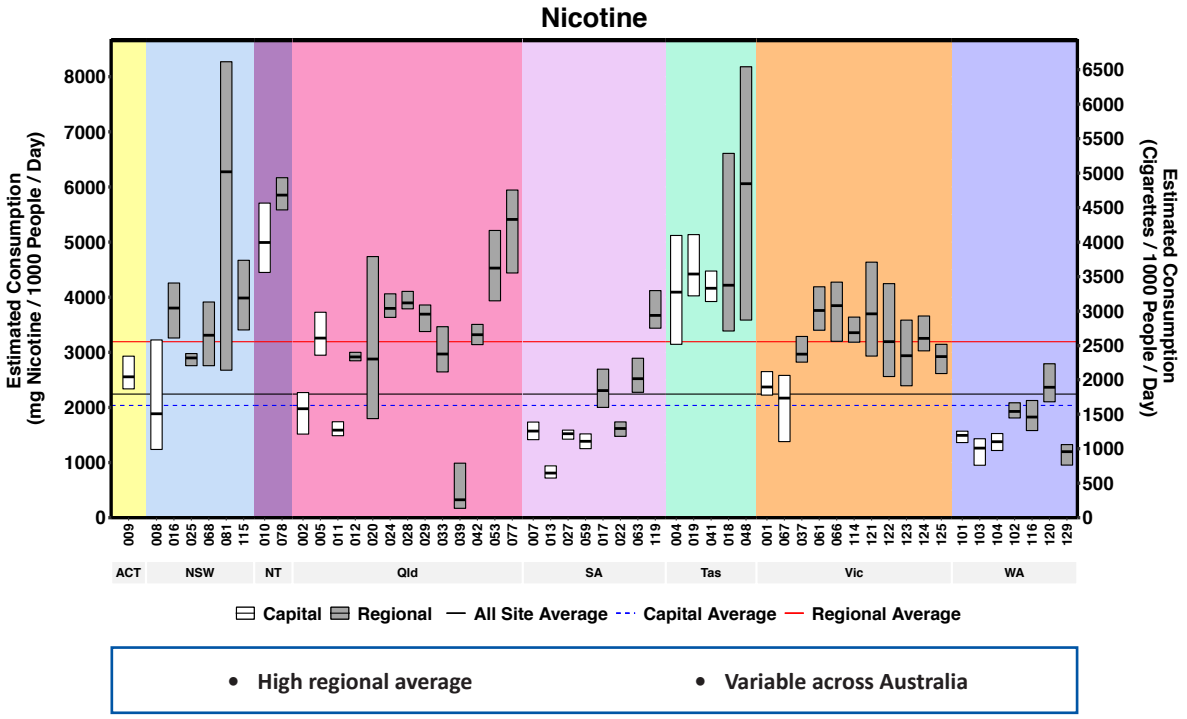


Figure 5: Estimated alcohol consumption for December 2019 in volume consumed per day (left axis) and standard drinks per day (right axis) per thousand people. The number of collection days varied from 5-7.

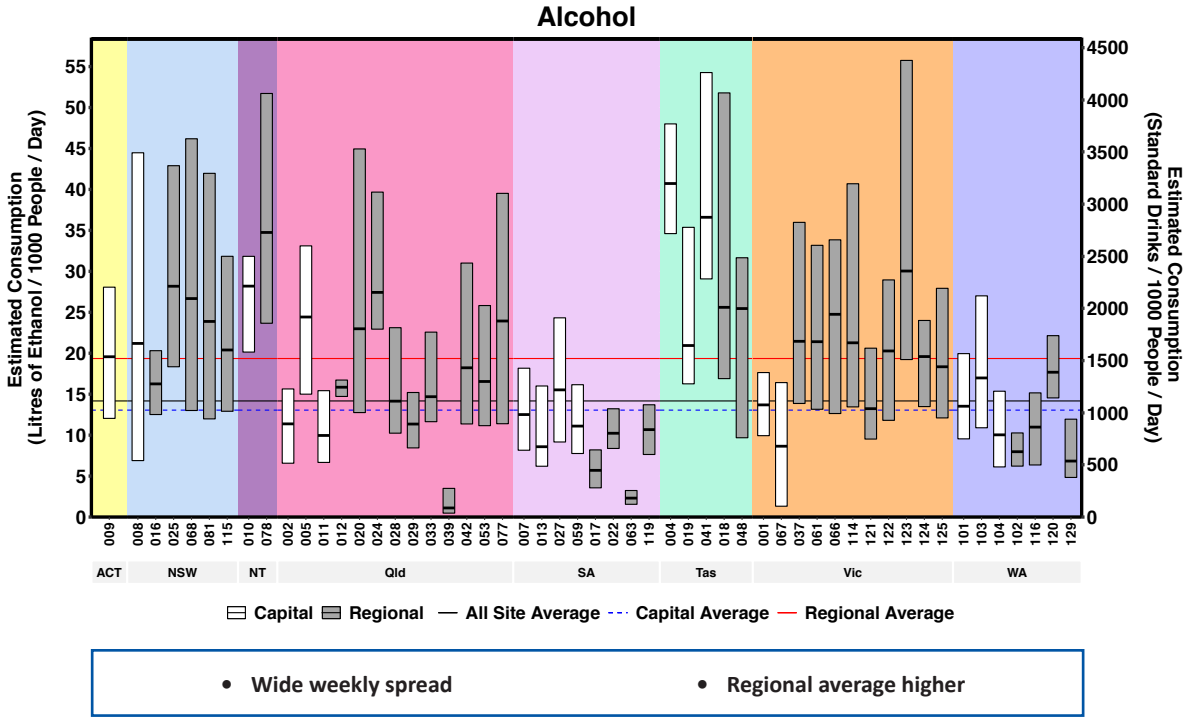


Figure 6: Estimated average nicotine consumption per jurisdiction for December 2019 in number of cigarettes per day per thousand people. The number of collection days varied from 5-7.

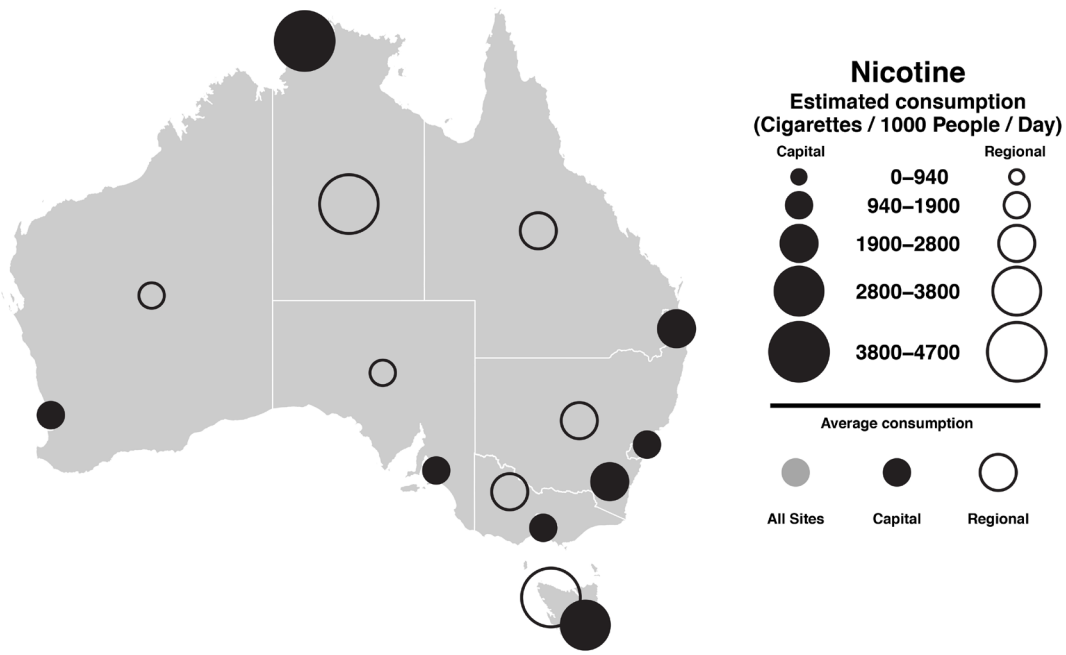
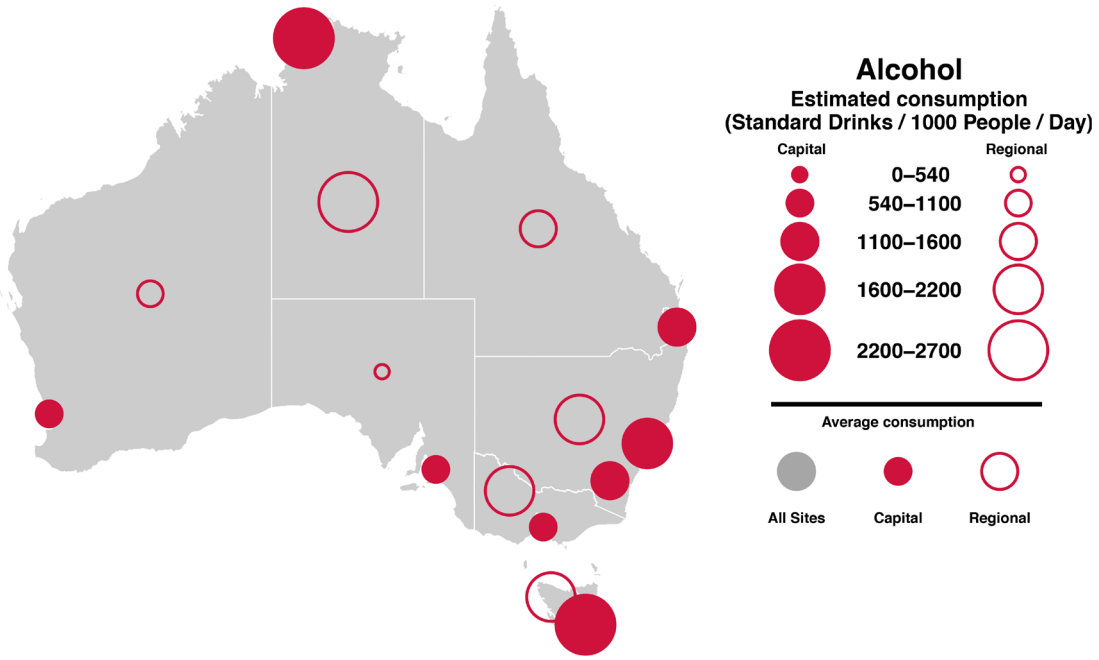


Figure 7: Estimated average alcohol consumption per jurisdiction for December 2019 in number of standard drinks per day per thousand people. The number of collection days varied from 5-7.



4.1.2 STIMULANTS

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

4.1.2.1 METHYLAMPHETAMINE

The average regional use of methylamphetamine was above that of capital city sites at more than 1,600 mg per thousand people per day (Figure 8). Site 81 in regional New South Wales and Site 66 in regional Victoria had the highest mean weekly use of methylamphetamine. The Northern Territory and South Australia defied the national trend, with capital city use generally higher than in regional areas. The mean consumption estimate for South Australia was the highest of the capital cities. However, regional use in the state was generally at the national regional average. A few sites in almost every state had relatively low levels compared to national averages, showing that use of the drug can be quite variable across the country.

4.1.2.2 AMPHETAMINE

The measured concentration of amphetamine in the December 2019 samples mostly fell within a range which is consistent with the reported excretion rates following methylamphetamine consumption (Gracia-Lor et al. 2016). The results were in agreement with our previous findings (see Appendix 4 of Report 1). Therefore, we assumed that the levels of amphetamine in wastewater samples were predominantly due to the metabolite of methylamphetamine. It is possible that some of the measured amphetamine could be the result of ingestion of the drug, but the high levels of methylamphetamine means a firm conclusion is not possible.

4.1.2.3 COCAINE

Benzoylecgonine, the specific metabolite of cocaine, was used to estimate the consumption of the stimulant. In contrast to methylamphetamine, capital city areas on average had higher cocaine use than regional centres (Figure 9). The difference was less pronounced than before. New South Wales tended to have higher consumption than other regions, although some sites in Queensland, the Australian Capital Territory and Victoria had relatively high use as well. Cocaine consumption was generally low in most other parts of Australia, particularly regional areas of Queensland, Western Australia and parts of regional South Australia and Victoria. Tasmanian regional sites were not able to provide weekend samples. As a larger proportion of cocaine may be consumed on weekends, these results may be under-representing consumption in that state.

4.1.2.4 MDMA (3,4-METHYLENEDIOXYMETHYLAMPHETAMINE)

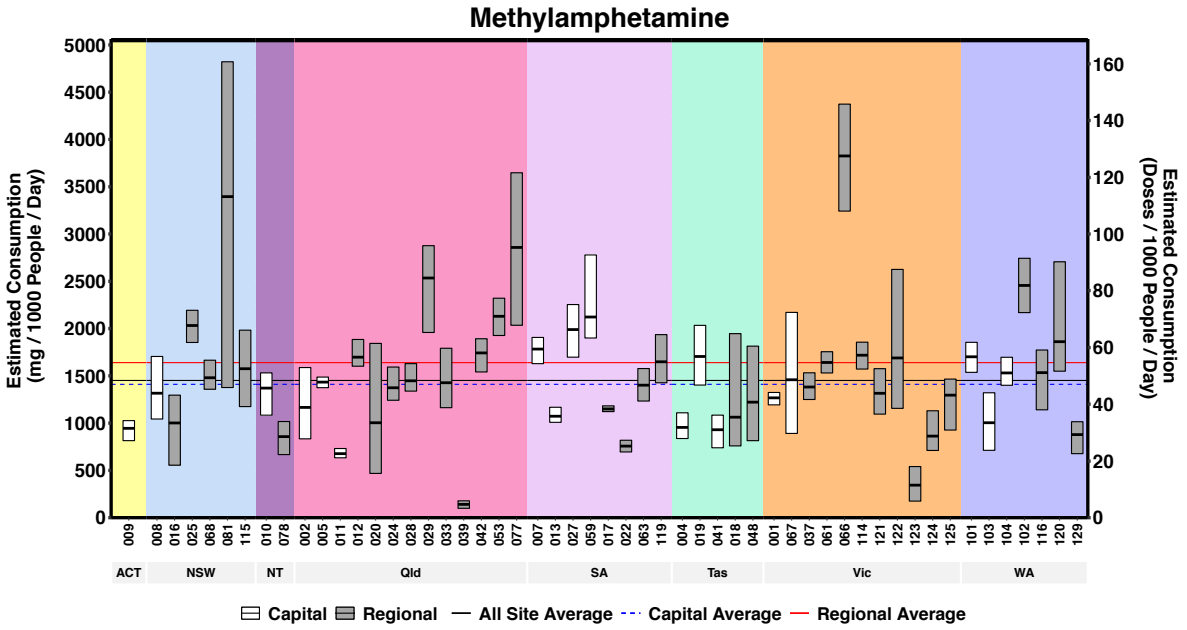
The average consumption of MDMA was lower in capital city than regional catchments (Figure 10). Western Australia was an exception where capital city use was clearly higher than in regional centres. Capital city sites in New South Wales and Western Australia had higher consumption estimates compared to the national averages. The large spread in values over the sampling week was consistent with the weekend use of the drug. A direct comparison of regional and capital city sites in some regions (e.g. Tasmania) may be inappropriate as a few regional sites did not sample on weekends when MDMA consumption is typically higher. See Appendix 2 for a list of the number of samples collected per site.

4.1.2.5 MDA (3,4-METHYLENEDIOXYAMPHETAMINE)

MDA is both a drug in its own right and a metabolite of MDMA. Since the proportion of MDA eliminated after MDMA consumption is known, this proportion of MDA attributable to MDMA metabolism was subtracted from the total measured amount of MDA for each site. Results for MDA were expressed as mg excreted per 1,000 people per day (daily mass load) and not as consumption due to the lack of metabolic information of MDA elimination following MDA consumption. The daily mass loads for regional sites were on average slightly higher than capital cities. High levels were evident across the sampling week at regional Queensland Site 12 (Figure 11). Elsewhere in the country, use appeared to be lower and less variable than MDMA in terms of mass load per day.

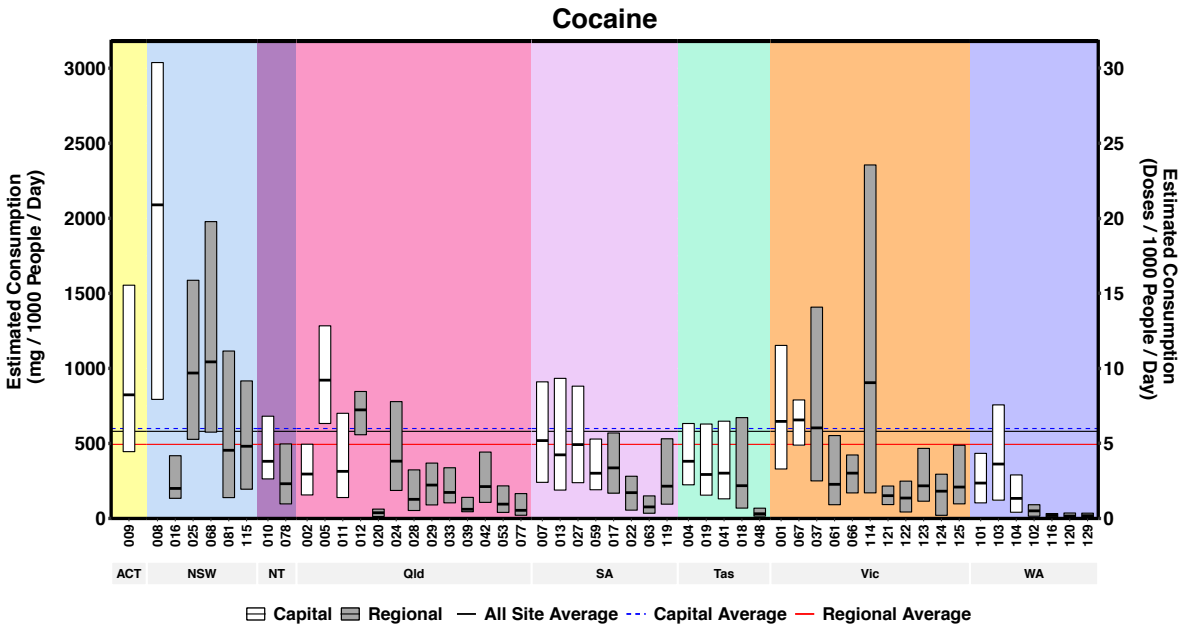
The scale of use of each stimulant is expressed as a bubble graph to compare regional and capital city use of methamphetamine (Figure 12), cocaine (Figure 13), MDMA (Figure 14) and MDA (Figure 15) across the country. The popularity of cocaine on the south-eastern seaboard remains apparent, while MDMA and MDA use also spread towards the north-east.

Figure 8: Estimated methylamphetamine consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



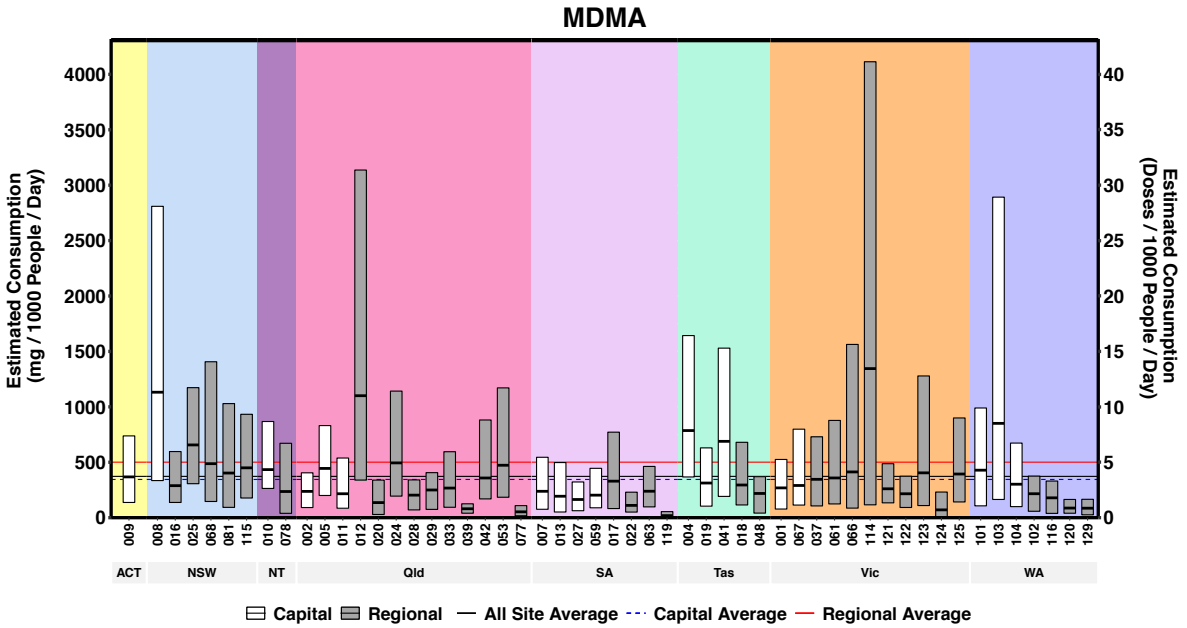
- Variable across Australia
- Higher regional consumption

Figure 9: Estimated cocaine consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



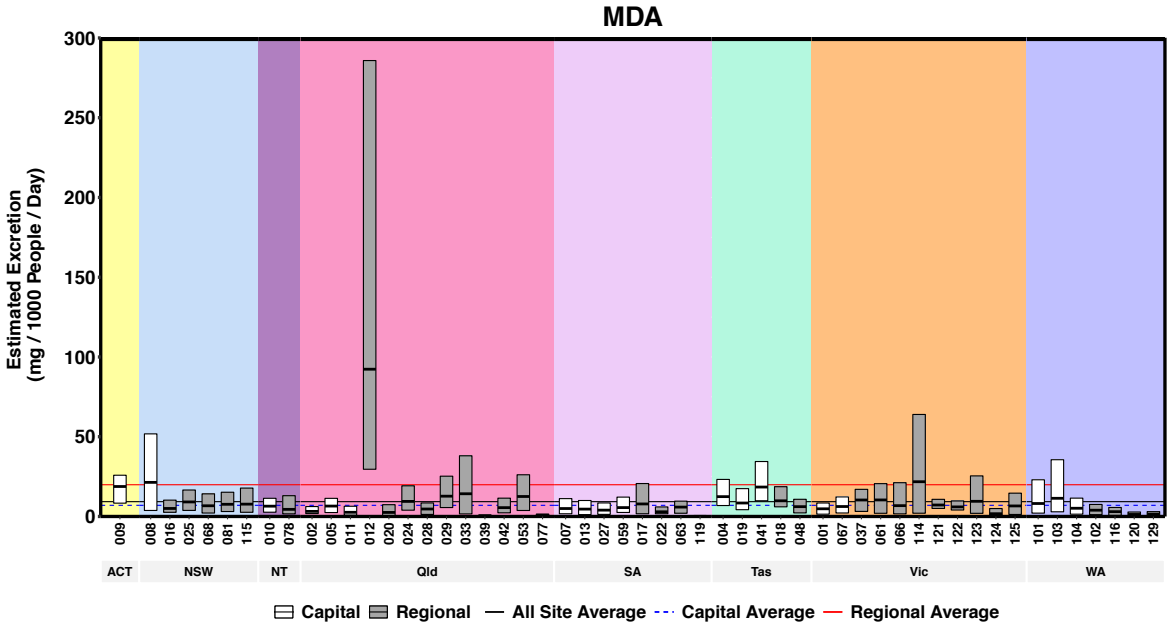
- High overall consumption in NSW
- Higher capital city consumption

Figure 10: Estimated MDMA consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Some exceptions, but low consumption rates nationally
- Wide weekly spread indicates higher weekend consumption

Figure 11: Estimated MDA excretion for December 2019 in mass excreted per day per thousand people. The number of collection days varied from 5-7.



- Relatively low levels in general
- Regional averages higher, similar to MDMA use

Figure 12: Estimated average methylamphetamine consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

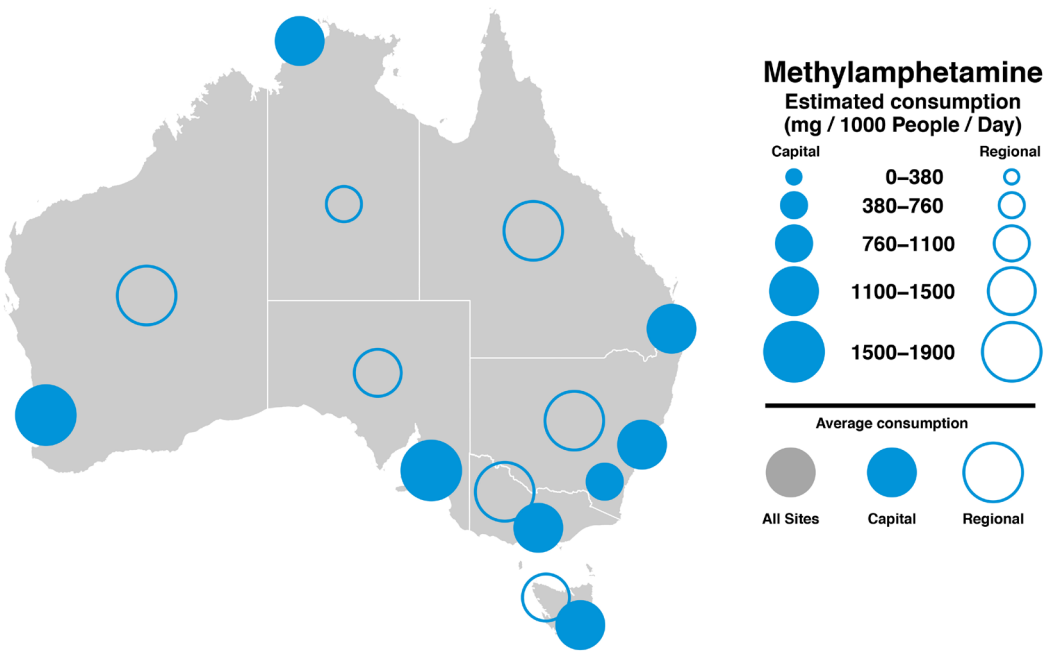


Figure 13: Estimated average cocaine consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

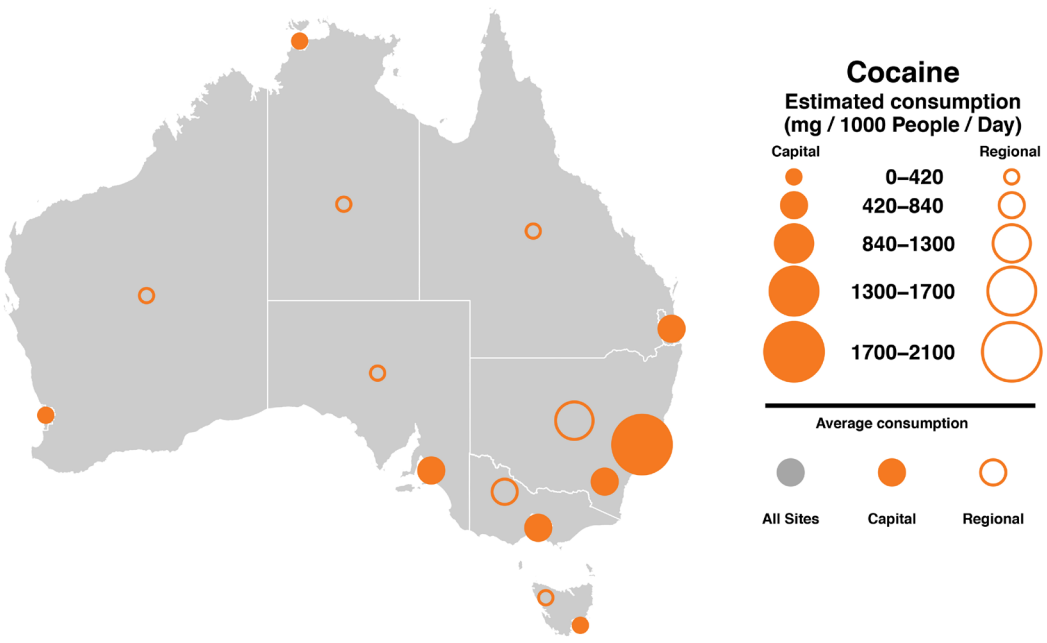


Figure 14: Estimated average MDMA consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

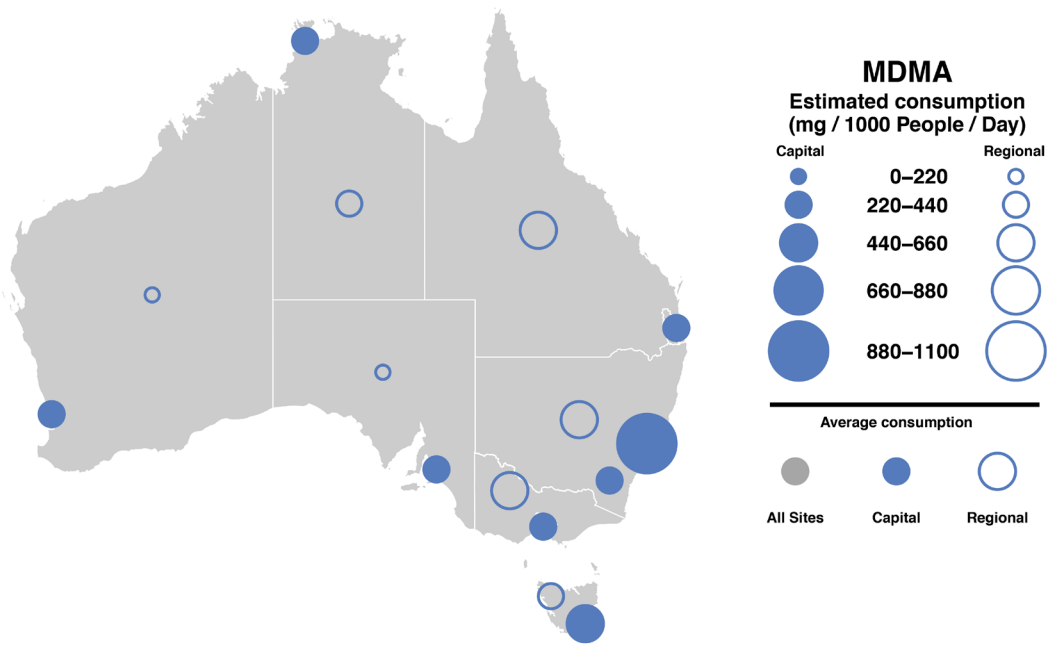
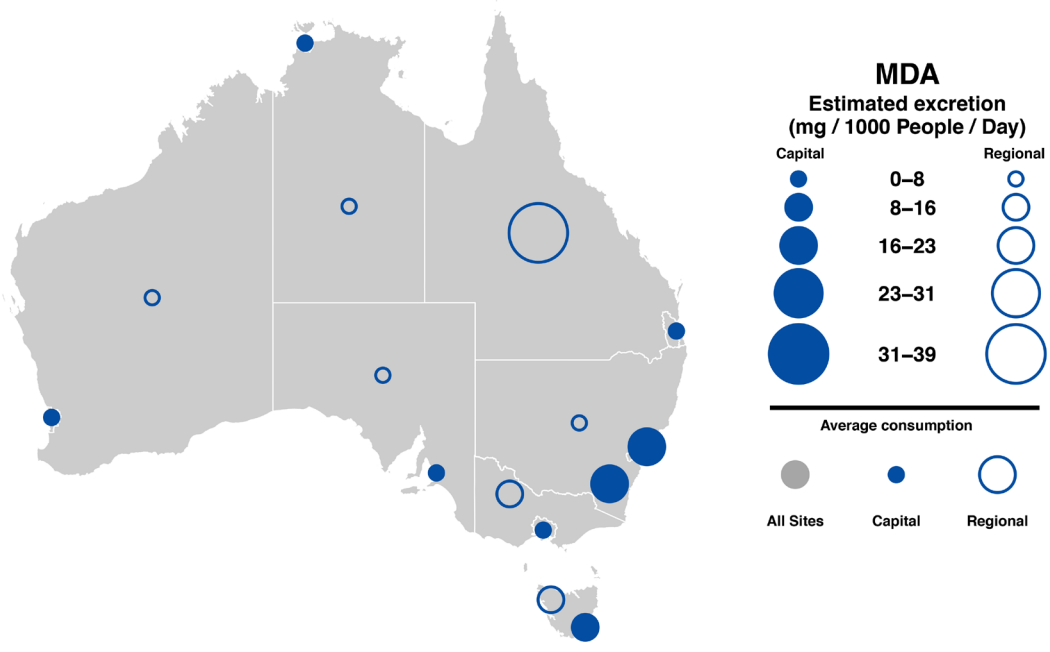


Figure 15: Estimated average MDA excretion per jurisdiction for December 2019 in mg excreted per day per thousand people. The number of collection days varied from 5-7.



4.1.3 OPIOIDS

Two prescription opioids were measured, as well as heroin, an illicit drug. Oxycodone and fentanyl are legally prescribed pharmaceuticals with abuse potential. Although wastewater analysis cannot be used to differentiate between prescribed use for therapeutic purposes and use for non-medical purposes, the relative scale of use of these substances remains of interest as they have the potential for addiction.

4.1.3.1 PHARMACEUTICAL OPIOIDS

The metabolism and excretion profiles of oxycodone and fentanyl are well characterised. The main metabolite of each compound was measured to estimate drug consumption.

Similar to previous reports, the overall regional average value for oxycodone consumption across the nation was very high, well above the capital city average (Figure 16). In general, regional Victoria had the highest consumption, in contrast to the capital city levels in that state which were at or below the national city average. Capital city Tasmania had the highest city use. Western Australia had relatively low consumption levels compared to the national averages, while city sites in New South Wales, the Northern Territory, Queensland and South Australia were mostly similar.

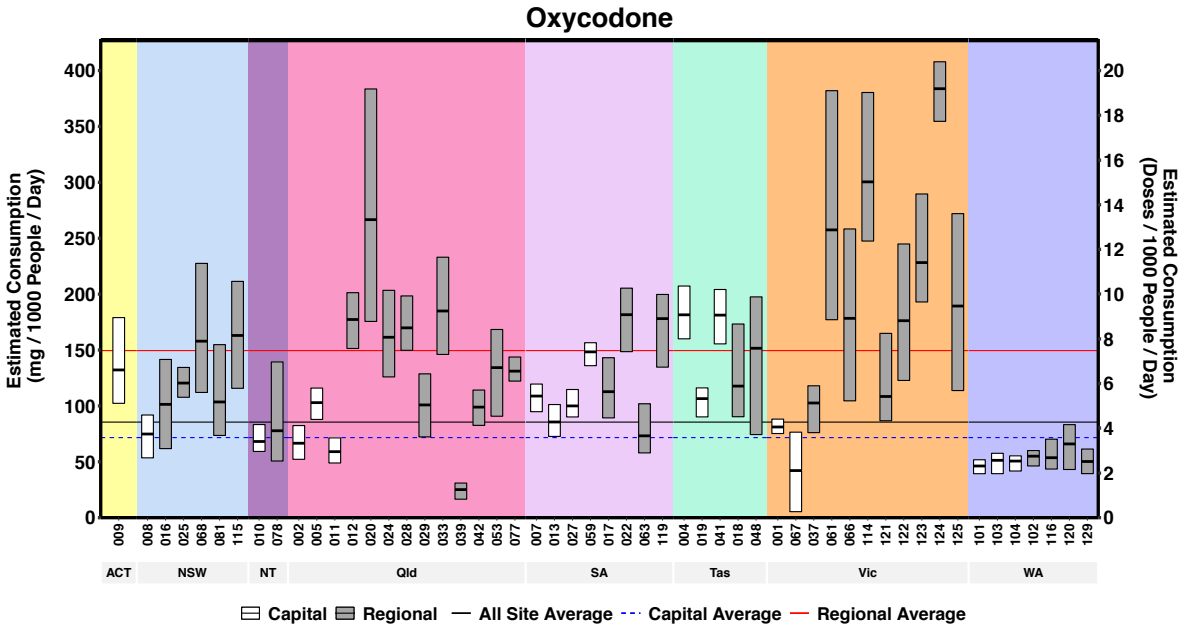
Fentanyl use was variable across Australia (Figure 17). Regional use of this pharmaceutical opioid also exceeded the capital city average, being almost double. Site 81 in regional New South Wales had much higher consumption than others (albeit consistent with previous results at that site). Factors such as average population age and density of medical services may account for some site-specific differences. The two Victorian capital city sites had very low use. Some sites in the Northern Territory, Tasmania and Victoria had levels below the quantification limits of the method.

The relative scale of oxycodone and fentanyl use was apparent when results were aggregated by jurisdiction and capital or regional area and presented in bubble graph form. Generally higher oxycodone consumption rates in regional areas and in capital city Tasmania were apparent (Figure 18). Fentanyl consumption was relatively consistent between most capital cities, apart from New South Wales (Figure 19).

4.1.3.2 HEROIN

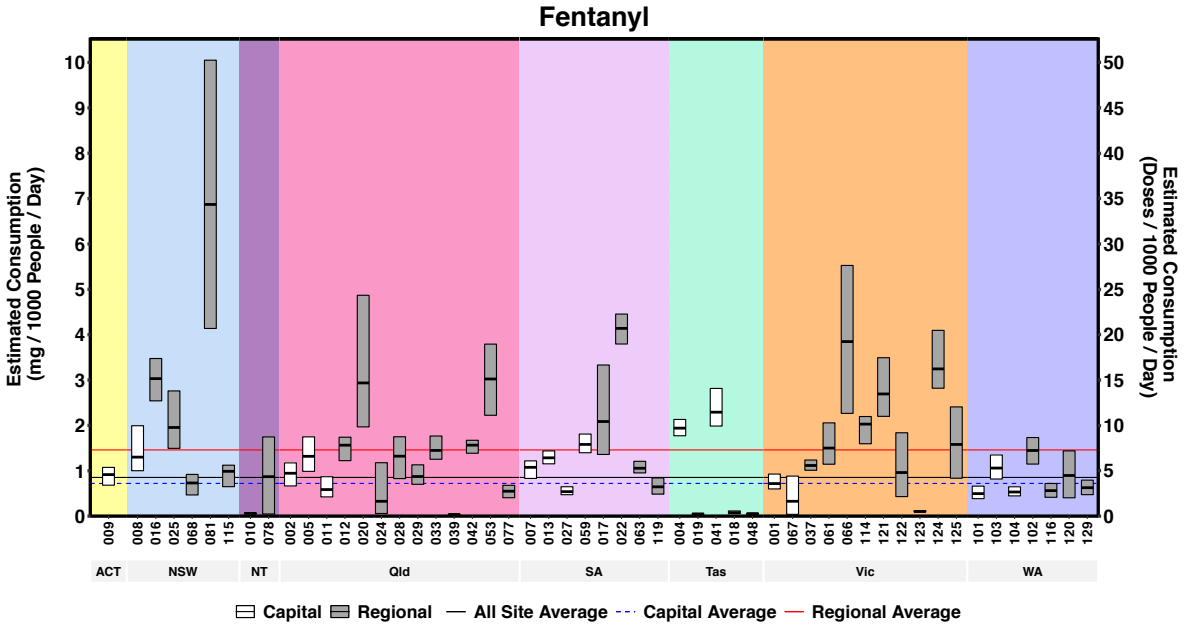
Heroin is metabolised in the body and excreted in low amounts as the unique metabolite, 6-monoacetylmorphine (6-MAM). Since the metabolite is characteristic of heroin use, it can be used to distinguish heroin from other opioids such as morphine and codeine. Unlike the two pharmaceutical opioids, heroin consumption in regional areas was generally much less than in the capital cities (Figure 20). Victoria Site 67 and Western Australia Site 104 had very high consumption rates across the sampling week, well above any other catchment. Most regional sites had levels at or below limits of quantification, as well as capital city sites in the Northern Territory, Queensland and Tasmania. Some regional sites in New South Wales and Victoria had heroin consumption at or above the capital city average. The elevated heroin consumption in capital city Victoria and Western Australia is clearly evident from the bubble graph (Figure 21).

Figure 16: Estimated oxycodone consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Higher regional average, particularly regional Victoria
- Tasmania the highest capital city sites

Figure 17: Estimated fentanyl consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Higher and variable regional average
- New South Wales highest consumption

Figure 18: Estimated average oxycodone consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

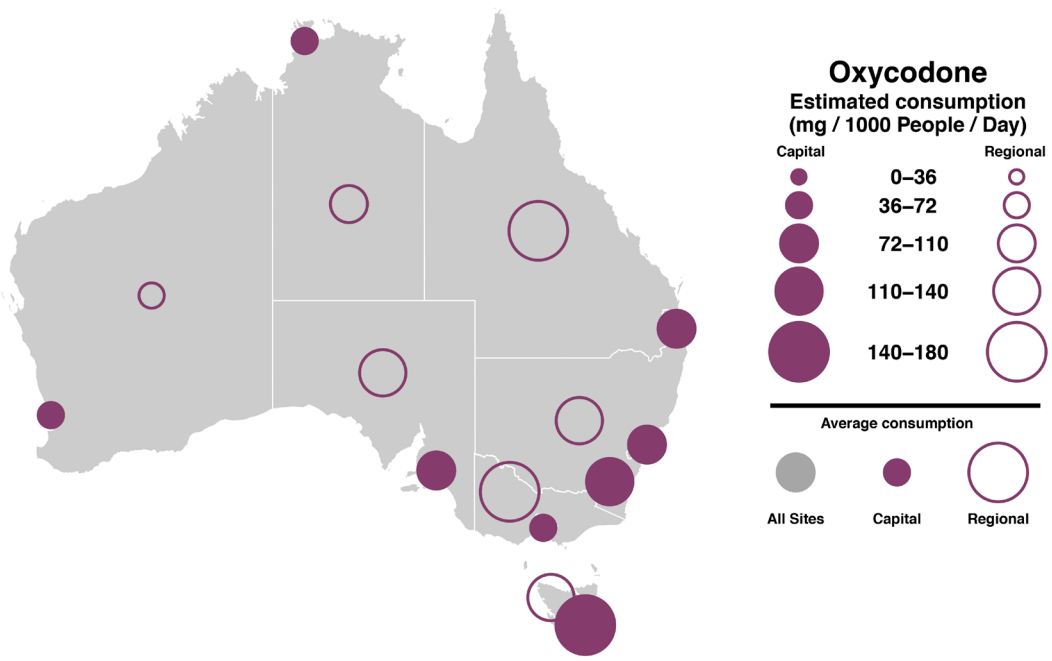


Figure 19: Estimated average fentanyl consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

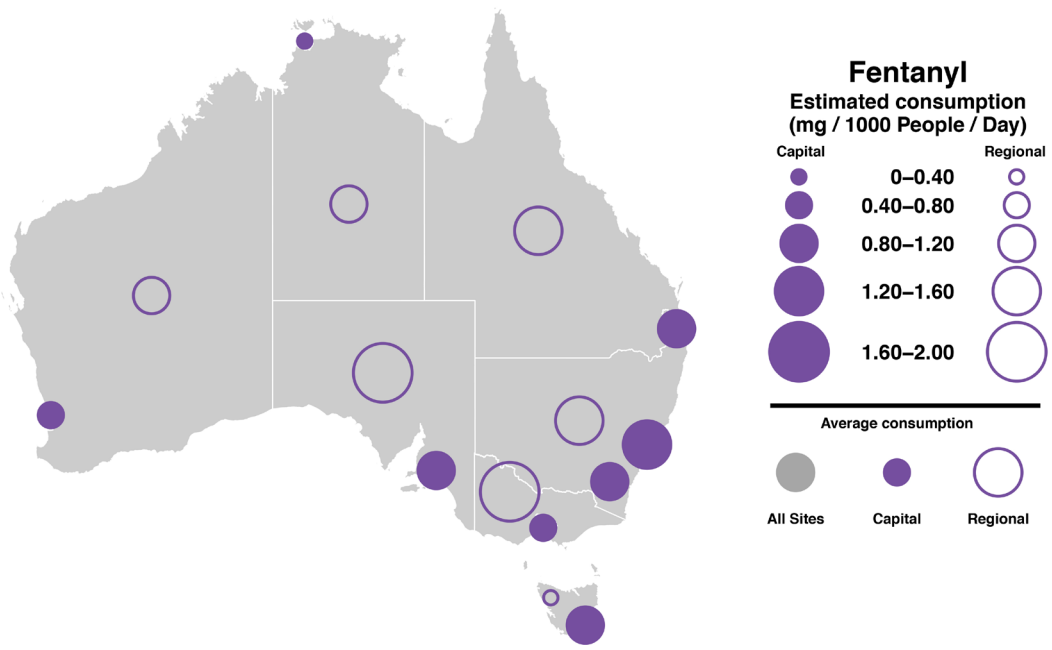
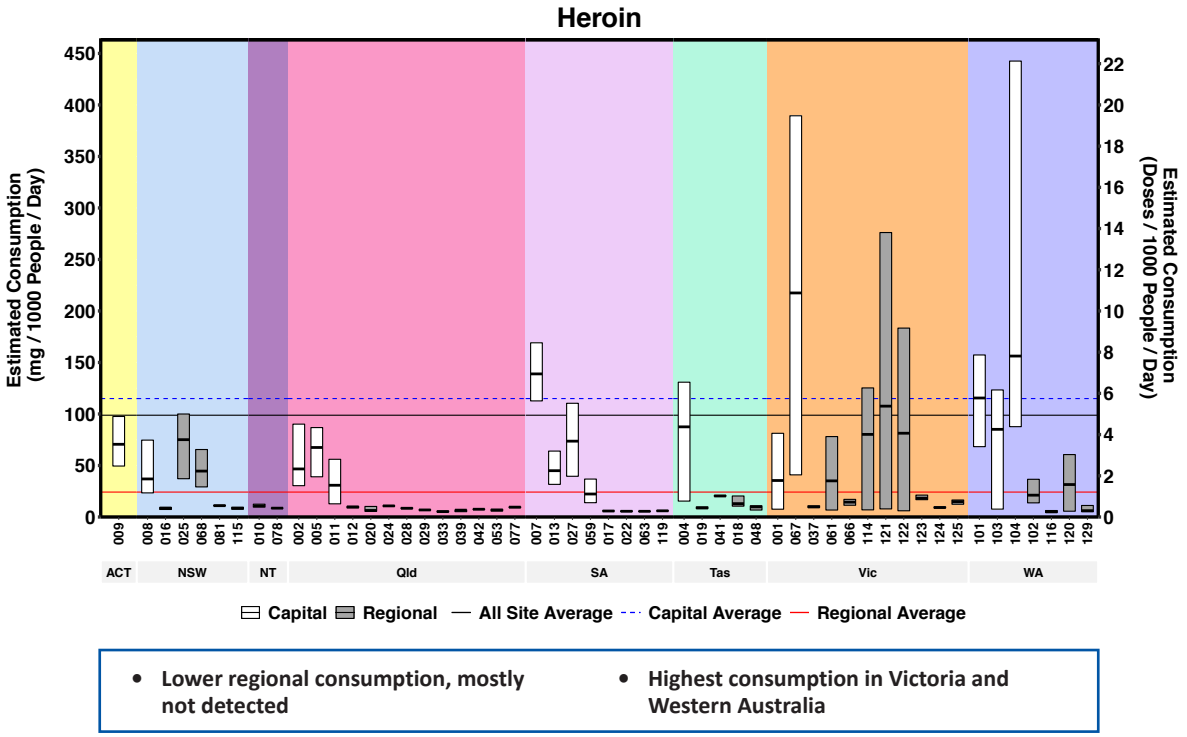
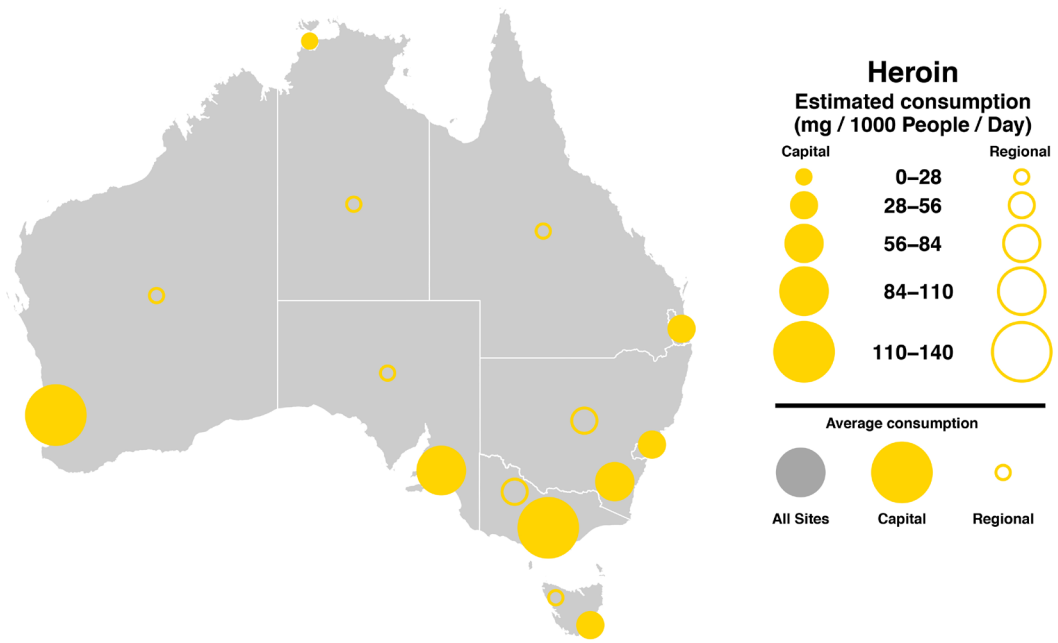


Figure 20: Estimated heroin consumption for December 2019 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Lower regional consumption, mostly not detected
- Highest consumption in Victoria and Western Australia

Figure 21: Estimated average heroin consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.



4.1.4 CANNABIS

Tetrahydrocannabinol (THC) is the main psychoactive compound found in cannabis. The compound is metabolised and largely cleared through the gut. A small proportion (0.06 per cent) is excreted through the kidneys as 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH). The latter is known to adsorb to various surfaces, including sewer infrastructure. Therefore, in terms of wastewater analysis, the sewer design and collection method may play a part in the reportable levels of the target metabolite used for the purposes of the NWDMP. Upon collection, samples have to be preserved to avoid degradation of THC-COOH, without using acidification (McCall et al. 2016). This is one reason why cannabis consumption is not reported on a regular basis in other countries where wastewater analysis is routinely conducted as acidification is a common preservation technique. For the NWDMP, separate samples are collected each day and preserved specifically for THC-COOH analysis.

Cannabis consumption was expressed as the daily mass load (mg) of consumed active ingredient (THC) consumed per 1,000 people. An average dose was not defined as for other drugs in the report. The dose of cannabis depends on several factors, such as the part of the plant, strain, or whether an extract was used. This will be included in graphical representations of the data when an appropriate dose becomes available.

Clear spatial differences were evident across Australia (Figure 22). The average use in regional areas exceeded capital city consumption. Site 81 in regional New South Wales recorded some very high daily values. Regional parts of the Northern Territory, Queensland, South Australia and Tasmania had higher consumption rates of the drug compared to the national average. Tasmanian Site 19 had the highest capital city consumption. The bubble plot and the jurisdictional differences in cannabis use across Australia show generally higher consumption in regional areas, and highest average capital city consumption in Tasmania (Figure 23).

Figure 22: Estimated cannabis consumption for December 2019 in mass consumed per day (left axis). The number of collection days varied from 5-7.

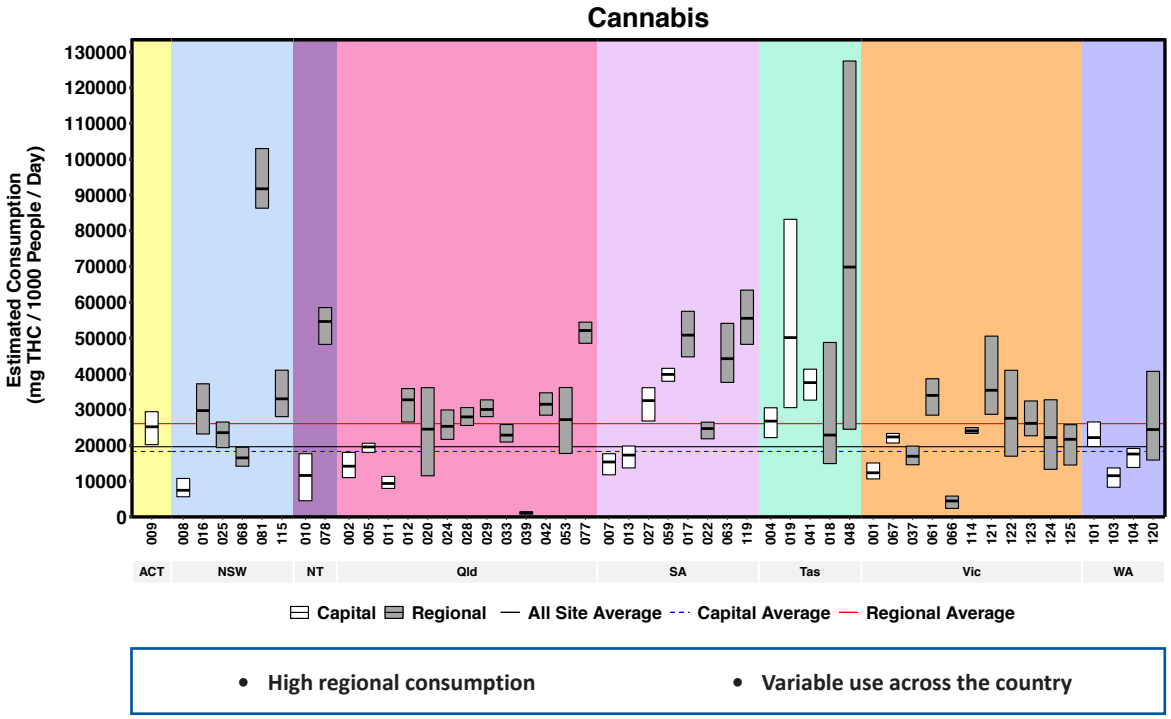
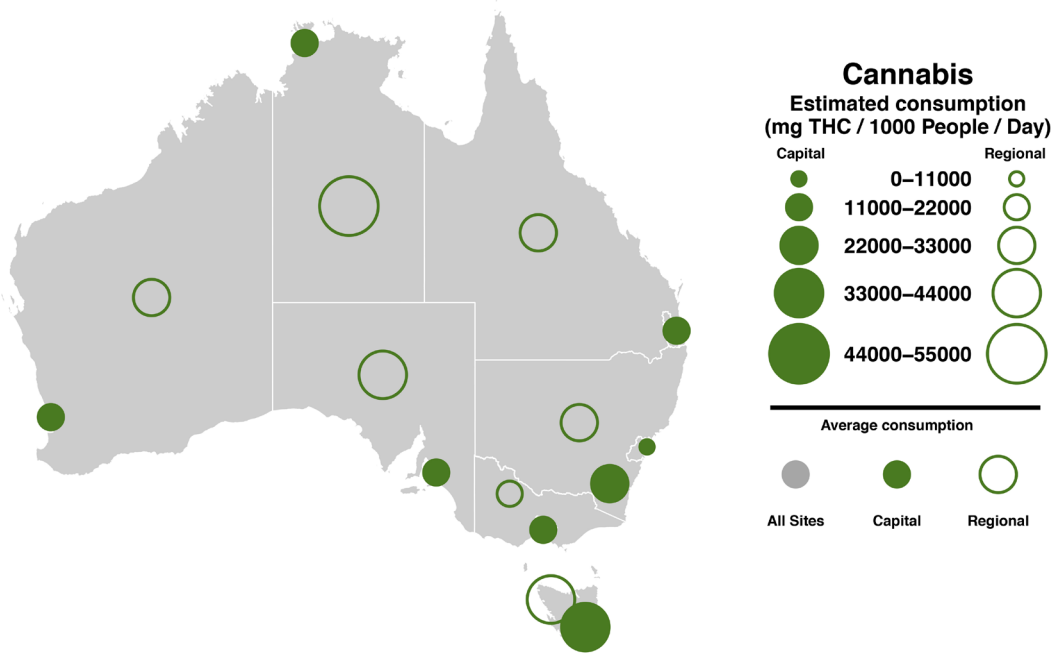


Figure 23: Estimated average cannabis consumption per jurisdiction for December 2019 in mg consumed per day per thousand people. The number of collection days varied from 5-7.



4.1.5 NEW PSYCHOACTIVE SUBSTANCES

Two compounds are included under the NPS class in the NWDMP: methylone and mephedrone. Limited information is available on the human metabolism and excretion of these drugs. Therefore, the parent compound was measured. Due to the low rates of detection for these drugs, results are reported as the number of detections made (Table 2) or the detection frequency (Figure 24). Sites that showed the presence of the two compounds are qualitatively listed in Table 2 for December 2019. The number of mephedrone detections was most frequent in New South Wales, followed by Queensland. A few detections were recorded in South Australia and a single one in Western Australia. For methylone, the majority of detections were observed in Queensland. Western Australia was next with almost a quarter of total detections, spread throughout most participating sites. A small number of cases of methylone were found in other parts of the country, including New South Wales, Victoria, South Australia and the Northern Territory. Only the Australian Capital Territory and Tasmania recorded no mephedrone and methylone detections in December 2019.

The temporal changes in detections per state and territory (proportion of samples above LOD) are shown for mephedrone and methylone in Figure 24a and 24b, respectively, and as bubble plots in Figure 24c. Mephedrone detections have remained relatively low, although the detection frequency has been on the increase in New South Wales and Western Australia. The number of detections of methylone has been variable, but the general trend over time is a decrease in most parts of the country. Detections of the two NPS were less frequent in regional areas.

Table 2: The number and code of sites per state and territory where mephedrone and methylone were detected. The total number of daily samples that were assessed was 361.

	Number of detections Dec 2019		Sites detected Dec 2019	
State /territory	**Mephedrone**	**Methylone**	**Mephedrone**	**Methylone**
ACT	0	0	–	–
NSW	14	3	008, 068	008
NT	0	1	–	010
Qld	6	20	005, 012	002, 005, 011, 012, 024, 029
SA	3	2	007, 059, 063	022
Tas	0	0	–	–
Vic	0	3	–	037, 114
WA	1	10	104	101, 103, 104, 102, 116
Total	**24**	**39**	**8 sites**	**16 sites**

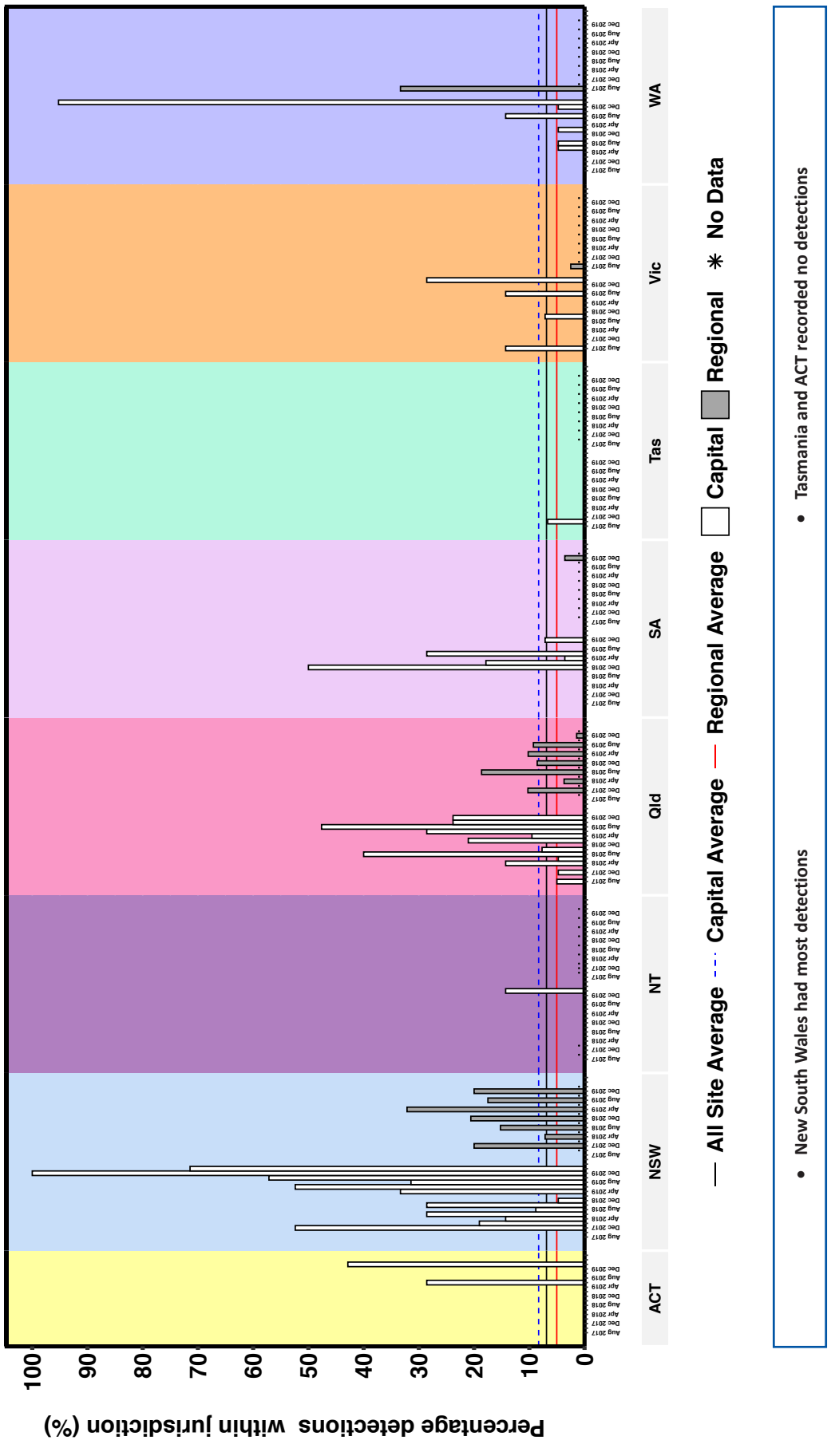


Figure 24a: Estimated percentage positive detections per jurisdiction for mephedrone, August 2017 to February 2020. This is the number of detections as a percentage of the total number of samples analysed per jurisdiction. The number of collection days varied from 5–7.

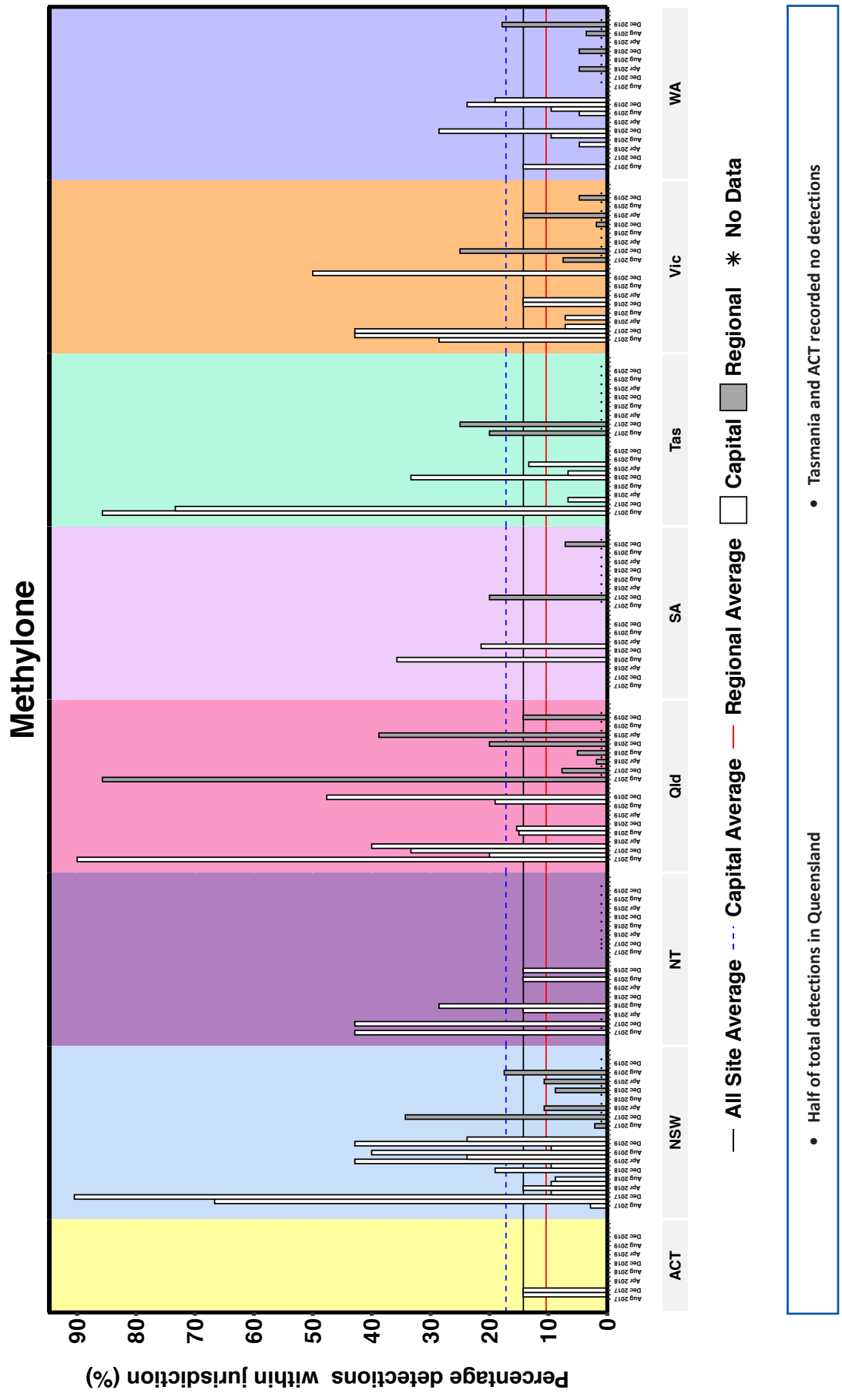
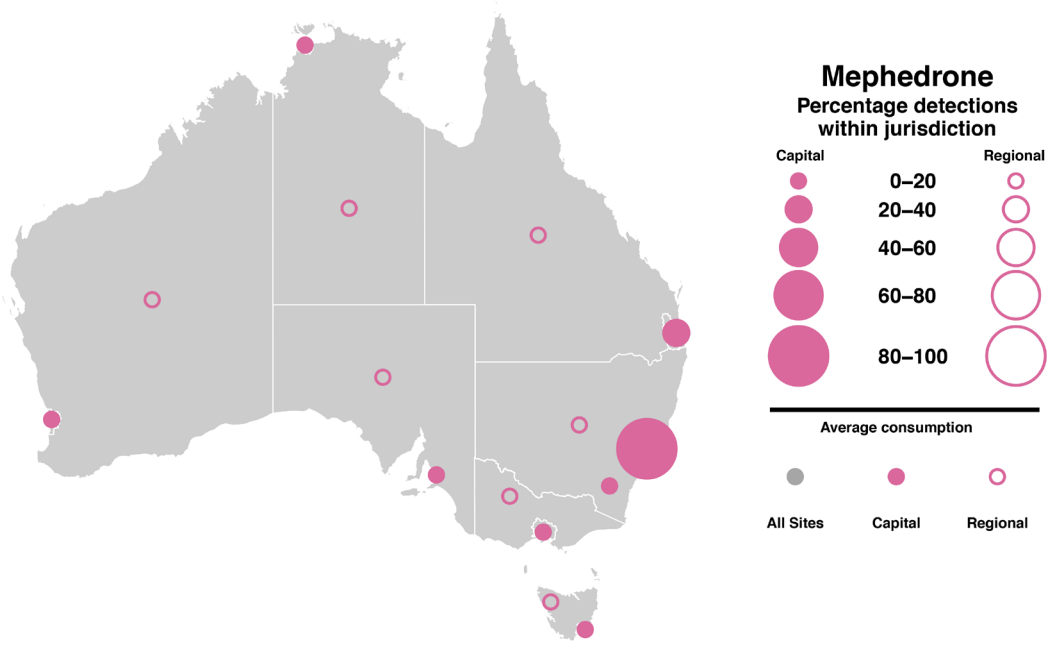
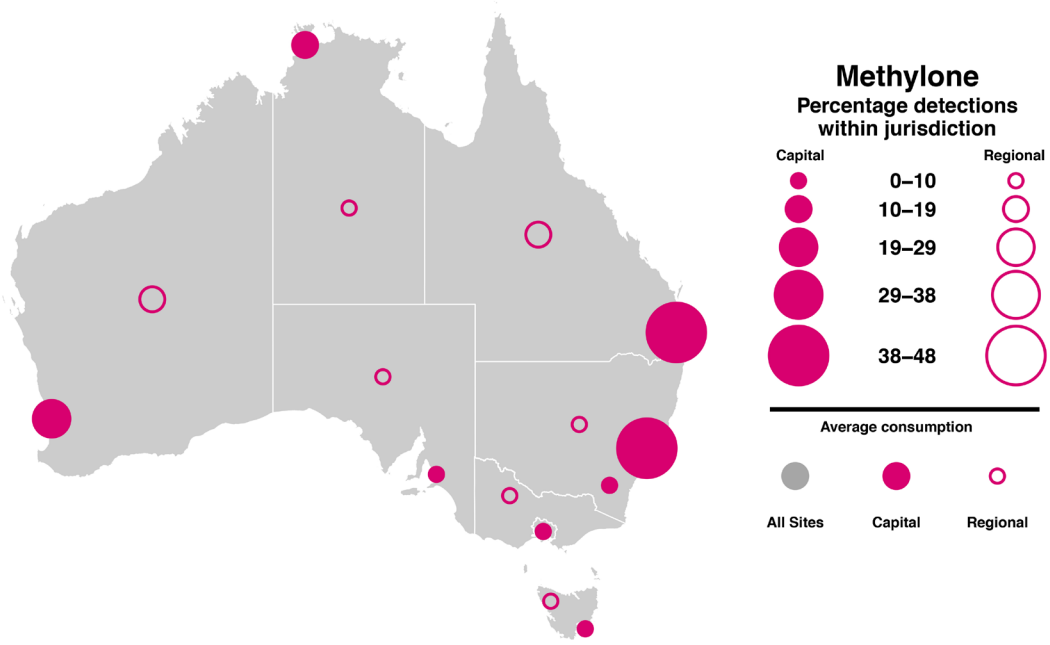


Figure 24b: Estimated percentage positive detections per jurisdiction for methylone, August 2017 to February 2020. This is the number of detections as a percentage of the total number of samples analysed per jurisdiction. The number of collection days varied from 5–7.

Figure 24c: Estimated percentage positive detections per jurisdiction for mephedrone and methylone for December 2019. This is the number of detections as a percentage of the total number of samples analysed per jurisdiction. The number of collection days varied from 5–7.





4.2 TEMPORAL CHANGES IN DRUG CONSUMPTION ESTIMATES BY JURISDICTION

The total level of each drug outlined in the preceding reports per state or territory was compared with subsequent collection periods included in the current report. Although every effort was made to assess the same sites for each period, the individual sites and the number of sites used to generate the population-weighted averages may have changed between periods. Comparing between time points should be done with caution. This would be most evident for the regional averages, which had more variation in participation between each period (see Appendix 2 and Appendix 3, Report 6 and Appendix 2 in this report).

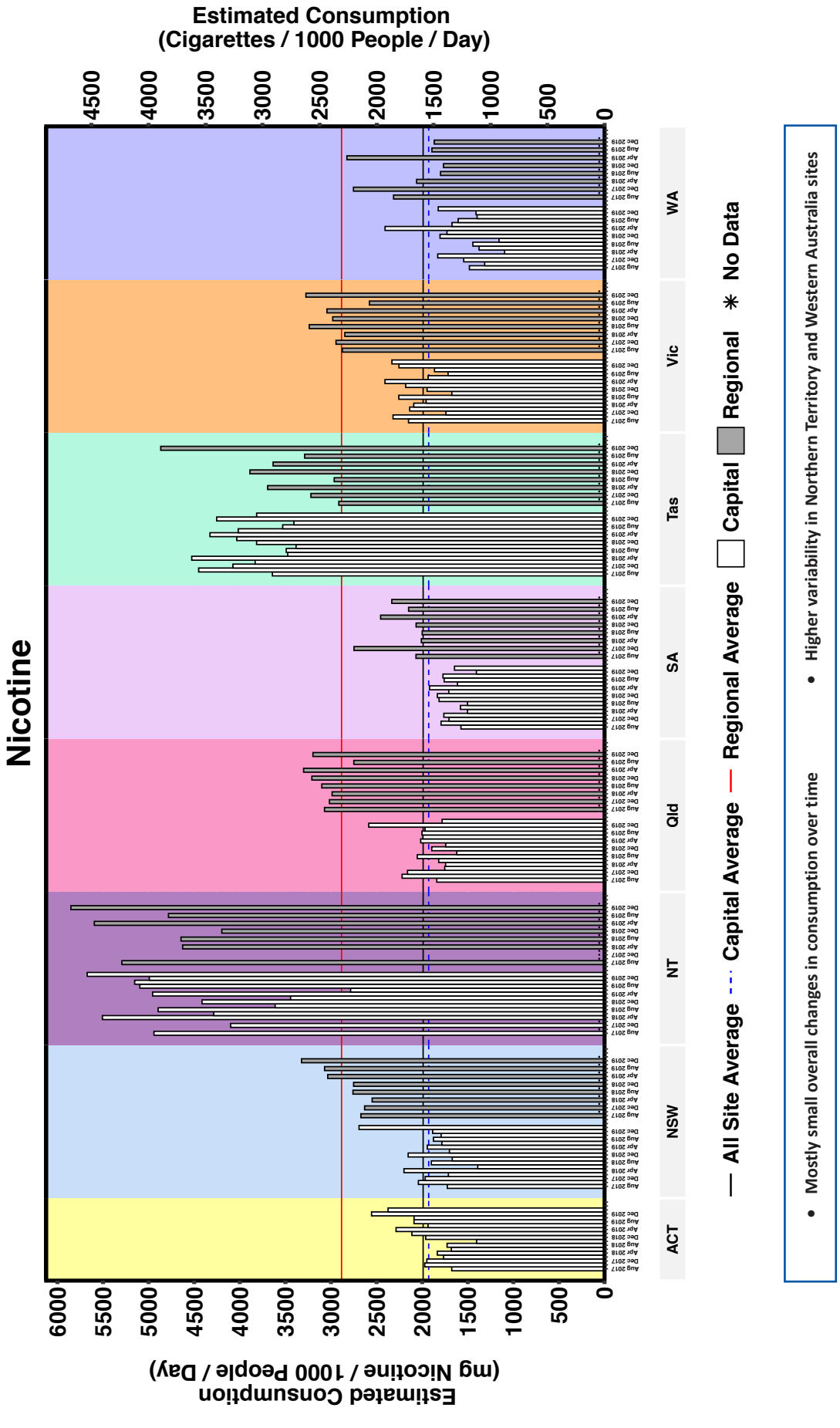
Note: the horizontal red, blue and black lines on each temporal graph which represent the averages are the cumulative average across all sampling time points and all samples analysed.

4.2.1 NICOTINE AND ALCOHOL

Nicotine consumption remained largely steady in most parts of the country, with some variability (Figure 25). Use in the capital city area of the Australian Capital Territory and regional New South Wales has increased, but no apparent long-term pattern was obvious elsewhere. The current sampling periods of October and December 2019 in regional Australia and up to February 2020 in capital city areas were not substantially different from the previous sampling periods in February and April. The cumulative regional average nicotine consumption (red line) remains well above capital city levels (blue dashed line).

The difference in the cumulative average consumption of alcohol in regional areas compared to the cities was less pronounced than nicotine, but consumption was also higher outside the capital cities. South Australia continued to be the only state where regional alcohol use was much lower than in the capital city (Figure 26). Consumption in this state, as well as Western Australia, appeared to be declining over the past two years. The regional centres in a number of states and territories showed an increase over the course of 2019. No clear trends were evident elsewhere in the country. The Northern Territory tended to have the highest overall use of alcohol since the start of the program, followed by Tasmania.

Figure 25: Estimated average consumption of nicotine by state/territory, August 2017 to February 2020, where 1 cigarette provides 1.25 mg of nicotine.[5]



5 Nicotine consumption data have been adjusted to refine the factor used to convert consumed mass load to dose. Overall trends in nicotine consumption remain unchanged.

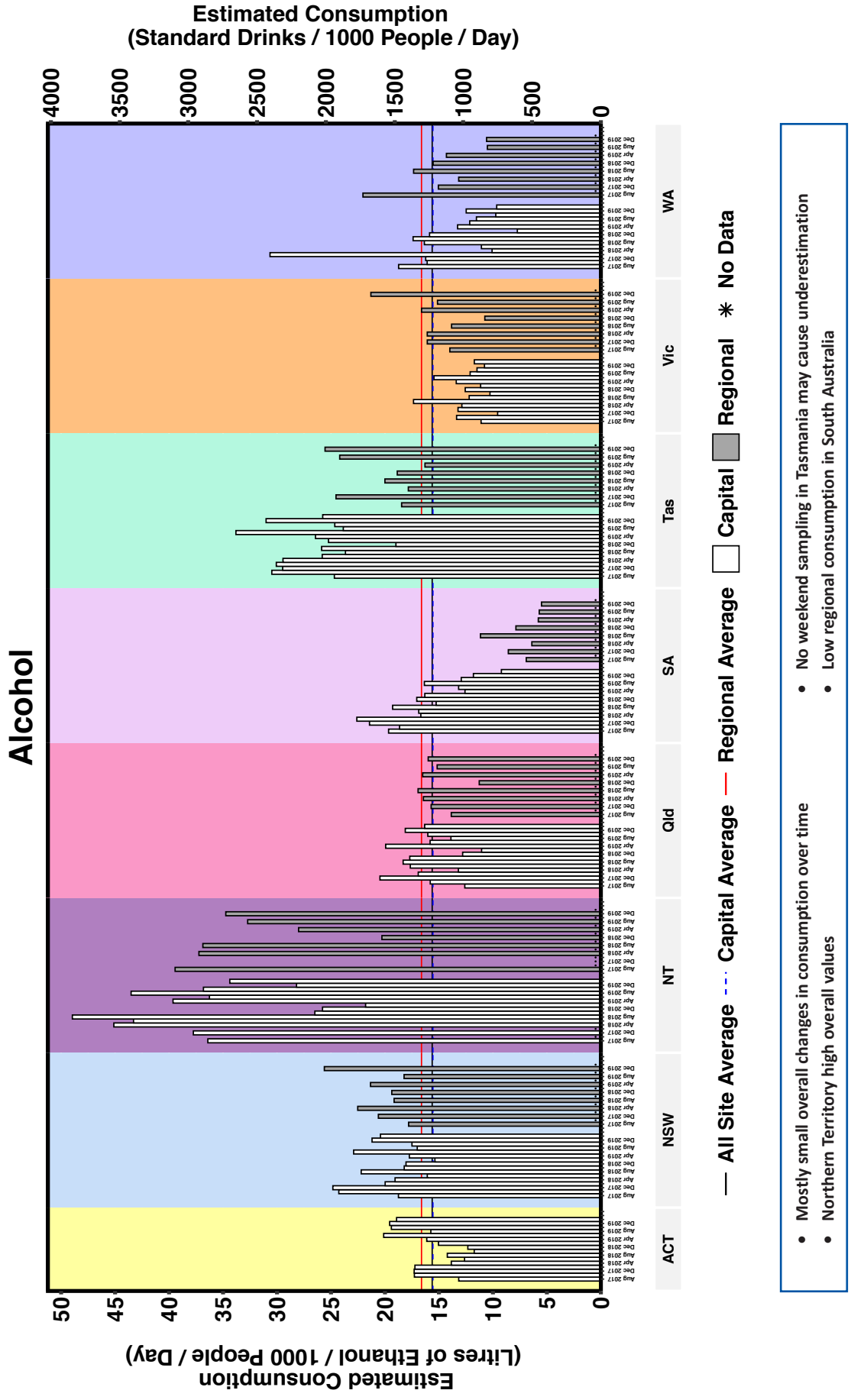


Figure 26: Estimated average consumption of alcohol by state/territory, August 2017 to February 2020. A standard drink is 10.0 g or 12.6 mL.

4.2.2 STIMULANTS

With the exception of capital city South Australia and regional Western Australia, a consistent overall upward trend in the use of methylamphetamine is evident over the total period of the program (Figure 27). Capital city South Australia is characterised by peaks and troughs in use over time, though the collections included in this report all show a progressive increase. Current use in some capital cities has levelled off to a certain extent, or even declined, such as in Victoria and the Northern Territory. Regional use in the Northern Territory and South Australia continue to be below city averages, in contrast to the national trend. Tasmania's regional use caught up with city levels in the current sampling period.

Long-term changes in use of methylamphetamine are also apparent in Queensland, South Australia and Western Australia, where data are available back to before the start of the NWDMP (Figure 28). The decline in South Australia since mid-2018 has been the longest continuous period over which the drug's use has been maintained at a lower level, following an approximate fourfold increase between 2009 and 2016. The historical increase in South Australia was also apparent between 2009 and 2016 in sites in regional Queensland, with up to fivefold increases in the methylamphetamine consumption rate being observed. In Victoria and Western Australia, the longer-term trends have been more variable and any increases of a relatively low magnitude.

Cocaine use shows an overall increasing trend in many jurisdictions since the inception of the program in 2016 (Figure 29). Consumption of the drug in some states and territories, for example the Northern Territory and Tasmania, tends to be variable, with no clear patterns emerging. Capital city New South Wales has consistently had the highest consumption in the nation. The trend continued in the current collection period, reaching historical high levels in the state in December 2019. In contrast, Tasmania and Western Australia capital city areas have relatively low consumption rates of cocaine. Average use across regional centres remains low, particularly in the Northern Territory, Tasmania and Western Australia.

MDMA use across Australia remained low overall, compared to methylamphetamine (Figure 30). Levels of the drug have been increasing in almost all jurisdictions since early to mid-2018. This was the case in both capital city and regional areas of most states and territories. The per capita drug use in capital city Northern Territory remained high compared to most other parts of the country, except for New South Wales where there was a recent spike in use.

MDA use, corrected for the proportion derived from MDMA (Khan & Nicell 2011), had relatively similar use between capital cities across the country, with slightly higher consumption in the Northern Territory and Tasmanian sites in 2018 (Figure 31). Apart from New South Wales, Queensland and Victoria, regional use tended to be lower than the cities. The national regional average was skewed somewhat by the high MDA levels detected at Site 012 in Queensland in August 2017 and December 2019. No long-term trends were apparent, though the prevalence of the drug has decreased in the Northern Territory and Tasmania over the past year.

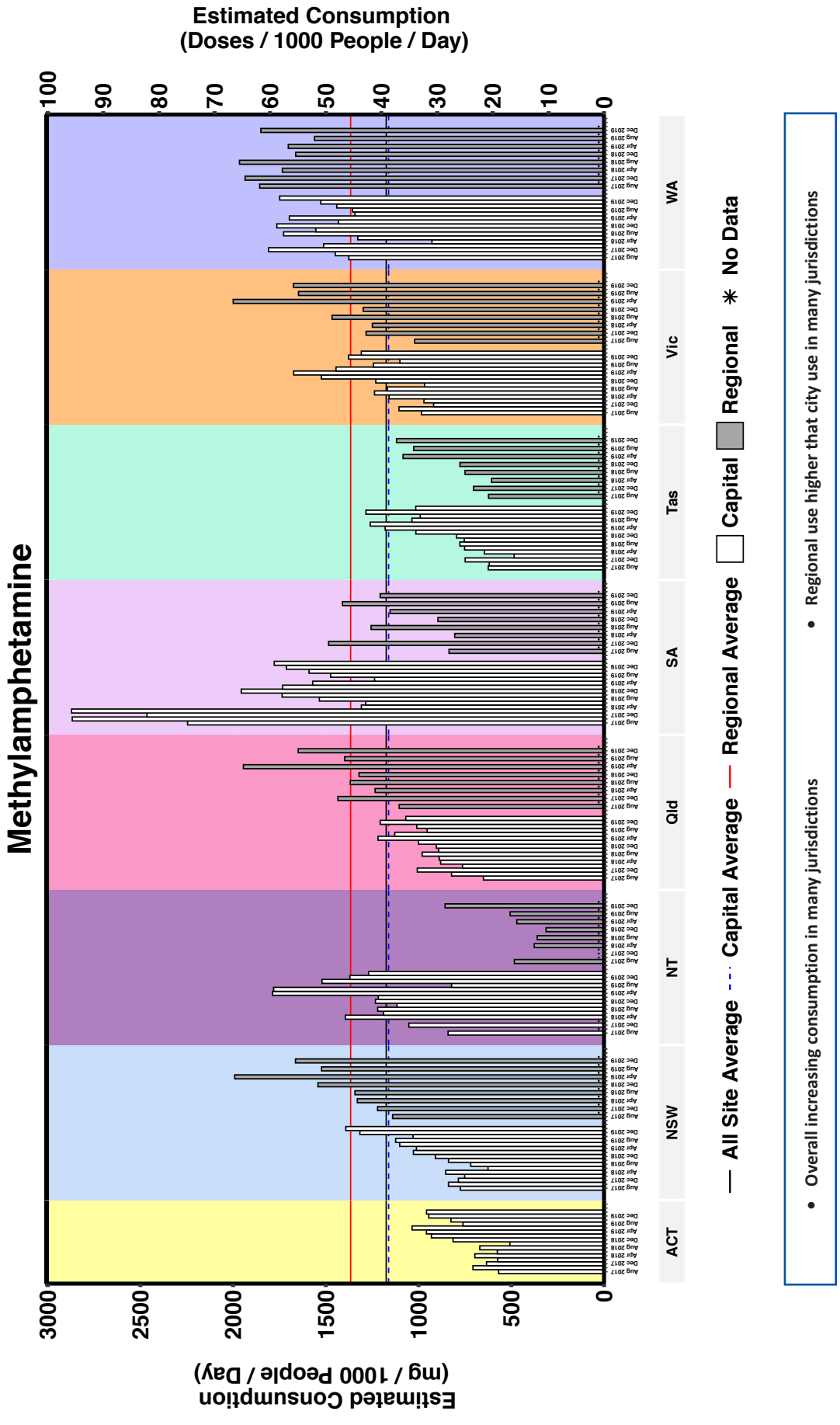


Figure 27: Estimated average consumption of methylamphetamine by state/territory, August 2017 to February 2020.

Figure 28: Change in methylamphetamine consumption for sites with historical data.

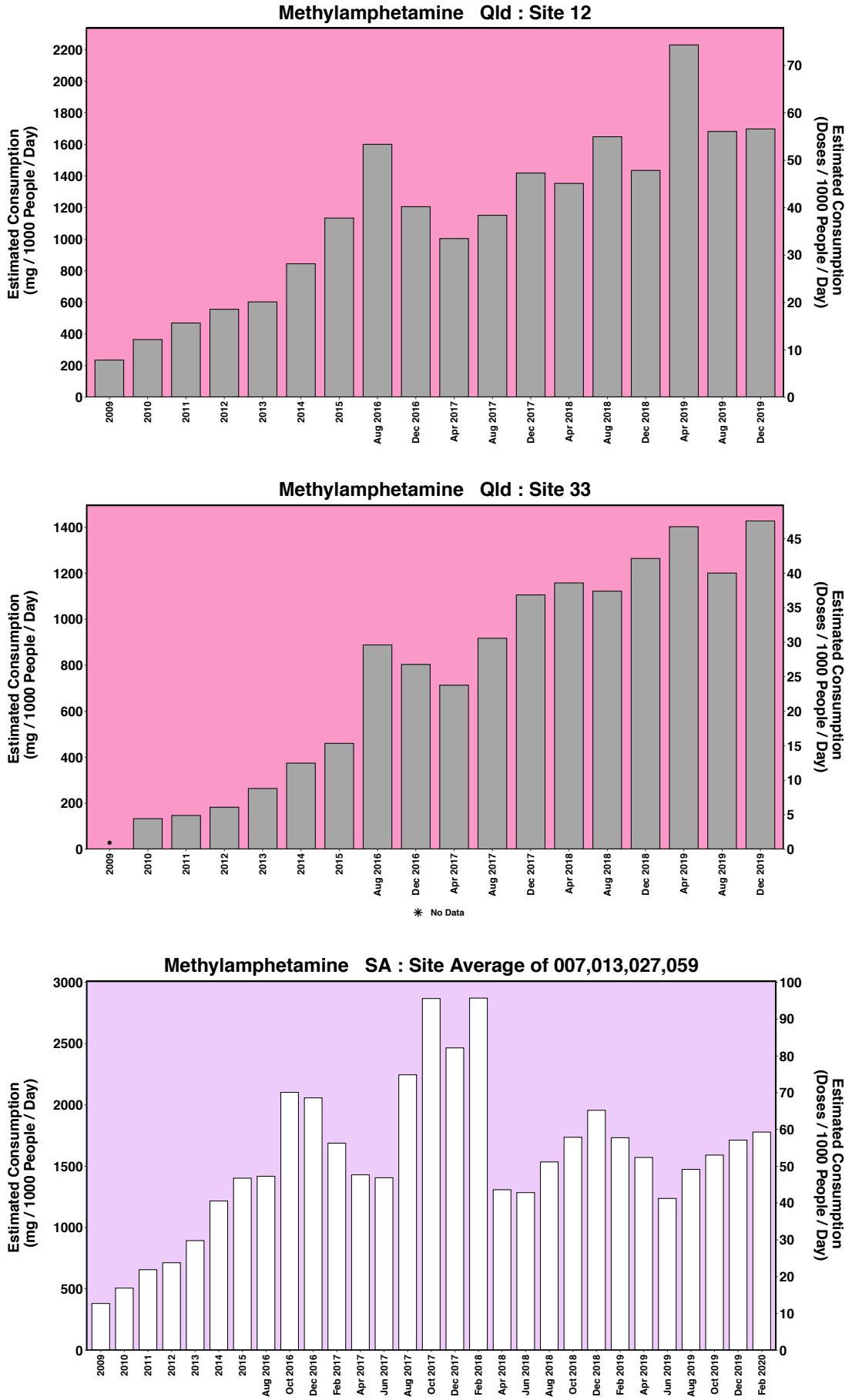
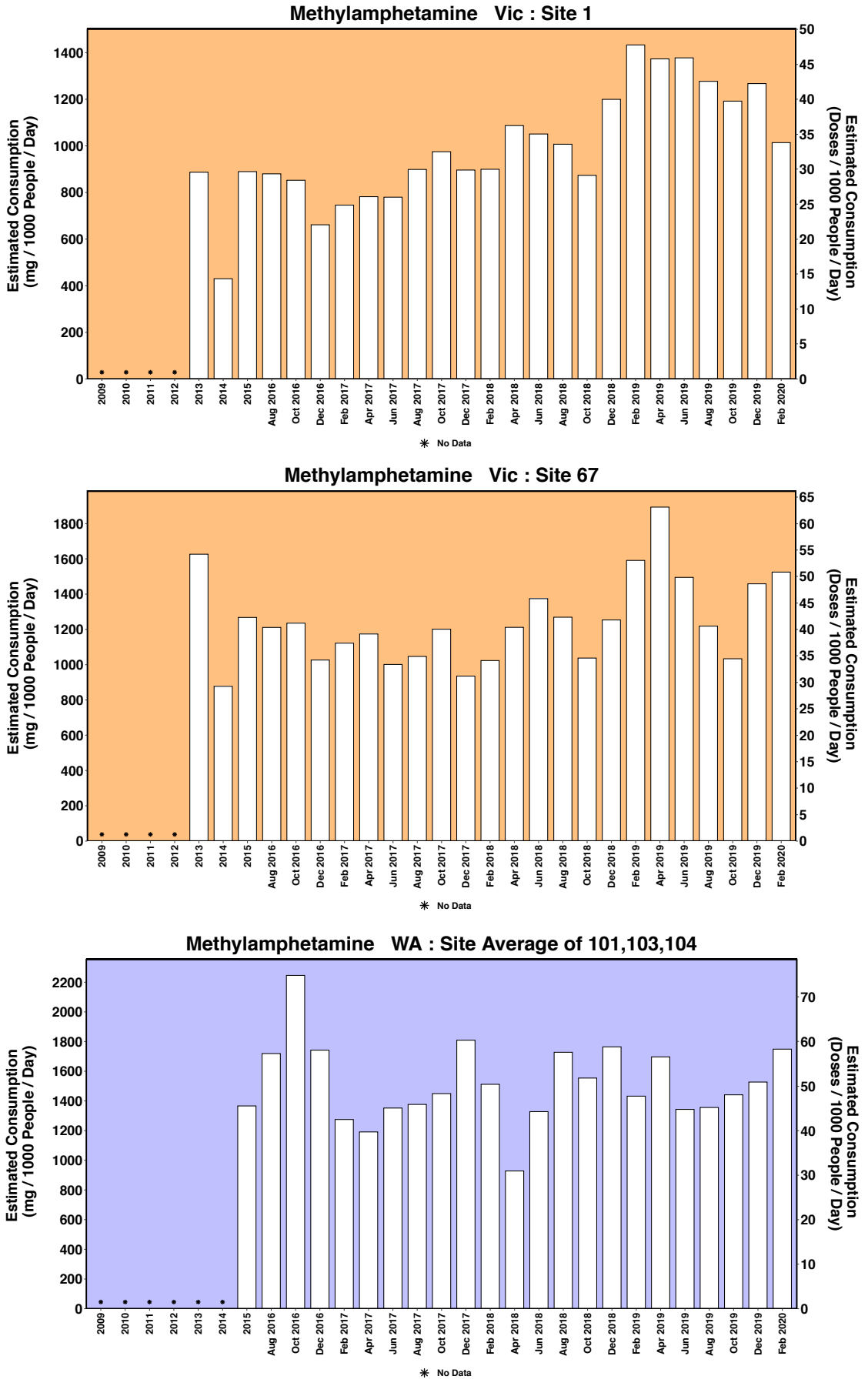


Figure 28 (continued): Change in methylamphetamine consumption for sites with historical data. Both Victorian sites were the average of one week per year in 2013, 2014 and 2015.



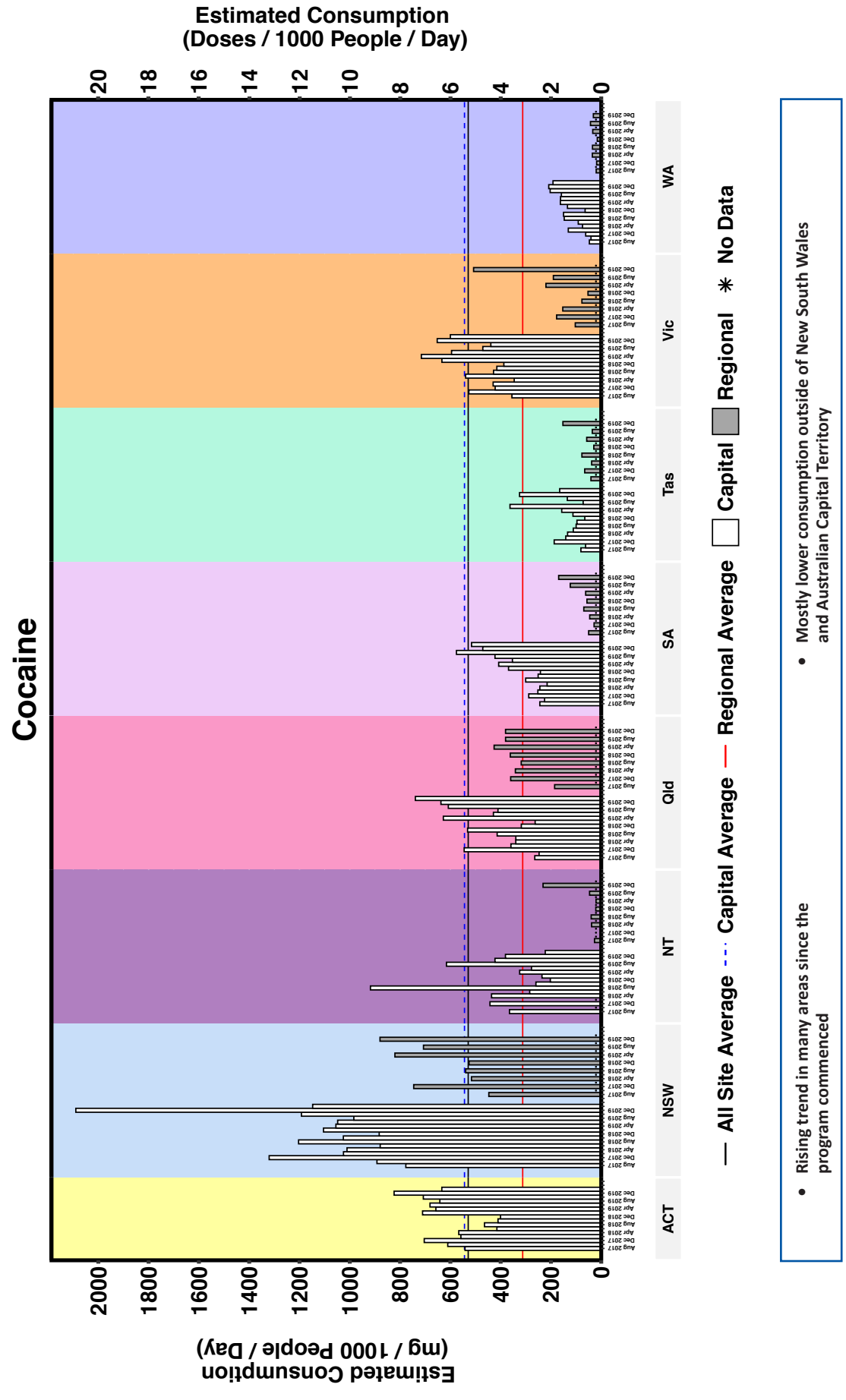


Figure 29: Estimated average consumption of cocaine by state/territory, August 2017 to February 2020.

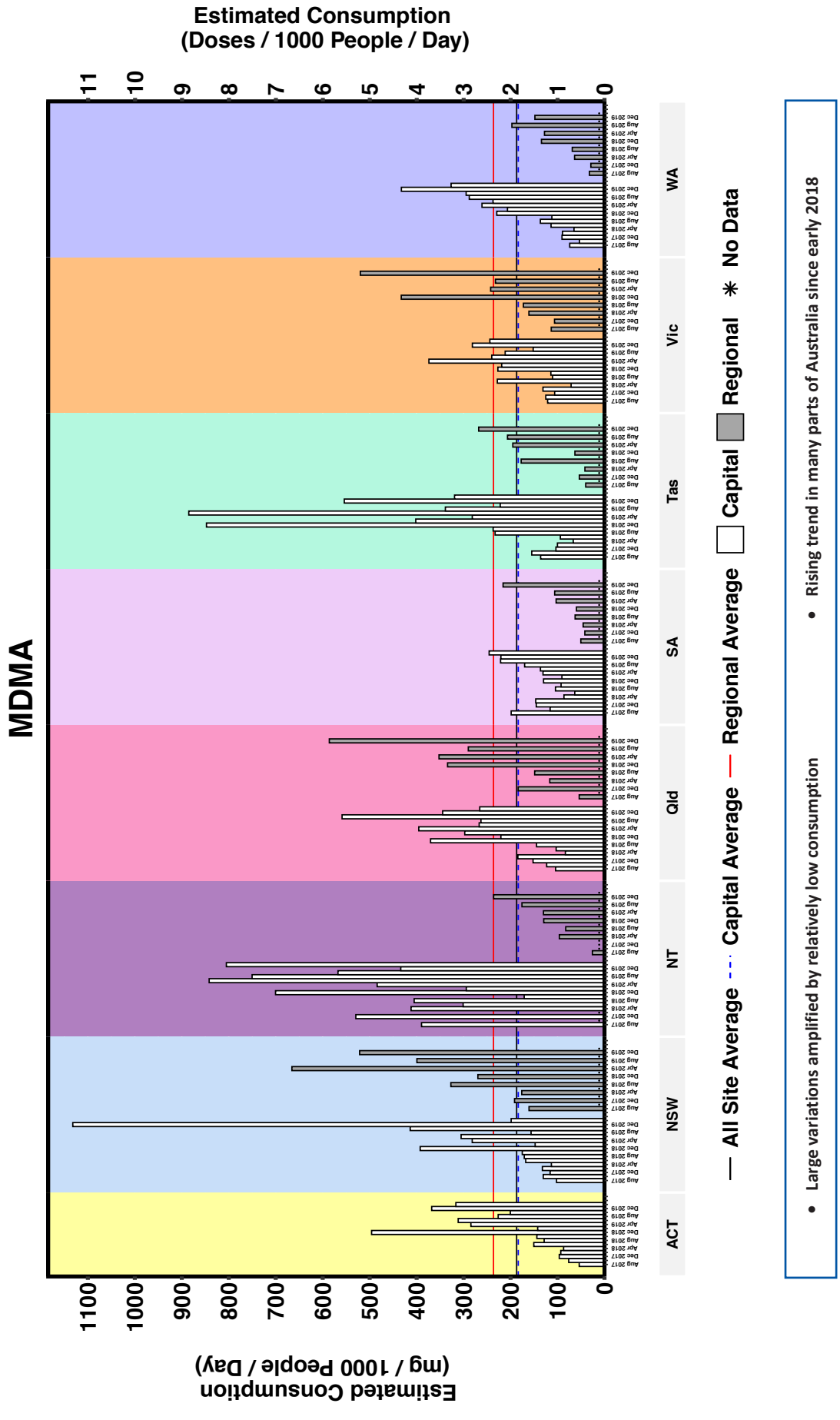


Figure 30: Estimated average consumption of MDMA by state/territory, August 2017 to February 2020.

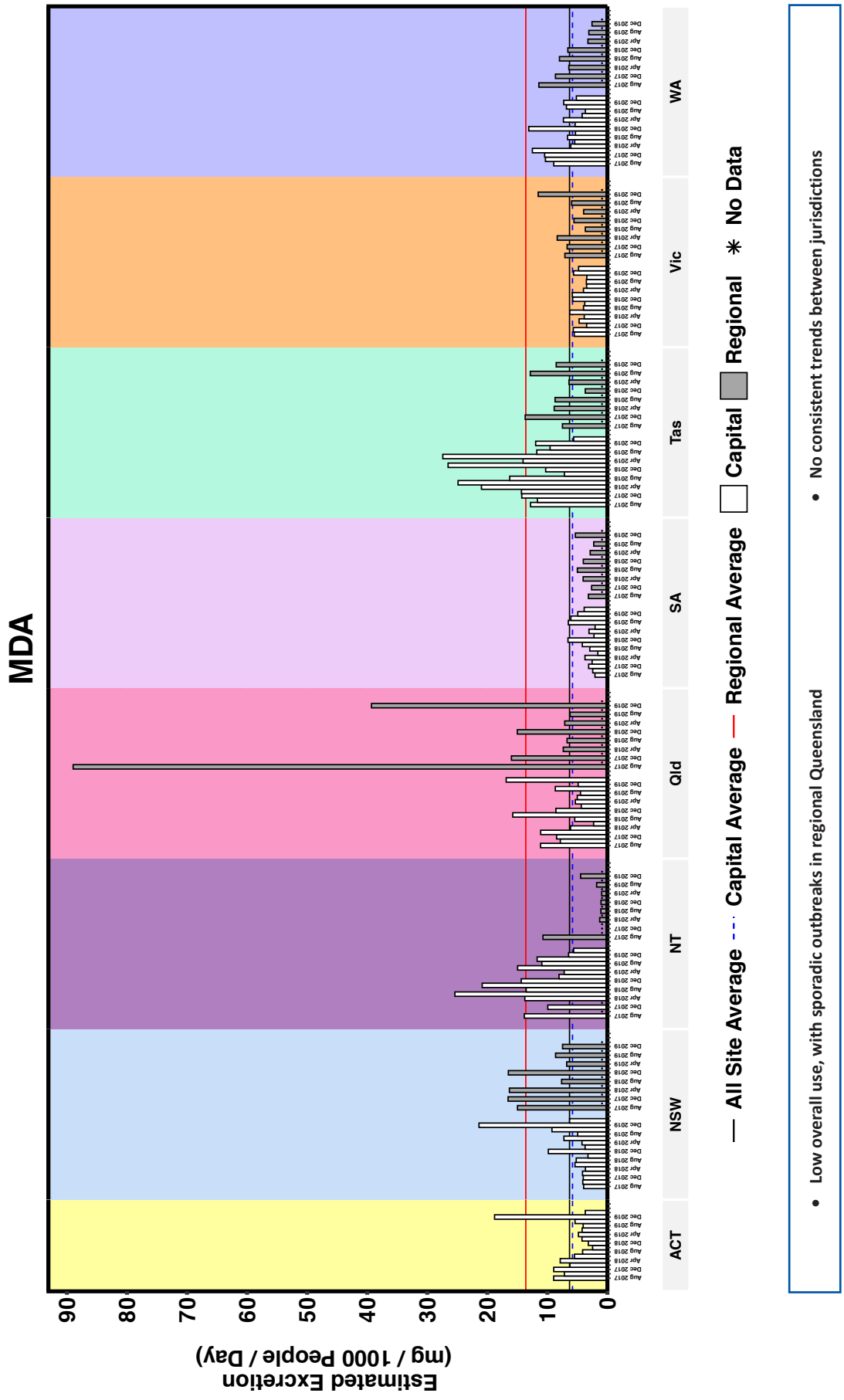


Figure 31: Estimated average excretion of MDA by state/territory, August 2017 to February 2020.

4.2.3 OPIOIDS

The use of oxycodone initially trended upwards in many parts of the country, with Tasmania and regional Victoria amongst the highest consumers. However, clear evidence is emerging that use of the drug has been declining since the historical highs (Figure 32). The same pattern is being observed in many parts of regional Australia. Nevertheless, a feature of oxycodone use in Australia is the very high regional levels compared to the capital cities. Western Australia has amongst the lowest users of oxycodone on a population basis.

Fentanyl use in regional Australia has also been high in comparison to capital cities (Figure 33). Like oxycodone, the upward trend in some states and territories has been arrested since middle to late 2018. The reversal in consumption of fentanyl was consistent across all parts of the country, except for parts of the Northern Territory. The apparent peak in fentanyl consumption was evident between mid to late 2017 and late 2018 in most jurisdictions.

In contrast to the pharmaceutical opioids, heroin use in Australia occurs largely in the capital cities, especially Victoria, New South Wales and the Australian Capital Territory (Figure 34). Use in the Australian Capital Territory, New South Wales, Queensland, South Australia, and Western Australia has been on the increase since the end of 2018. Capital city Victoria has the highest overall consumption of heroin. Tasmania, the Northern Territory and regional parts of Queensland and South Australia were amongst the lowest users. Heroin consumption has been measured in capital city South Australia since 2013 (Figure 35). The declining levels of heroin consumption in South Australia have been part of a long-term trend, reaching the lowest levels in February 2019. Since then, heroin use in South Australia has increased again to levels last observed in 2017.

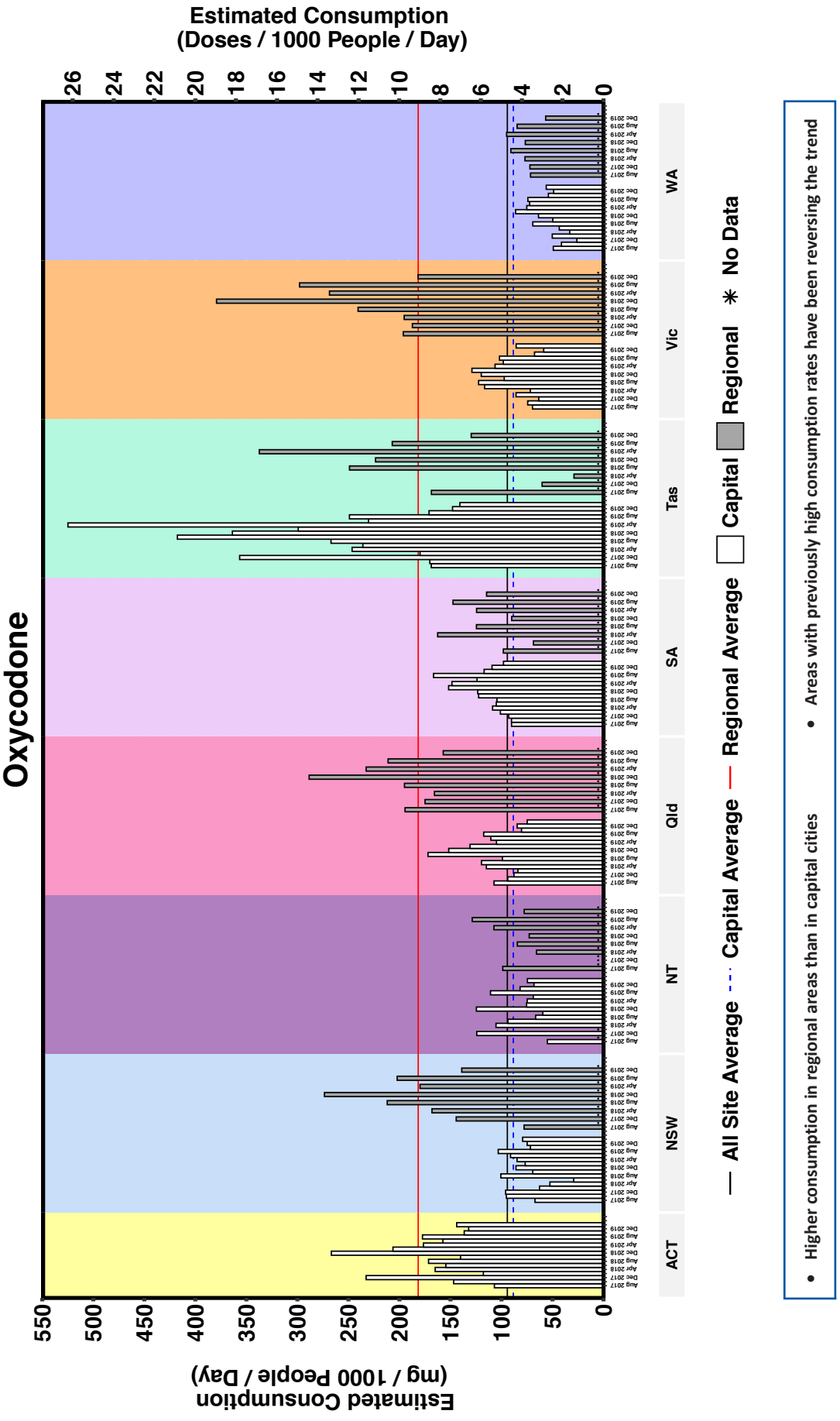


Figure 32: Estimated average consumption of oxycodone by state/territory, August 2017 to February 2020.

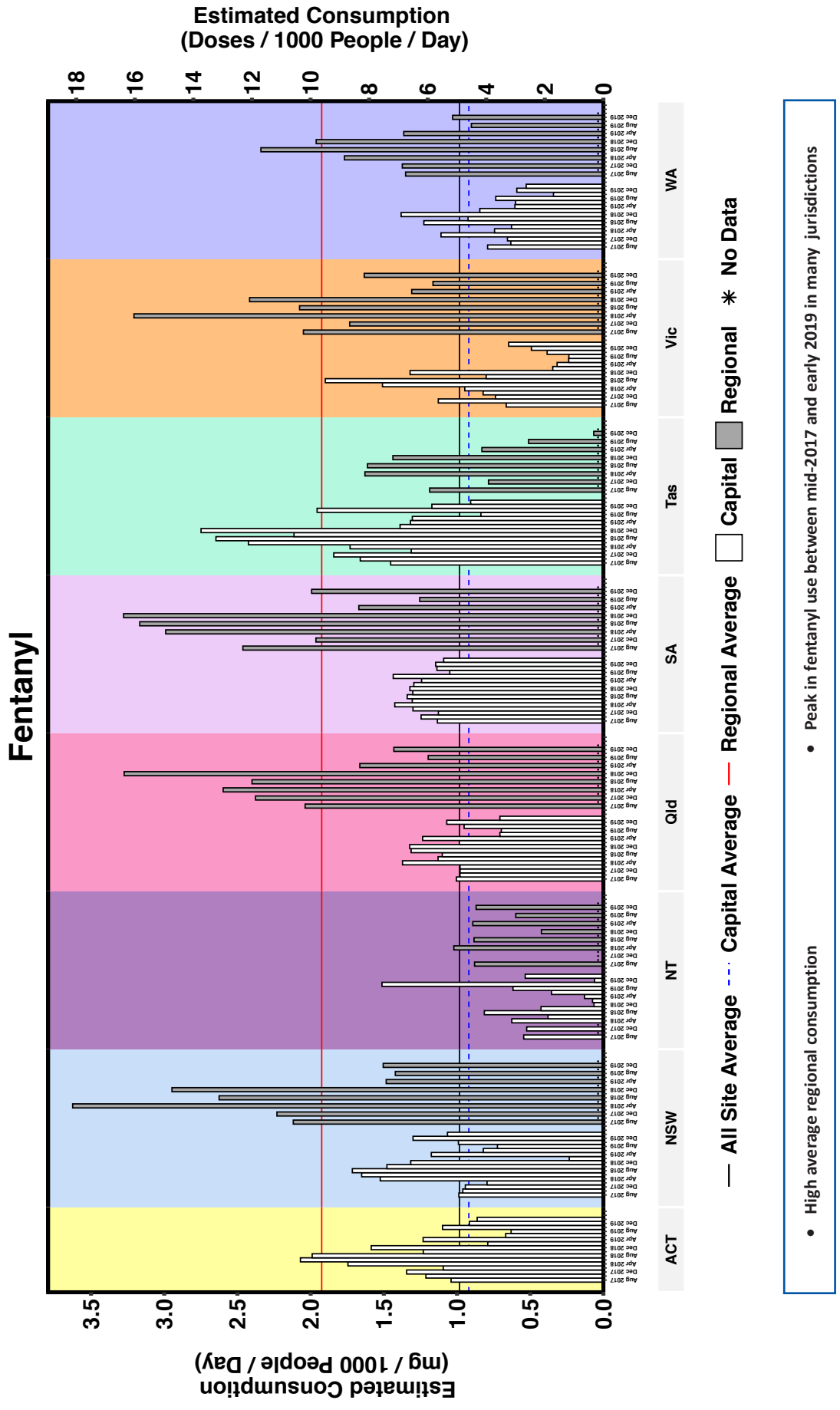


Figure 33: Estimated average consumption of fentanyl by state/territory, August 2017 to February 2020.

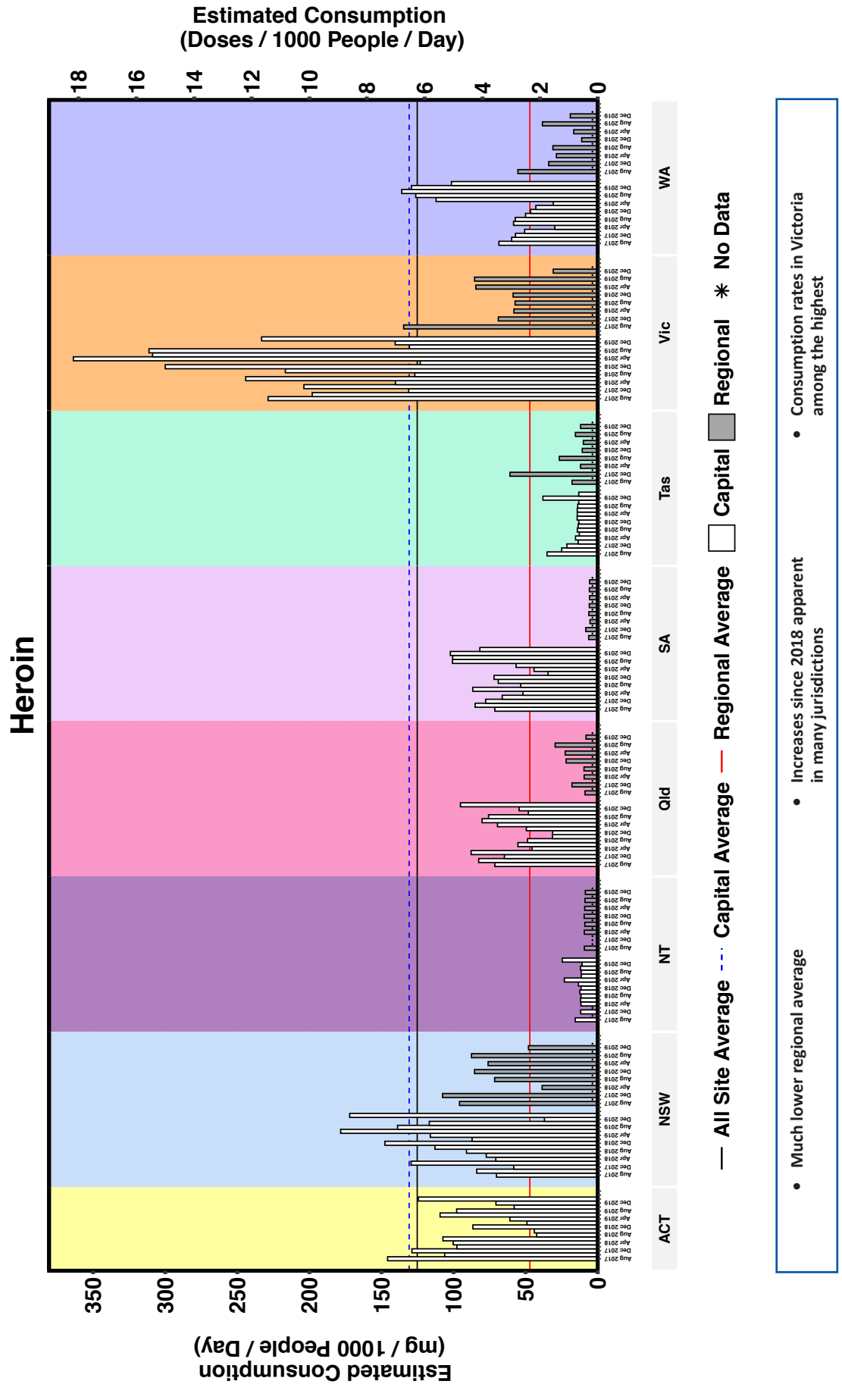
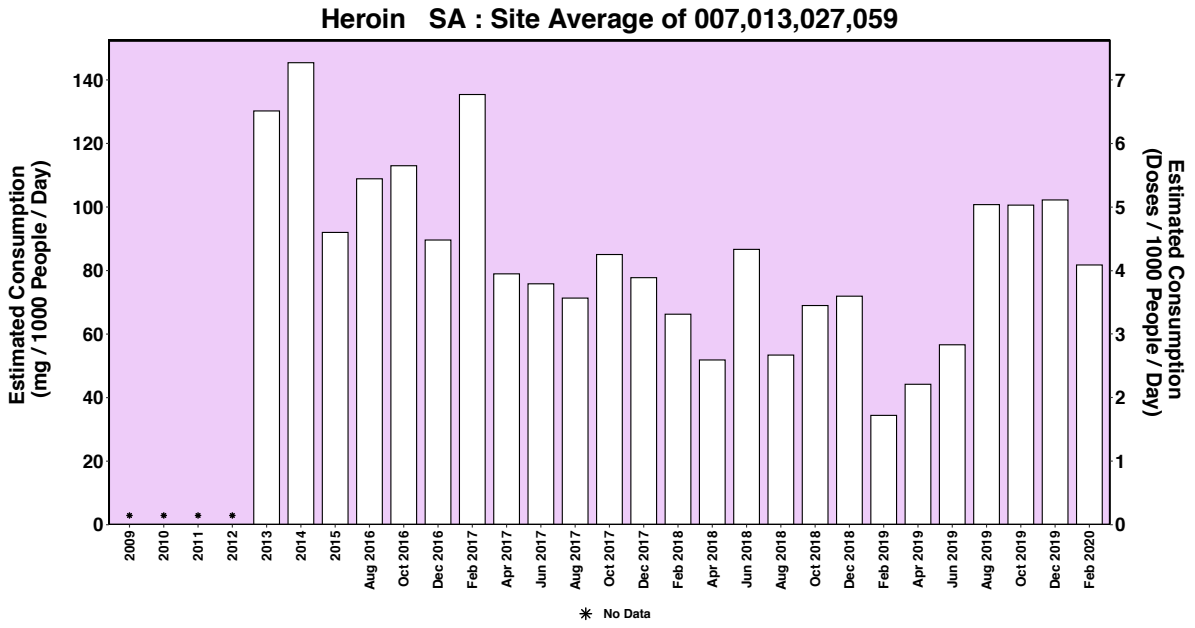


Figure 34: Estimated average consumption of heroin by state/territory, August 2017 to February 2020.

Figure 35: Change in heroin consumption for South Australia.



4.2.4 CANNABIS

Cannabis was first included in the program in August 2018. Since that time, trends appear to be region-specific and no common pattern is evident. The Australian Capital Territory, New South Wales and Victoria had relatively stable levels, with some short-term fluctuations (Figure 36). Capital city Queensland and Western Australia showed decreases, while South Australia had a peak in early 2019. Further trends may become apparent with a longer time series, as has become evident with other substances recorded in the program. Regional consumption was higher than capital city levels, with the highest consumption spread over several states and territories, in particular the Northern Territory, Tasmania and regional South Australia. Use in sites of the larger population centres of New South Wales, Victoria and Queensland was much lower. Consumption in these capital cities was less than half that in the regional areas within the jurisdiction.

Consumption of cannabis has previously been measured in capital city South Australia since 2011. Use of the substance has seen small but steady increases over the course of the program, particularly from April 2017 to the highest consumption rate in April 2019 (Figure 38). Consumption rates have declined since then and returned to levels observed in 2017.

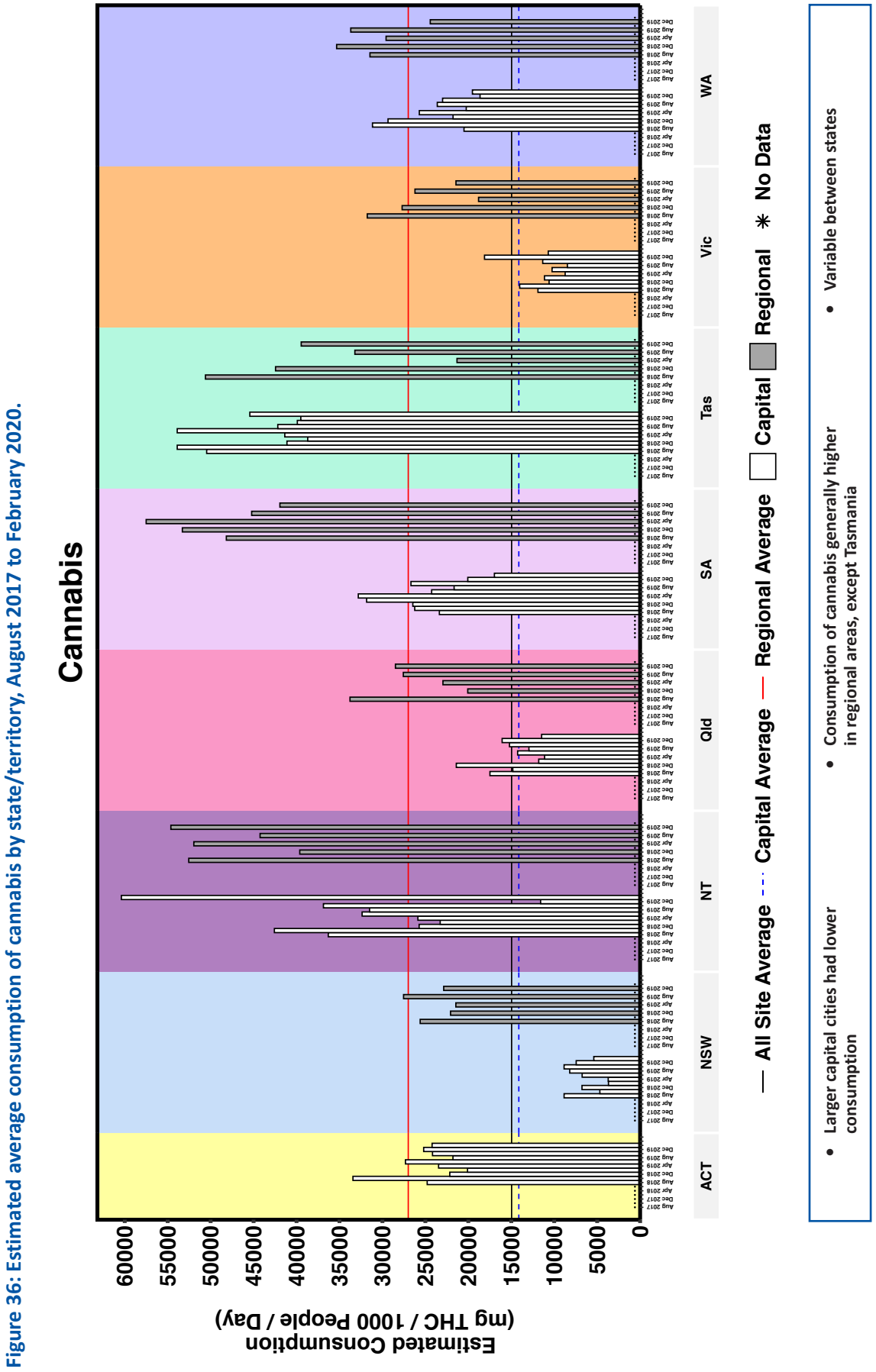
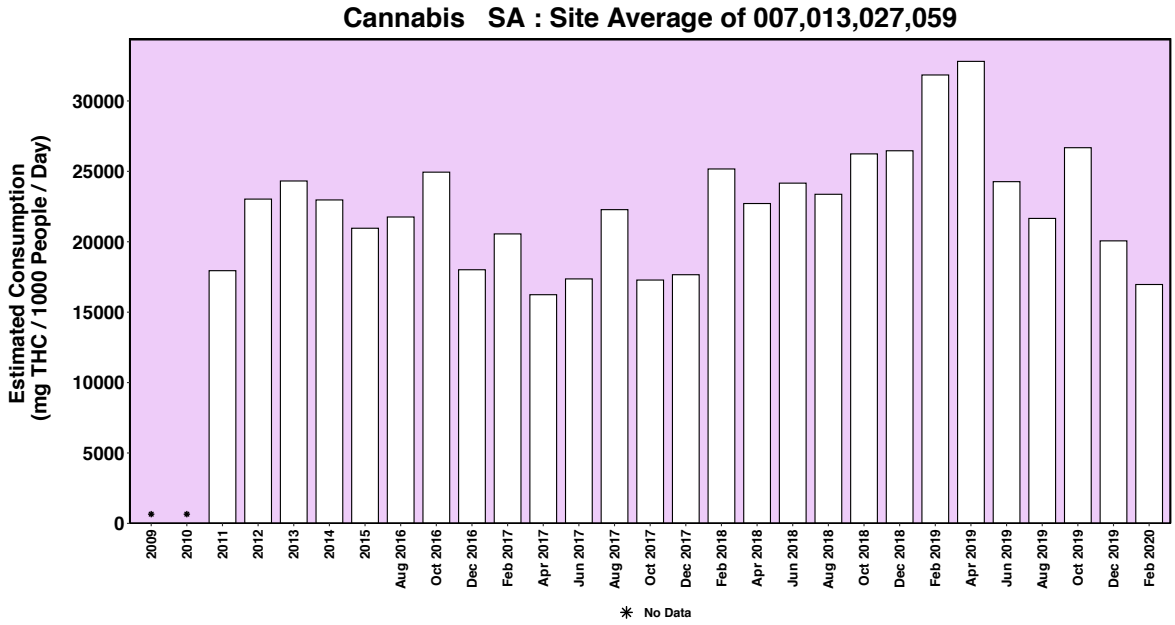


Figure 36: Estimated average consumption of cannabis by state/territory, August 2017 to February 2020.

Figure 37: Change in cannabis consumption in capital city South Australia. Cannabis is detected via the THC metabolite THC-COOH.



4.2.5 NEW PSYCHOACTIVE SUBSTANCES (NPS)

Methylone and mephedrone were only detected sporadically and at very low levels compared to other substances included in the report (December 2019 mephedrone and methylone results are shown in Table 2).

4.2.6 CAPITAL CITY AND REGIONAL AVERAGES

In order to show the national trends in the use of individual substances, all capital city and regional sites were combined and displayed as separate graphs for the total sampling period (Figure 38).

Methylamphetamine consumption rates declined from October 2016 to June 2017, followed by increases from mid to late 2017, particularly in regional areas. Since then the trend has fluctuated, with small rises and troughs apparent in both capital city and regional areas. Current use of methylamphetamine at the national level fits a long-term upward trend, starting in mid-2017.

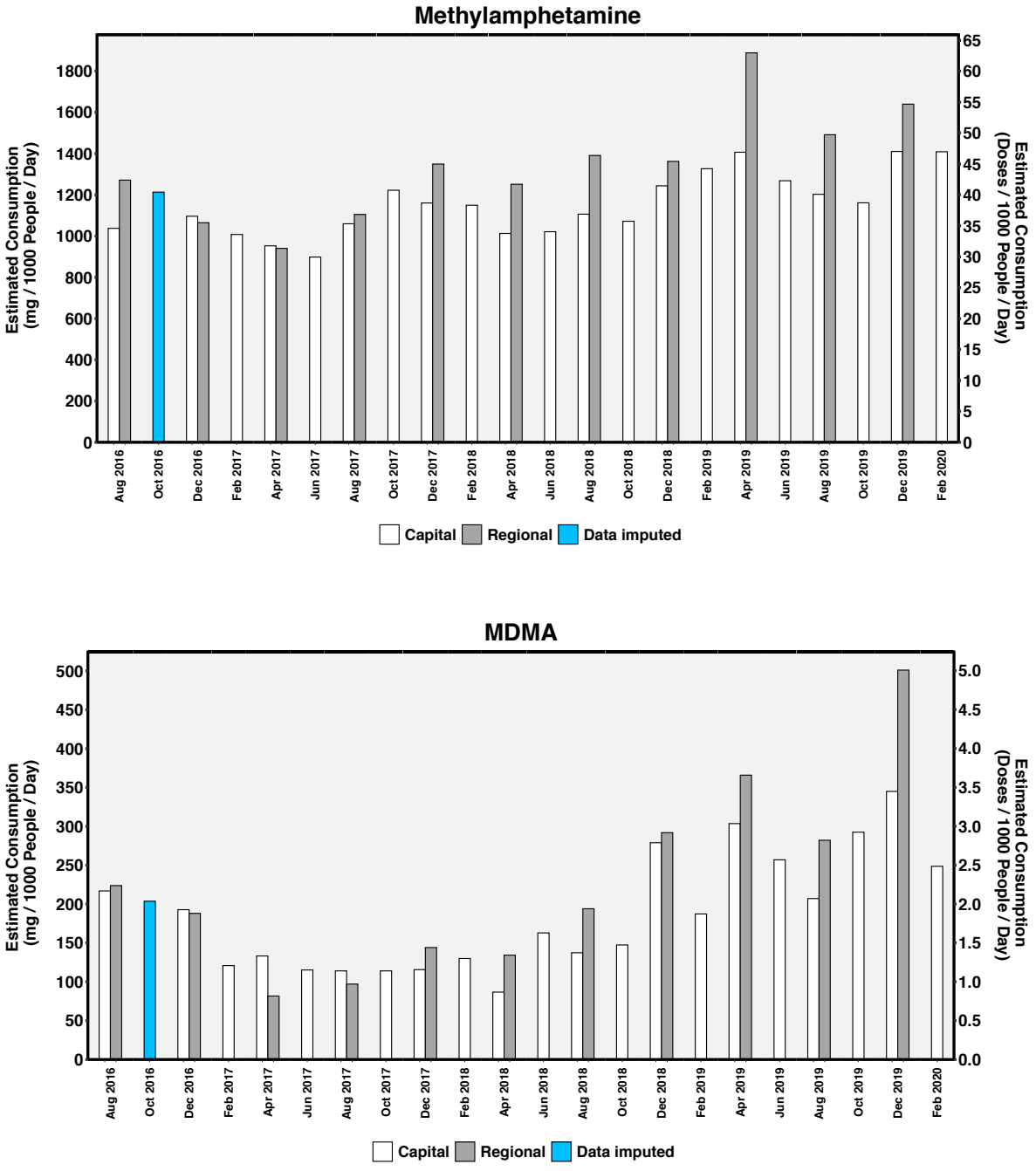
MDMA consumption rates declined overall over the first year of the program but have since increased gradually with some month-to-month variation observed over the course of 2018 and 2019. The initial rate of decline was more pronounced in regional areas (August 2016 to April 2017). From mid-2018 to the present, use of MDMA has increased in regional parts of Australia, reaching its highest levels since the commencement of the program during the current reporting period. In comparison, capital city levels have remained relatively steady over the past year.

Cocaine and heroin consumption showed some short-term variations, both in terms of capital city and regional levels. However, the long-term trends over the entire program show that cocaine consumption is increasing, with national rates at their highest points since the beginning of the program for both regional and capital city averages. The gap between city and regional use also appears to be decreasing. Heroin consumption in the capital cities is more variable. The overall trend appears to be essentially flat, considering the low number of doses per capita. Heroin consumption in regional areas remains low. A slight decrease occurred in the current reporting period.

In terms of legal substances with abuse potential, alcohol and nicotine consumption remained largely unchanged from the start of the program, with only small fluctuations evident (Figure 39). Results from this reporting period have been in line with previous findings, both in terms of regional and capital city areas. Nicotine consumption remained substantially higher in regional areas compared to the capital city average. In the case of alcohol, the averages have drifted apart somewhat in favour of regional centres in the current set of results. A distinct difference between capital cities and regional Australia was observed for the two pharmaceutical opioids monitored in the program. Capital city populations consumed both drugs at substantially lower levels compared to regional areas. Fentanyl use showed a peak in consumption from late 2017 to early 2019, stabilising to the lowest consumption rates observed during the program. Oxycodone consumption in regional areas increased steadily after early 2017 and reached a peak in December 2018, declining since then. In contrast, average capital city use of oxycodone has remained relatively stable.

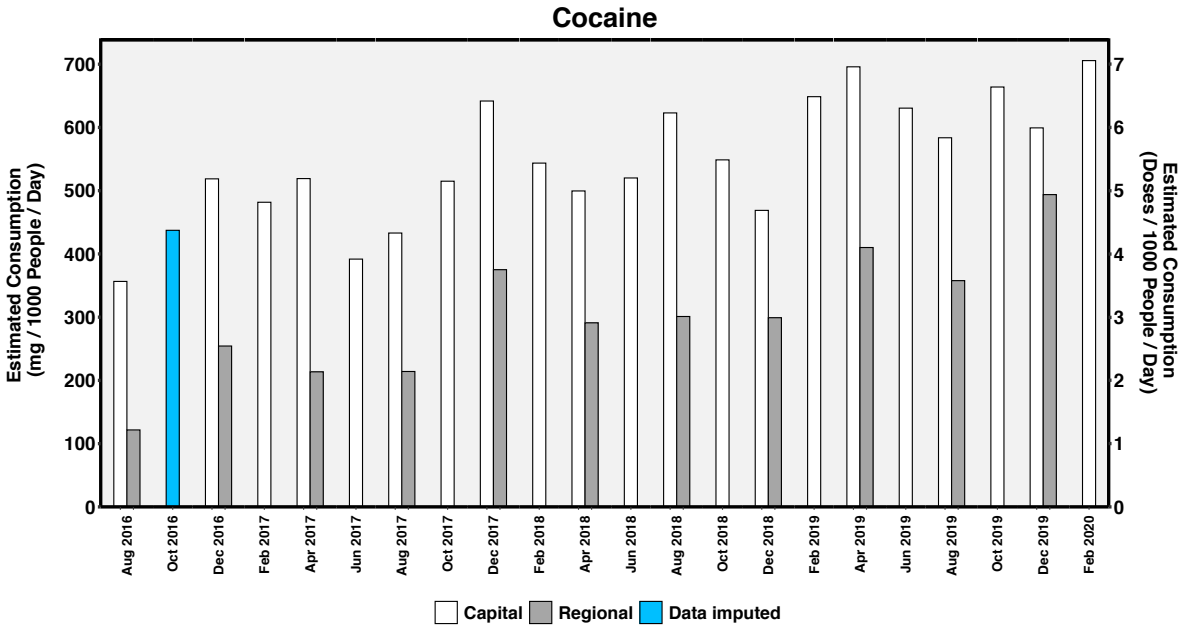
The remaining substances, cannabis, MDA, mephedrone and methylone had mixed findings in the national context. Cannabis appeared essentially steady across capital cities and somewhat more variable in regional areas (Figure 40). MDA also appeared stable across city sites, although regional sites had large variability which has partially been driven by sites in Queensland (for example, August 2017 and December 2019 high consumption rates were mainly influenced by Site 012). The mephedrone and methylone detection rates varied across the course of the program for samples collected in capital city and regional areas. Methylone detections have been on the decline and have remained low since 2017. The detection frequency of mephedrone in capital cities has increased from a low base to the highest levels observed in the program in February 2020, while regional centres have remained relatively steady.

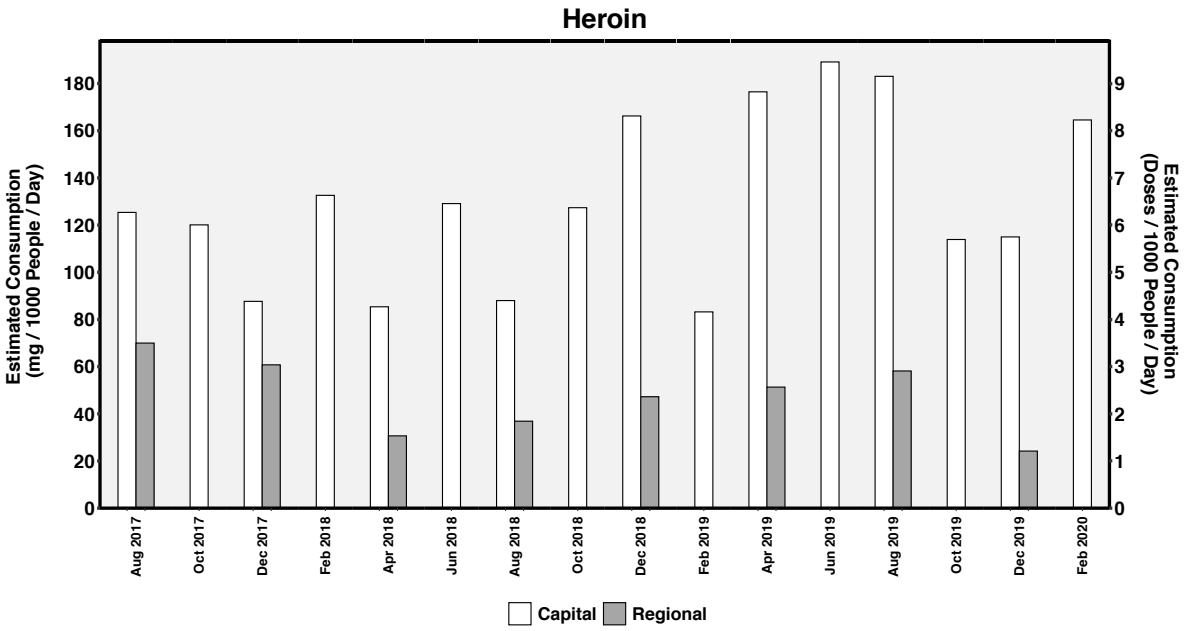
Figure 38: The population-weighted average of all sites for methylamphetamine, MDMA, cocaine and heroin.



Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

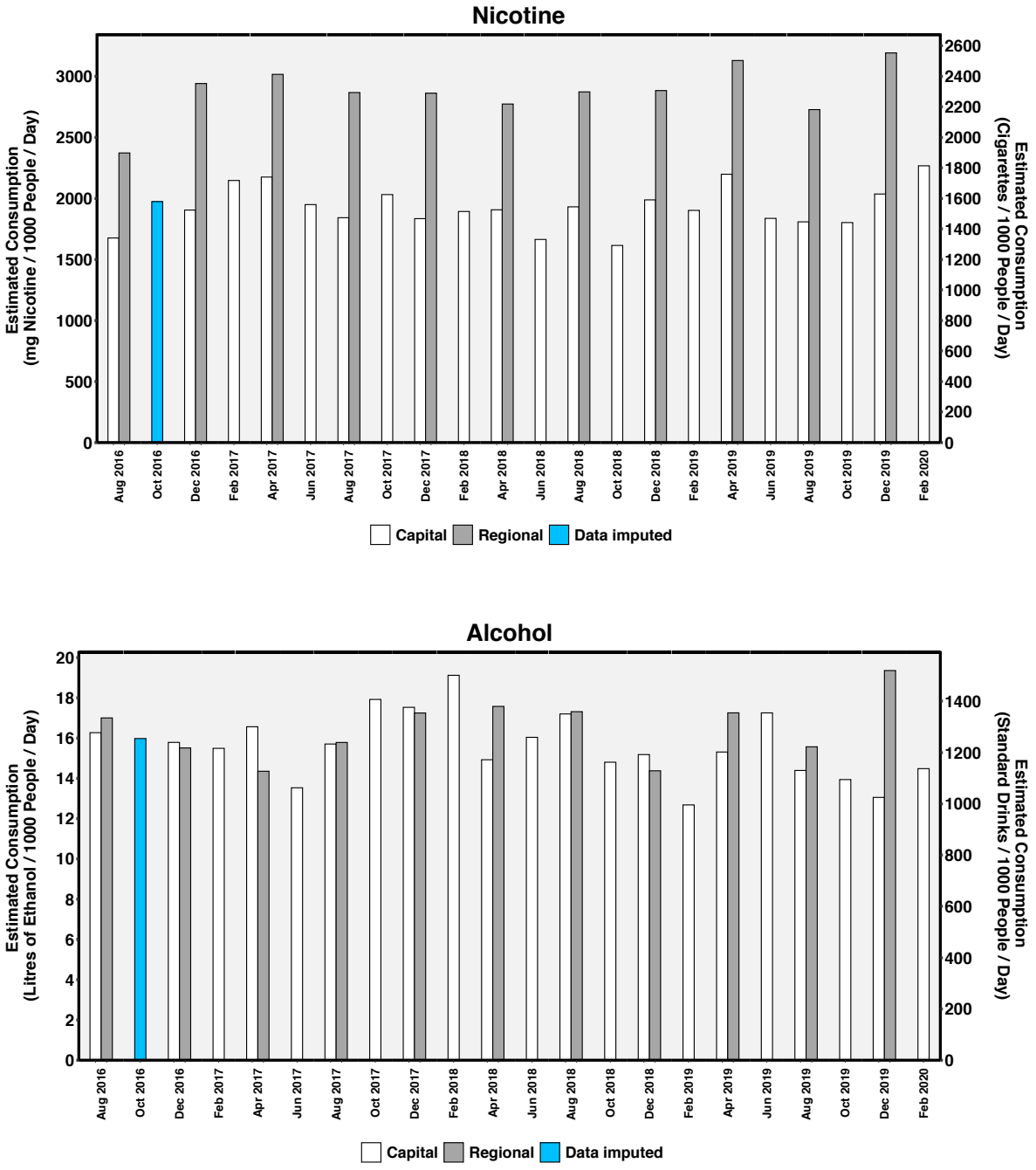
Figure 38 (continued): The population-weighted average of all sites for methylamphetamine, MDMA, cocaine and heroin.





Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

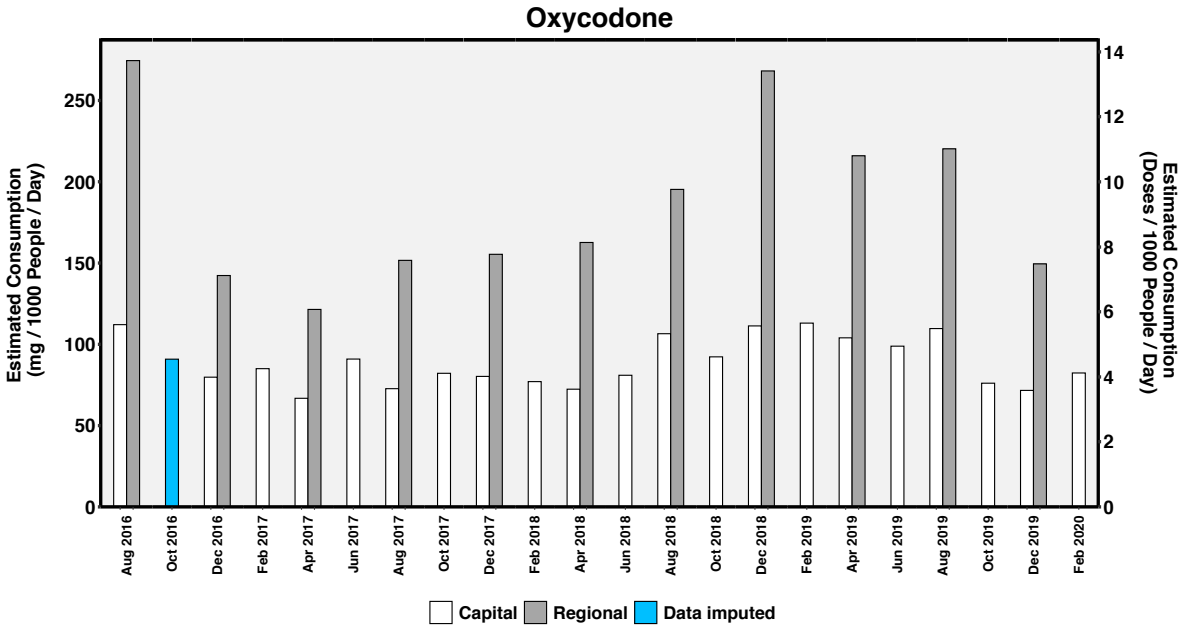
Figure 39: The population-weighted average of all sites for nicotine[6], alcohol, oxycodone and fentanyl.

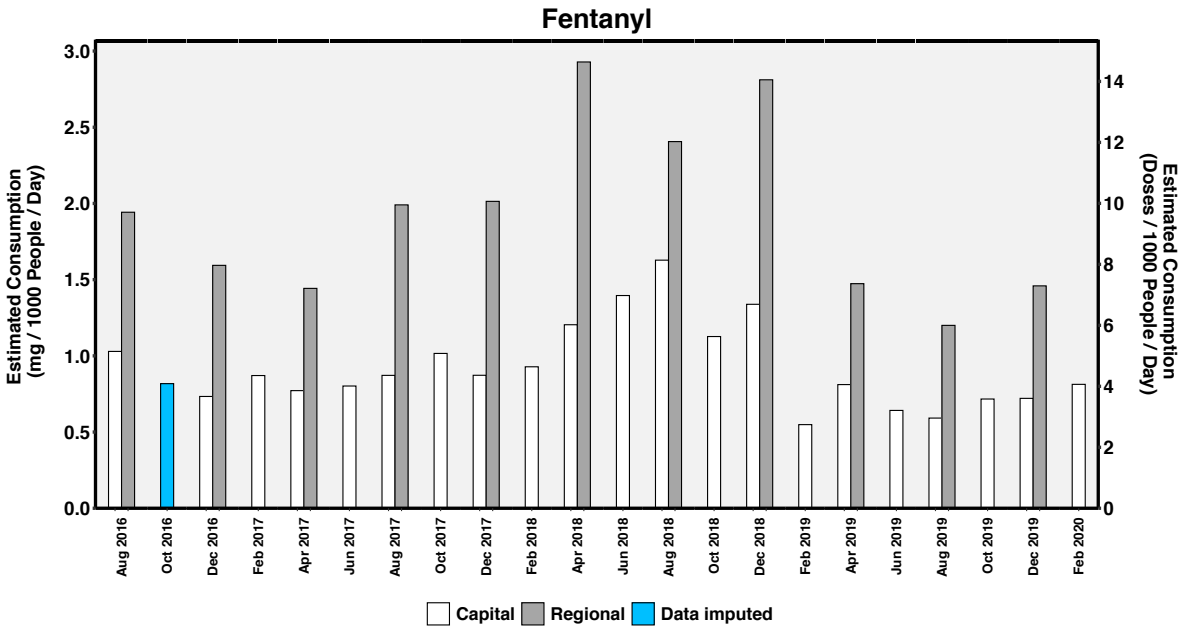


Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

6 Nicotine consumption data have been adjusted to refine the factor used to convert consumed mass load to dose. Overall trends in nicotine consumption remain unchanged.

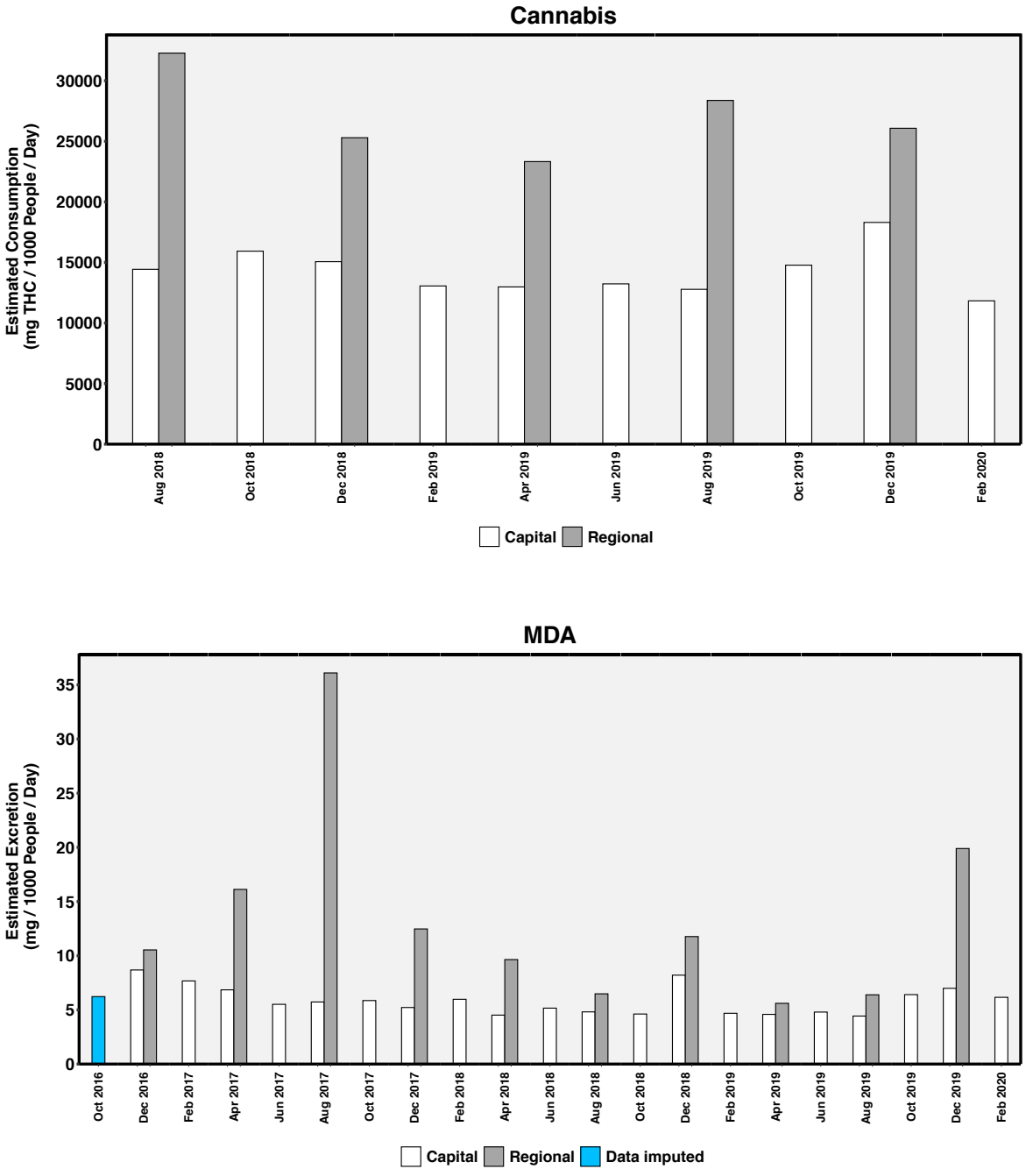
Figure 39 (continued): The population-weighted average of all sites for nicotine, alcohol, oxycodone and fentanyl.





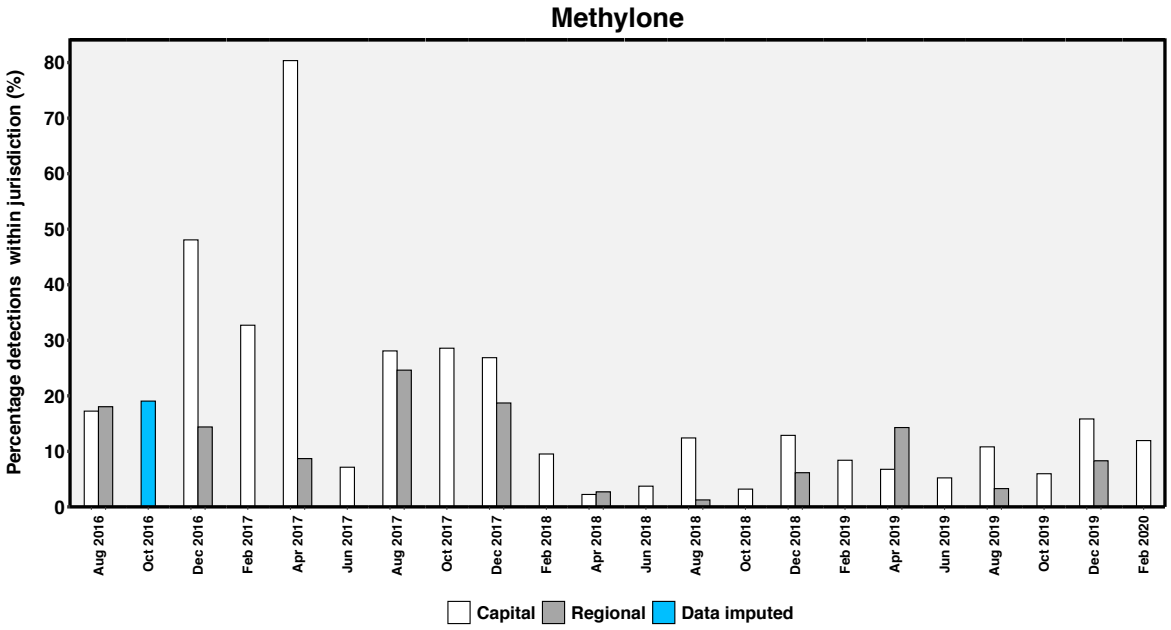
Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

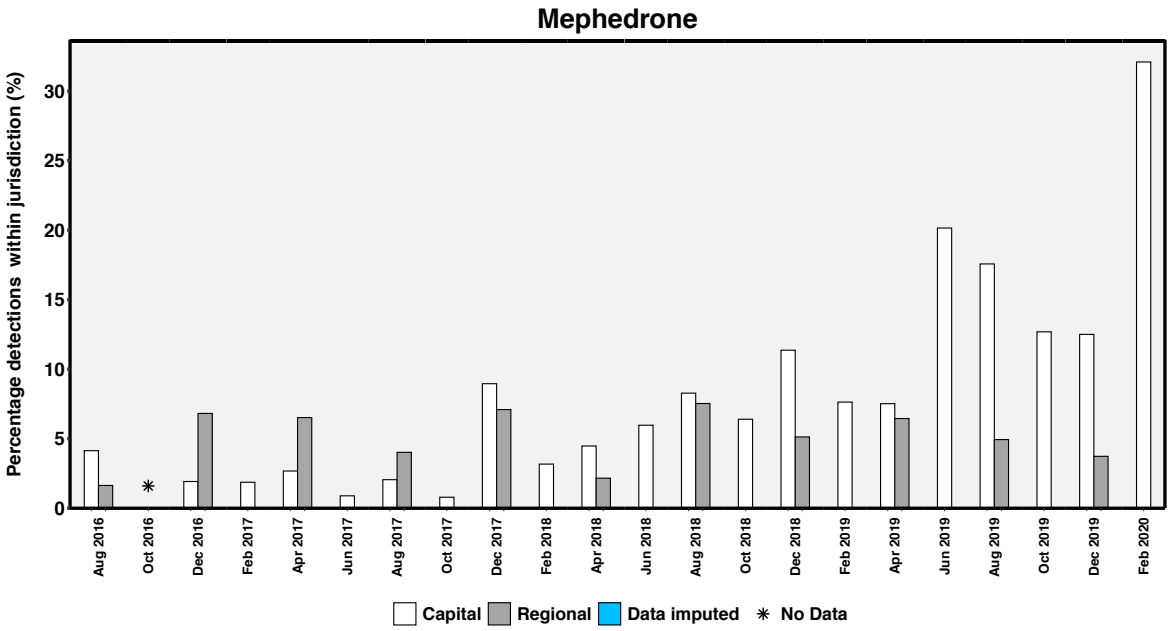
Figure 40: The population-weighted average of all sites for cannabis, MDA, methylone and mephedrone.



Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

Figure 40 (continued): The population-weighted average of all sites for cannabis, MDA, methylone and mephedrone.





Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

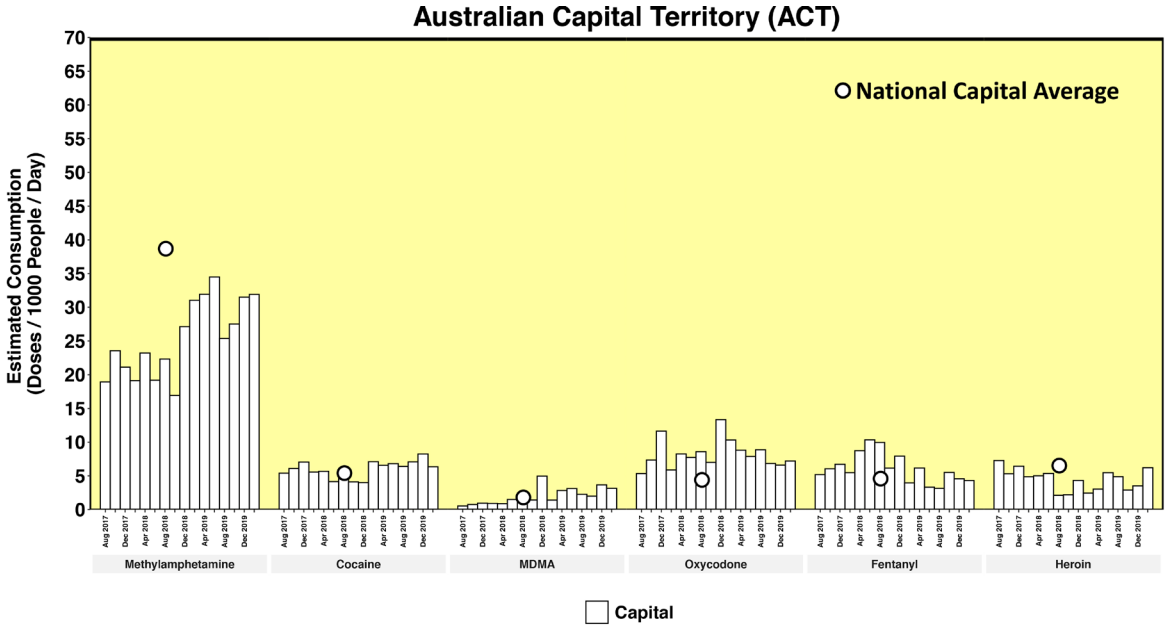
4.3 DRUG PROFILE FOR EACH STATE AND TERRITORY

For the purpose of comparing the scale of use of different types of drugs within the same region (for example, within a state or territory), drug consumption was reported as the number of doses consumed. Cannabis was omitted from this section since the definition of a typical dose of cannabis is not well defined and has not been included in this or previous reports. This will be included in comparisons when an appropriate dose for cannabis becomes available. In the absence of pharmacokinetic excretion data for MDA, methylone and mephedrone, these compounds were also excluded from the section.

When the amount of drug measured in wastewater was normalised for population size and average dose consumed (conversion factors listed in Report 1, and in Appendix 1), alcohol and nicotine remained consistently the highest consumed drugs in all states and territories. For example, the national average consumption of nicotine and alcohol per 1,000 people per day were approximately 1,700 cigarettes (Figure 4) and 1,100 standard drinks (Figure 5), whereas for methylamphetamine, the national average consumption was closer to 50 doses per 1,000 people per day (Figure 8).

Aside from nicotine and alcohol, of the illicit stimulants with dose information available, methylamphetamine use remained highest of the drugs included in the report. This was the case across all regions of Australia, with the scale of use of methylamphetamine consistently high for both capital cities and regional sites (Figure 41). When a dose becomes available for cannabis, this will be included in comparisons. In terms of the profiles of other drugs monitored by the NWDMP (cocaine, MDMA, oxycodone and fentanyl), no other consistent patterns of usage within the different states and territories were observed other than those described in previous sections.

Figure 41: Profile of average drug consumption by state or territory, August 2017 to February 2020. 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). The circles represent the cumulative national average of all time points for respective drugs.



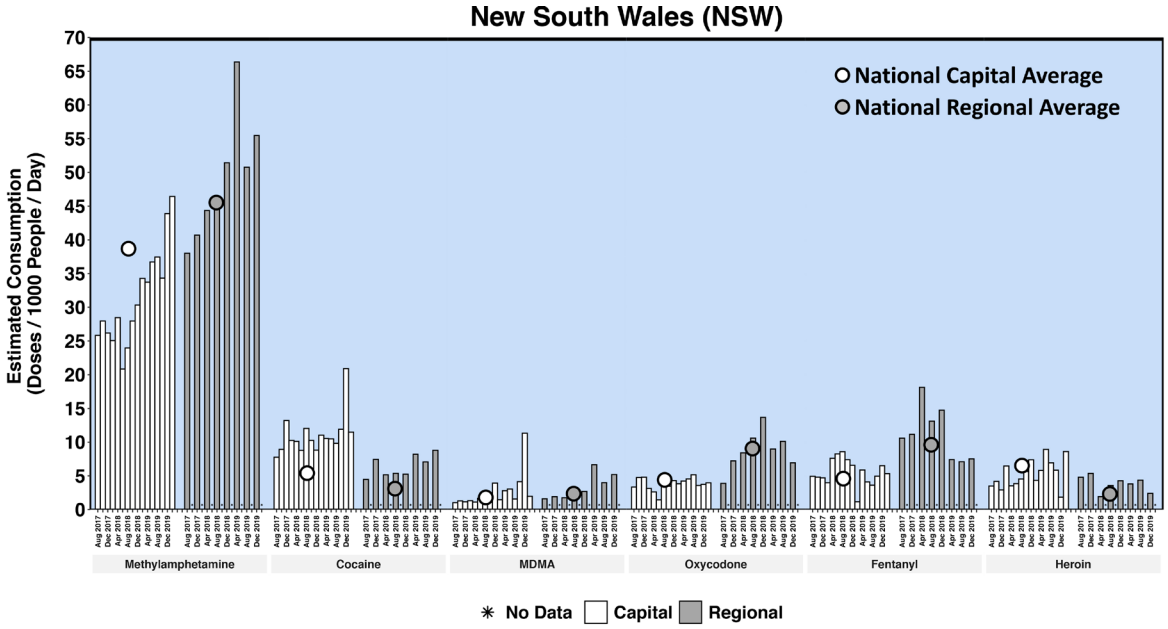
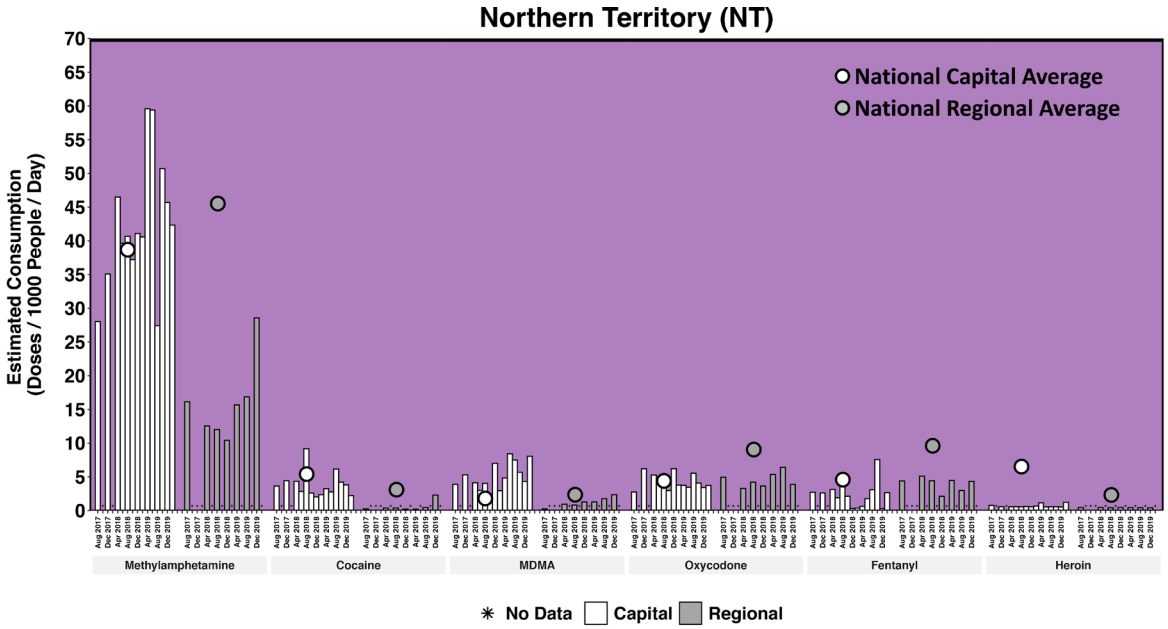


Figure 41 (continued): Profile of average drug consumption by state or territory, August 2017 to February 2020.



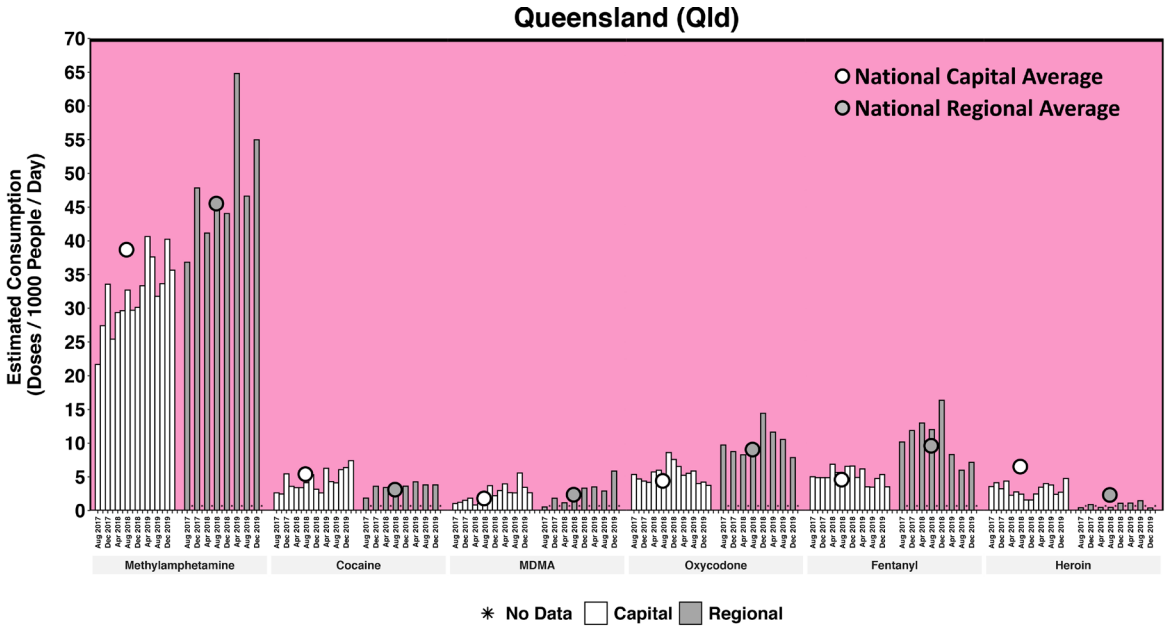
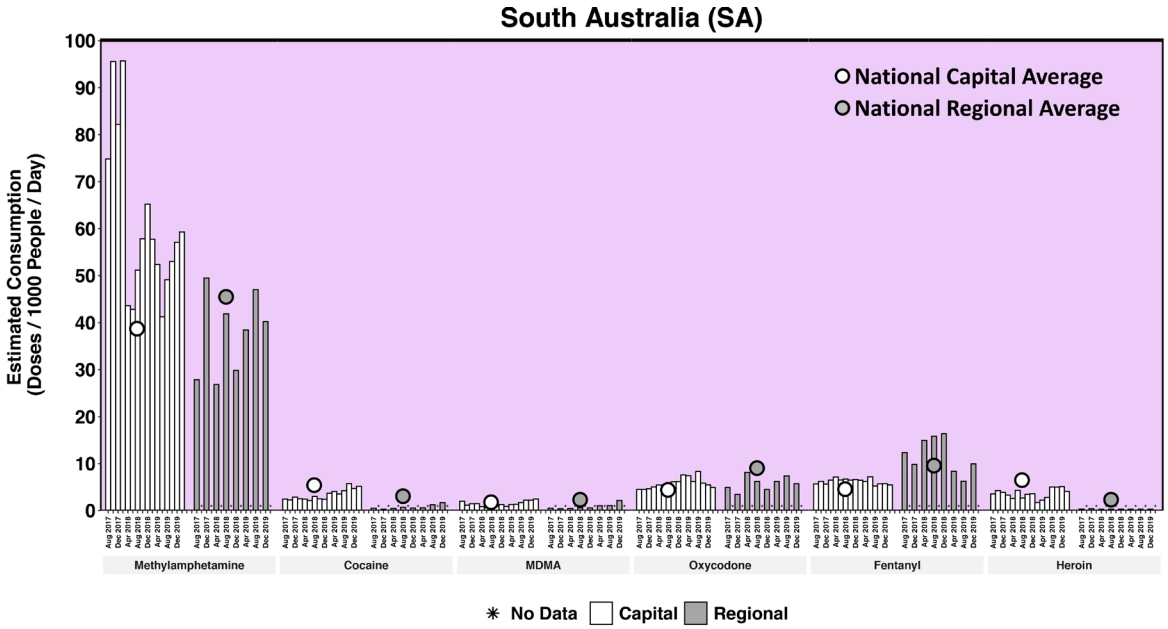


Figure 41 (continued): Profile of average drug consumption by state or territory, August 2017 to February 2020. Note: the y axes for South Australia is higher than the other jurisdictions.



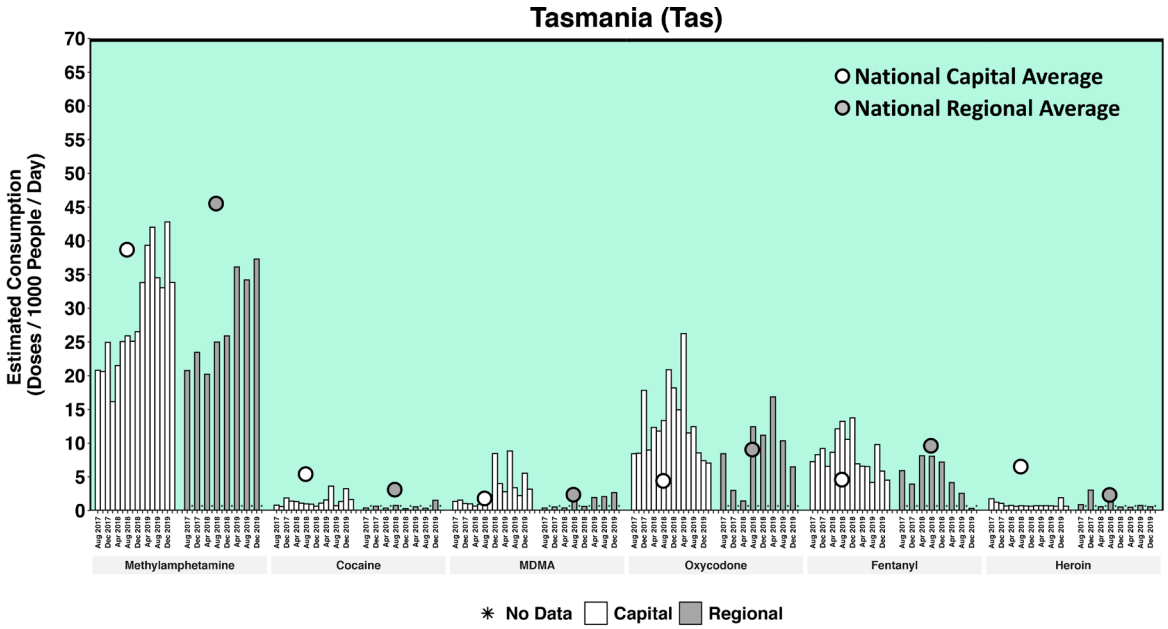
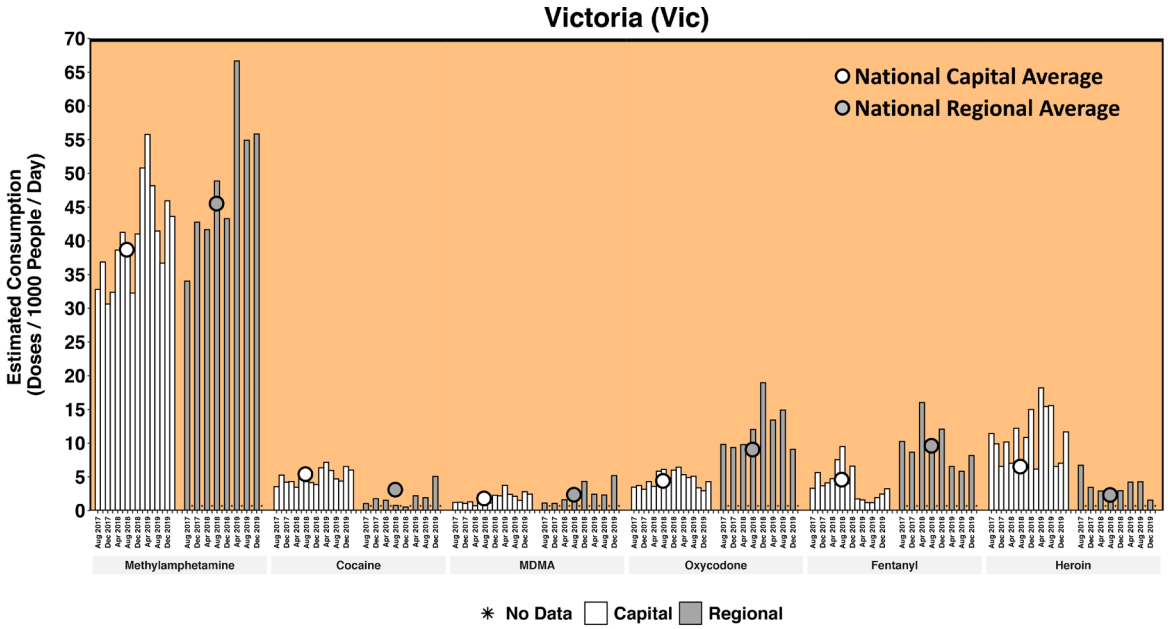
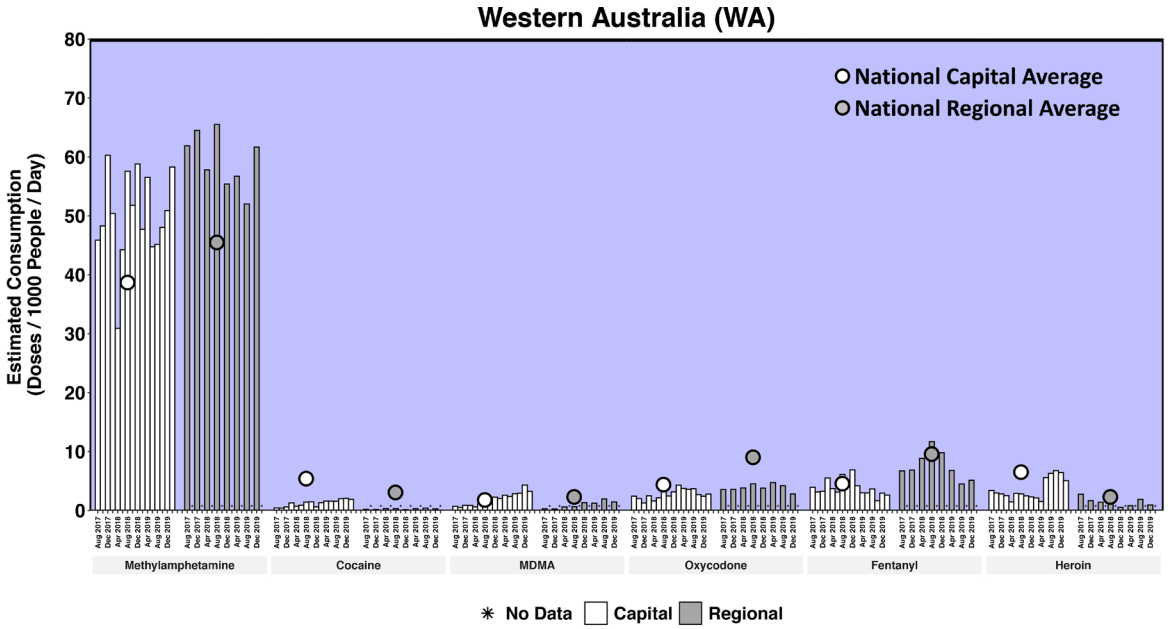


Figure 41 (continued): Profile of average drug consumption by state or territory, August 2017 to February 2020. Note: the y axes for Western Australia is higher than the other jurisdictions.



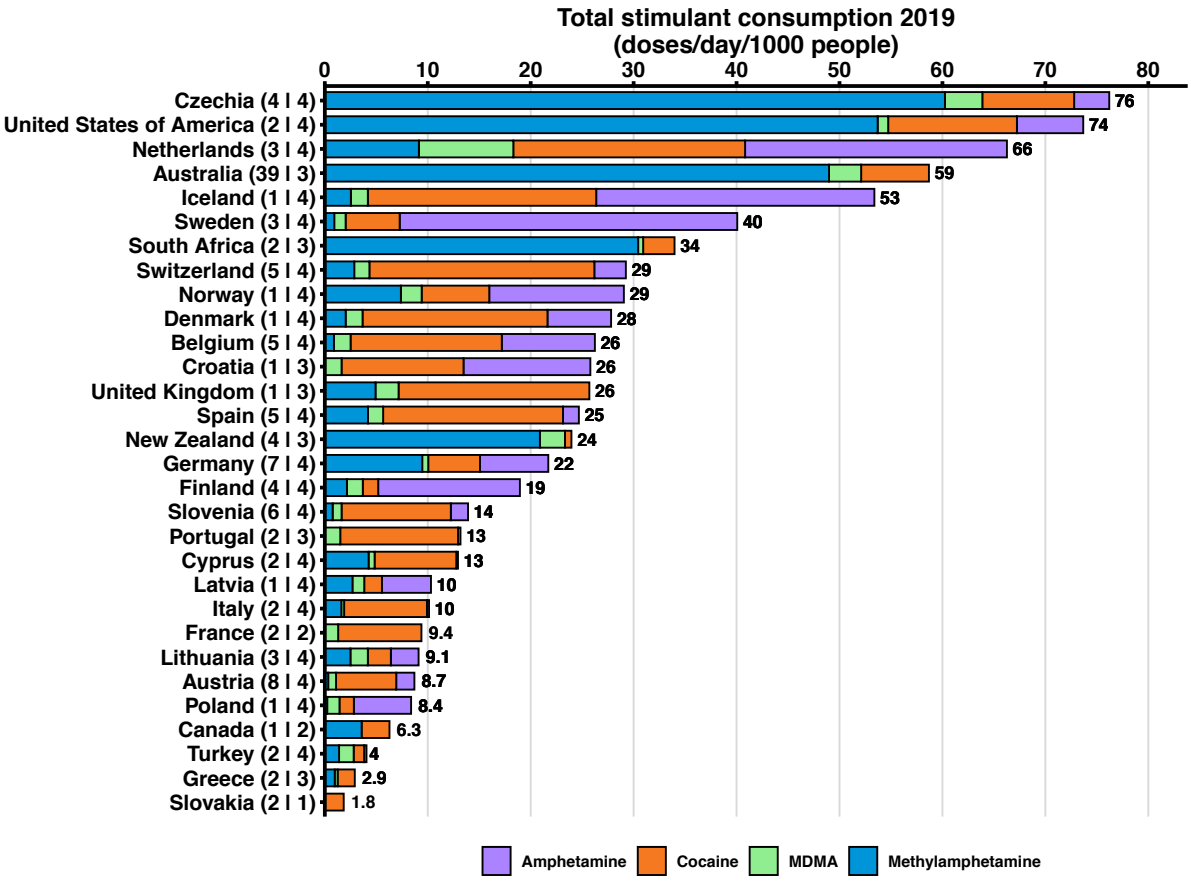


5: INTERNATIONAL COMPARISONS

A comparison of stimulant levels in Australia with international levels was done to show the relative scale of use. Such comparisons need to be understood in the context of different global preferences and availability of drugs between countries. Latest international data for Europe, North America, Oceania and South Africa were used as reported by the Sewage Core Group Europe (SCORE), 2019. However, the SCORE data relate in many cases to only a single site per country participating in the study and is therefore unlikely to be representative of drug use in the entire country.

Throughout many parts of Europe, amphetamine is more commonly used than methylamphetamine, while the opposite is true in Australia. Therefore, in the first instance, the four common stimulants were added together and expressed as doses per day per normalised population (Figure 42). In the case of amphetamine, all data considered the percentage of the drug which is derived from methylamphetamine metabolism. Australia ranked fourth highest in terms of combined stimulant use after Czechia (the Czech Republic), the United States of America (USA) and the Netherlands. It is apparent that the ranking is very much a consequence of local methylamphetamine use.

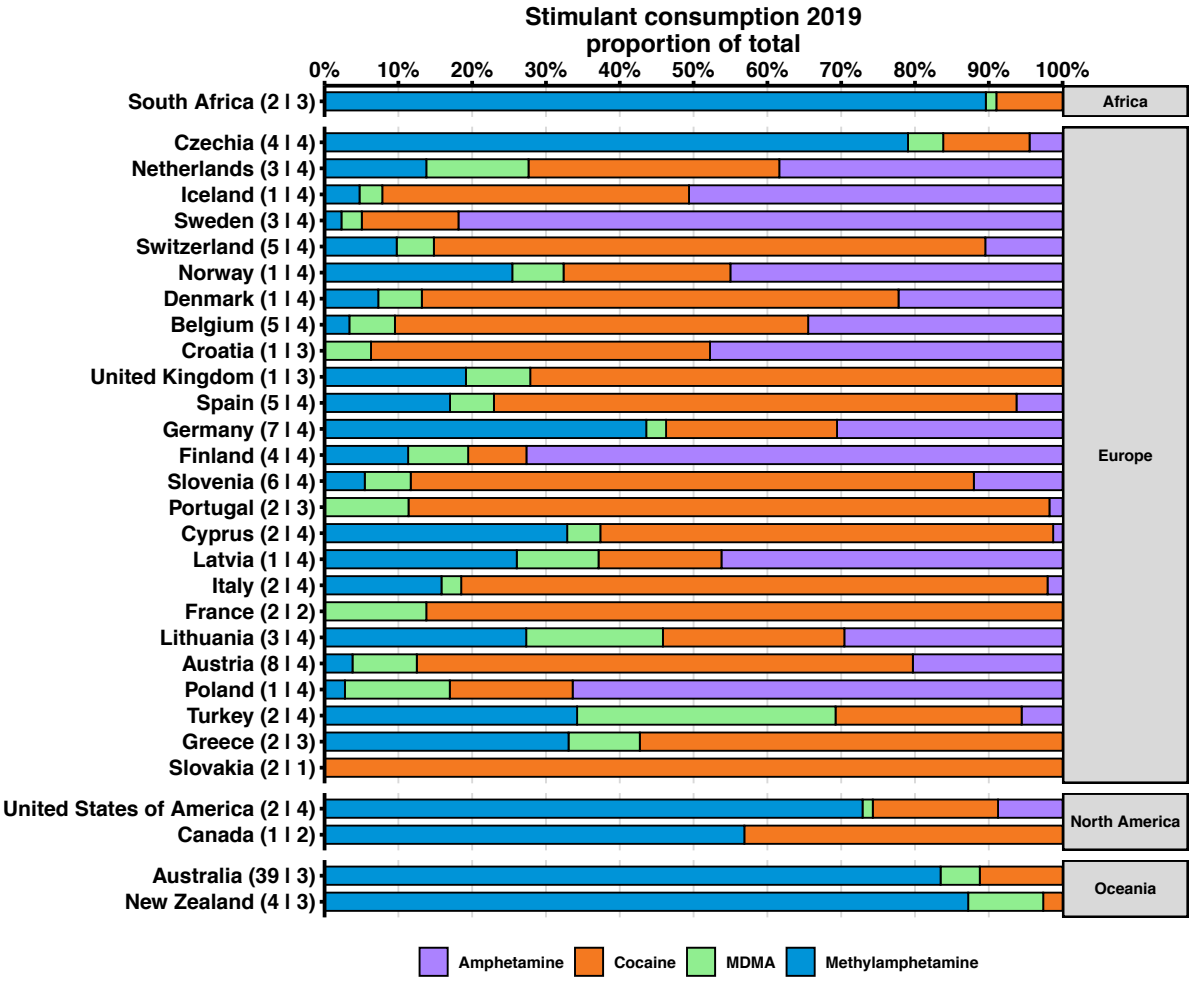
Figure 42: The total amount of stimulant consumed (as doses per 1,000 people per day) by a country as a population weighted average of the number of reported sites.



Note: the international 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. Other data are from SCORE (2019) and various excretion factors applied are reported in Report 1, Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia. All SCORE data were from March 2019. Australian data is from December 2019.

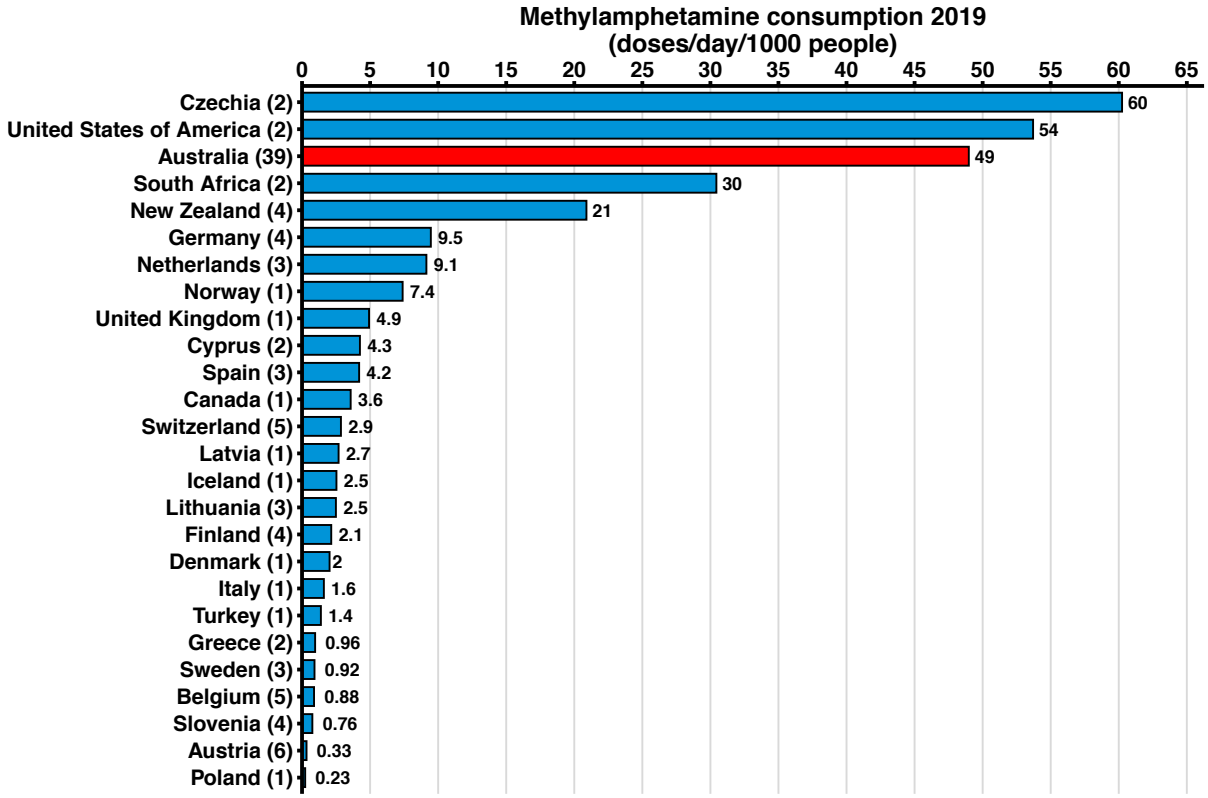
The proportion of stimulants in Australia was also compared with four commonly used stimulants in countries and regions included in the 2019 SCORE report. This is the same data as presented in Figure 42, but each drug was represented as a percentage of the total reported stimulant load within each country (Figure 43). This representation of data reveals the contribution of each drug in a regional and national context, scaled to the same value (100%). Australia is heavily influenced by methylamphetamine use, similar to New Zealand, North America, Czechia and South Africa. In contrast, countries such as Sweden, Finland and Poland have proportionally higher amphetamine use, while Switzerland, the United Kingdom, Slovenia, Portugal and others have much higher cocaine consumption. Cocaine use in New Zealand is less than MDMA, while in Australia the order is the opposite.

Figure 43: National population weighted average consumption for cities reported from the SCORE study in 2019 for methylamphetamine, MDMA, cocaine and amphetamine, represented as the proportion of the total stimulant consumption. The numbers in brackets represent the number of cities and the number of stimulant substances with results.



The high methylamphetamine levels in Australia in the international context was evident when comparing the drugs individually on an international level (Figure 44). Methylamphetamine levels in Australia were the third highest compared to other countries participating in the SCORE study. Some countries in the world with reasonably high methylamphetamine use according to police actions or research papers, such as in Asia and other parts of the Americas, do not participate in the SCORE study and are not represented here.

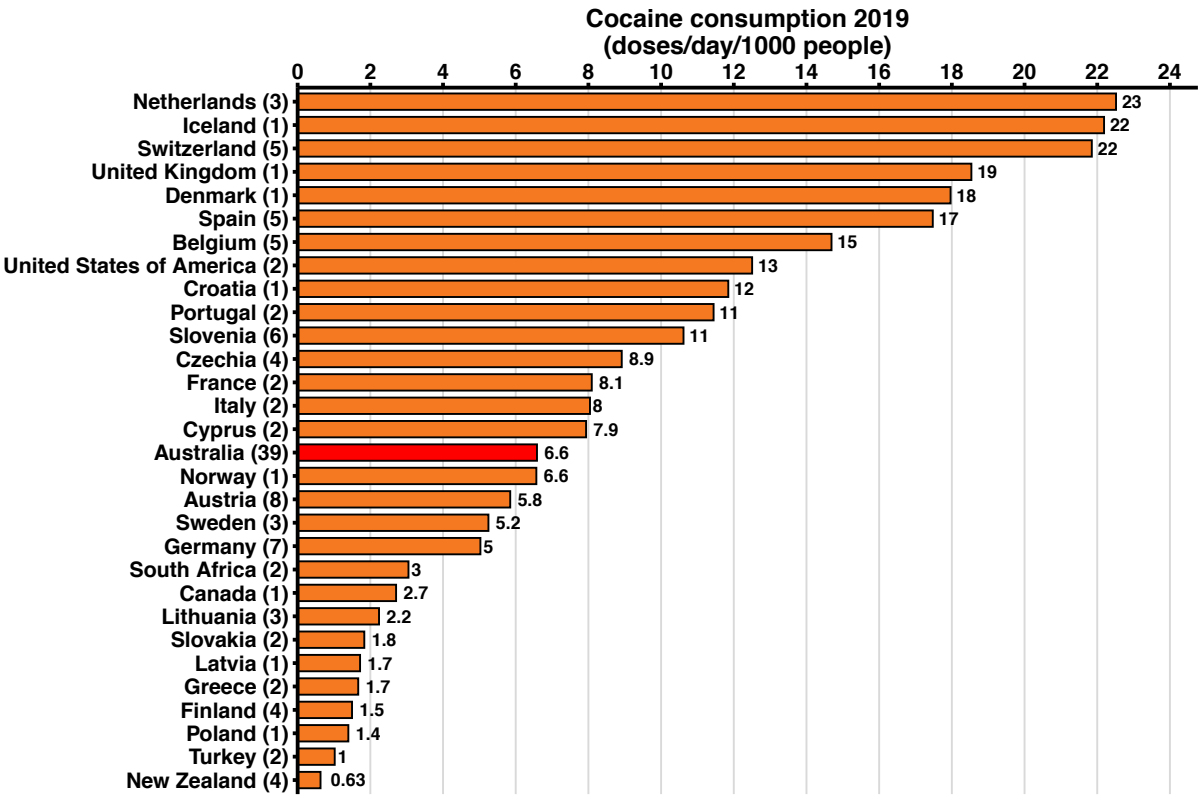
Figure 44: National population weighted average consumption for countries in Africa, Europe, North America and Oceania for methylamphetamine consumed on a per capita basis.



Note: the international 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. Other data are from SCORE (2019) and various excretion factors applied are reported in Report 1, Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia. All SCORE data were from March 2019. Australian data is from December 2019.

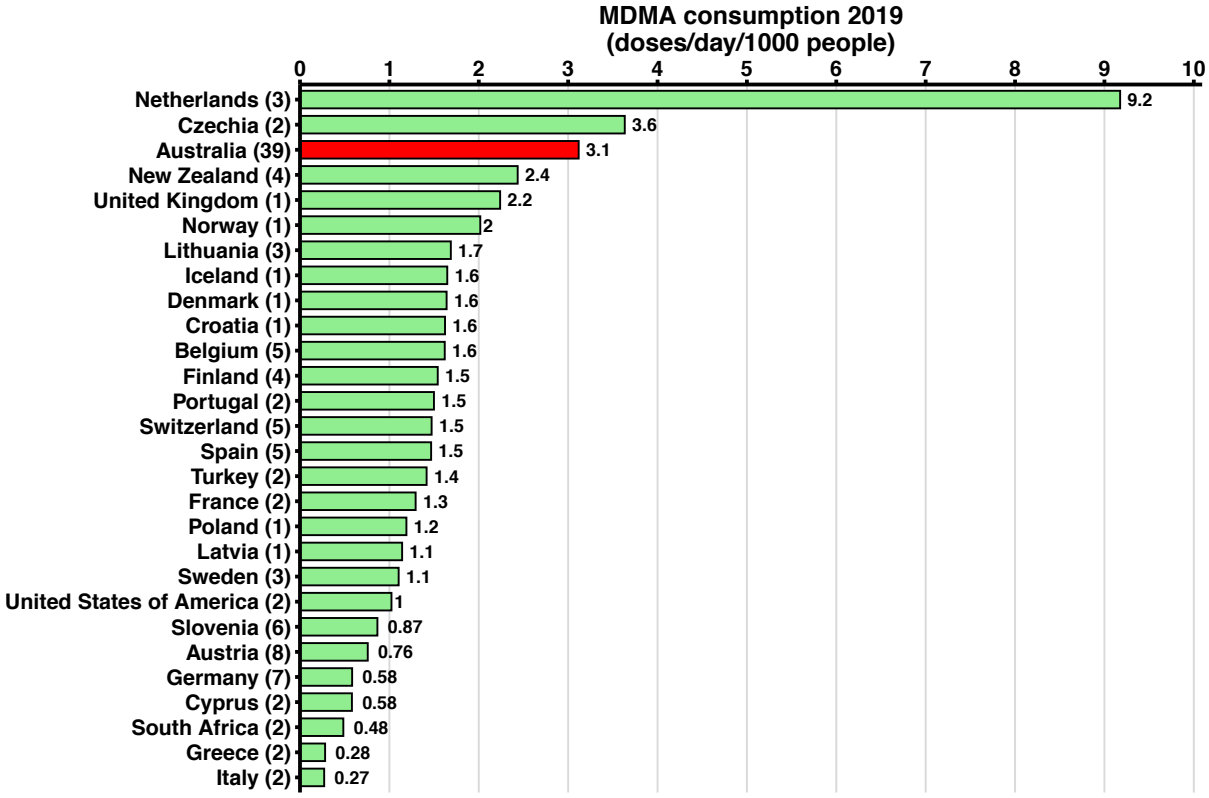
Compared to drug usage patterns in the SCORE dataset, Australian cocaine consumption was at the lower level (Figure 45), while MDMA use ranked towards the higher end of European and international levels (Figure 46).

Figure 45: National population weighted average consumption for countries in in Africa, Europe, North America and Oceania for cocaine consumed on a per capita basis.



Note: the international 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. Other data are from SCORE (2019) and various excretion factors applied are reported in Report 1, Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia. All SCORE data were from March 2019. Australian data is from December 2019.

Figure 46: National population weighted average consumption for countries in Africa, Europe, North America and Oceania for MDMA consumed on a per capita basis.



Note: the international 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. Other data are from SCORE (2019) and various excretion factors applied are reported in Report 1, Table 1. SCORE reports measured raw loads in sewers and doses were calculated in the same way as for Australia. All SCORE data were from March 2019. Australian data is from December 2019.

6: ACKNOWLEDGMENTS

The project team sincerely thanks the numerous WWTP operators involved in sample collection and WWTP management agencies for providing flow volumes and 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 (DASSA), for their permission to use historical and current data from South Australia, as well as the Western Australia Police Force for permission to use data and for members assisting the University of South Australia with logistics. The University of Queensland thanks Geoff Eaglesham for his contributions to the analytical work for this study and Rachel Mackie and PhD students at QAEHS for their assistance for sample collection and sample processing.

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 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.

The symbols/images used in Figure 1 in the report were provided courtesy of the Integration and Application Network, University of Maryland, Center for Environmental Science (ian.umces.edu/symbols/).

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8: APPENDICES

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

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

Analyte/metabolite	Drug	Limit of detection (LOD) [ng/L]	Limit of quantification (LOQ) [ng/L]	Excretion factor	Standard dose pure drug (mg)
Amphetamine	Amphetamine	12	16	0.394[a]	30[b]
Cocaine	Cocaine	17	50	0.075[b]	100[b]
Cotinine	Nicotine	33	100	0.3[c]	1.25[c]
Norfentanyl	Fentanyl	0.1	0.1	0.3[d]	0.2[d]
MDA *	MDA	1	4	n.a.	n.a.[#]
MDMA	MDMA	1.5	2	0.225[b]	100[b]
Mephedrone	Mephedrone	0.4	0.8	n.a.	n.a.
Methylamphetamine	Methylamphetamine	33	100	0.39[g]	30[b]
Methylone	Methylone	0.01	0.1	n.a.	n.a.
Hydroxycotinine	Nicotine	17	50	0.44[c]	1.25[c]
Noroxycodone	Oxycodone	0.1	1	0.22[f]	20[d]
Ethyl Sulphate	Alcohol (ethanol)	167	500	0.00012[e]	10g[e]
Benzoylecgonine	Cocaine	33	100	0.35[g]	100[b]
6-Monoacetylmorphine	Heroin	0.5	1.0	0.013[h]	20[i]
THC-COOH	THC (Cannabis)	30	180	0.006[b]	n.a.

n.a. = data not available; a = (Khan and Nicell 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); h = (Boerner et al. 1975); i = (Sullivan et al. 2006).

* Data is not available in the scientific literature for the proportion of MDA that is eliminated after MDA consumption. However, data is available detailing the proportion of MDA eliminated after MDMA consumption. Therefore, our MDA estimate of mg excreted per day per 1,000 people is the amount of MDA excreted from the population after considering the metabolic fraction excreted from MDMA.

It is likely that the dose for MDA is similar to that of MDMA, or 100 mg.

APPENDIX 2: SAMPLING DETAILS OF EACH SITE FOR OCTOBER AND DECEMBER 2019, AND FEBRUARY 2020[7]

Sites	Capital or Regional	Oct 2019	Dec 2019	Feb 2020	Population
ACT: 009	Capital	7	7	7	> 150,000
NSW: 003	Capital	7	–	7	> 150,000
NSW: 006	Capital	7	–	7	> 150,000
NSW: 008	Capital	7	7	7	> 150,000
NSW: 021	Capital	–	–	–	30,000 to 150,000
NSW: 071	Capital	–	–	–	> 150,000
NSW: 016	Regional	–	7	–	30,000 to 150,000
NSW: 025	Regional	–	7	–	30,000 to 150,000
NSW: 040	Regional	–	–	–	< 30,000
NSW: 051	Regional	–	–	–	< 30,000
NSW: 068	Regional	–	7	–	> 150,000
NSW: 081	Regional	–	7	–	< 30,000
NSW: 115	Regional	–	7	–	30,000 to 150,000
NT: 010	Capital	7	7	7	30,000 to 150,000
NT: 078	Regional	–	7	–	< 30,000
Qld: 002	Capital	7	7	7	> 150,000
Qld: 005	Capital	7	7	7	> 150,000
Qld: 011	Capital	7	7	7	> 150,000
Qld: 012	Regional	–	7	–	> 150,000
Qld: 020	Regional	–	7	–	< 30,000
Qld: 024	Regional	–	7	–	30,000 to 150,000
Qld: 028	Regional	–	7	–	30,000 to 150,000
Qld: 029	Regional	–	7	–	30,000 to 150,000
Qld: 033	Regional	–	7	–	30,000 to 150,000
Qld: 039	Regional	–	7	–	< 30,000
Qld: 042	Regional	–	7	–	30,000 to 150,000
Qld: 053	Regional	–	7	–	< 30,000
Qld: 077	Regional	–	7	–	< 30,000
Qld: 092	Regional	–	–	–	< 30,000
SA: 007	Capital	7	7	7	> 150,000
SA: 013	Capital	7	7	7	> 150,000
SA: 027	Capital	7	7	7	30,000 to 150,000
SA: 059	Capital	7	7	7	> 150,000
SA: 017	Regional	–	7	–	< 30,000
SA: 022	Regional	–	7	–	< 30,000
SA: 063	Regional	–	7	–	< 30,000
SA: 076	Regional	–	–	–	< 30,000
SA: 119	Regional	–	7	–	< 30,000

7 Sampling details of each wastewater treatment plant for the previous collection periods are available in Report 7, Appendix 2 and Report 6, Appendix 3.

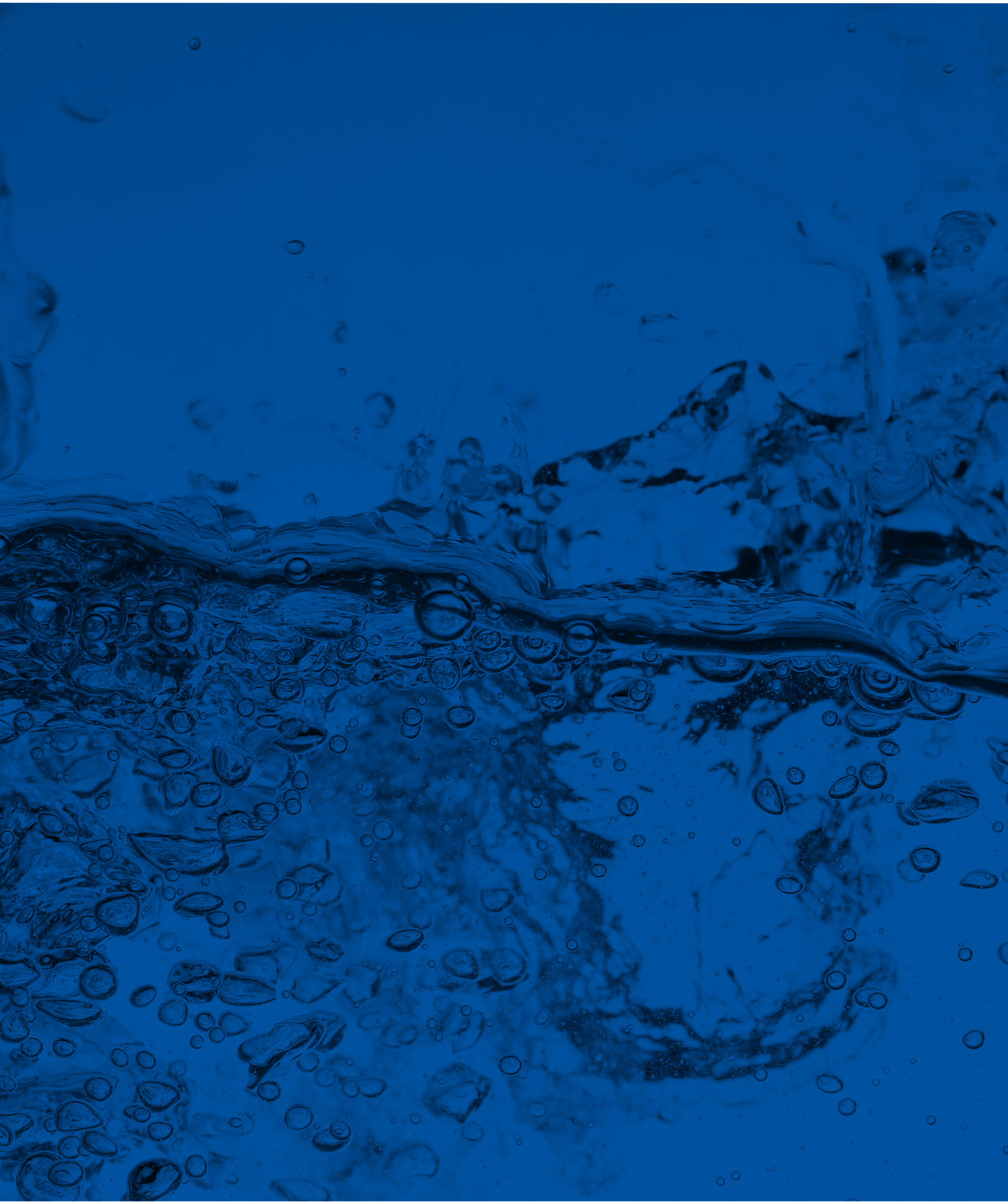
APPENDIX 2 (CONTINUED): SAMPLING DETAILS OF EACH SITE FOR OCTOBER AND DECEMBER 2019, AND FEBRUARY 2020

Sites	Capital or Regional	Oct 2019	Dec 2019	Feb 2020	Population
Tas: 004	Capital	5	5	5	< 30,000
Tas: 019	Capital	5	5	5	< 30,000
Tas: 041	Capital	5	5	5	< 30,000
Tas: 018	Regional	–	5	–	< 30,000
Tas: 038	Regional	–	–	–	< 30,000
Tas: 048	Regional	–	5	–	< 30,000
Tas: 058	Regional	–	–	–	< 30,000
Vic: 001	Capital	7	7	7	> 150,000
Vic: 067	Capital	7	7	7	> 150,000
Vic: 037	Regional	–	7	–	> 150,000
Vic: 046	Regional	–	–	–	30,000 to 150,000
Vic: 061	Regional	–	7	–	30,000 to 150,000
Vic: 062	Regional	–	–	–	< 30,000
Vic: 066	Regional	–	7	–	30,000 to 150,000
Vic: 114	Regional	–	7	–	30,000 to 150,000
Vic: 121	Regional	–	7	–	< 30,000
Vic: 122	Regional	–	7	–	< 30,000
Vic: 123	Regional	–	7	–	< 30,000
Vic: 124	Regional	–	7	–	< 30,000
Vic: 125	Regional	–	7	–	30,000 to 150,000
WA: 101	Capital	7	7	7	> 150,000
WA: 103	Capital	7	7	7	> 150,000
WA: 104	Capital	7	7	7	> 150,000
WA: 102	Regional	–	7	–	30,000 to 150,000
WA: 116	Regional	–	7	–	< 30,000
WA: 118	Regional	–	–	–	< 30,000
WA: 120	Regional	–	7	–	30,000 to 150,000
WA: 129	Regional	–	7	–	< 30,000
Regional Sites		–	35	–	
Capital Sites		20	18	20	
Total Sites		20	53	20	
Regional Samples		–	241	–	
Capital Samples		134	120	134	
Total Samples		134	361	134	
Cumulative Samples		4,419	4,780	4,914	

APPENDIX 3: PROPORTION OF SAMPLES ABOVE LOD (%) FOR EACH DRUG AND PERIOD ASSESSED[8]

Drug	Capital or Regional	Oct 2019	Dec 2019	Feb 2020
Alcohol	Capital	100	100	100
Alcohol	Regional	–	100	–
Cannabis	Capital	100	100	100
Cannabis	Regional	–	100	–
Cocaine	Capital	99	100	100
Cocaine	Regional	–	88	–
Fentanyl	Capital	89	87	90
Fentanyl	Regional	–	87	–
Heroin	Capital	61	81	79
Heroin	Regional	–	18	–
MDA	Capital	99	100	99
MDA	Regional	–	97	–
MDMA	Capital	100	100	100
MDMA	Regional	–	100	–
Mephedrone	Capital	12	2	13
Mephedrone	Regional	–	2	–
Methylamphetamine	Capital	100	100	100
Methylamphetamine	Regional	–	100	–
Methylone	Capital	6	16	12
Methylone	Regional	–	8	–
Nicotine	Capital	100	100	100
Nicotine	Regional	–	100	–
Oxycodone	Capital	100	100	100
Oxycodone	Regional	–	100	–

8 Percentage detection for previous collection periods are available in Report 7, 8, 9, Appendix 3 and Report 6, Appendix 4.



CONCLUSIONS

CONCLUSIONS

For the tenth report of the National Wastewater Drug Monitoring Program, wastewater analysis was conducted in October and December 2019, and February 2020. The program has identified variations in patterns of drug consumption, both over time and within and between jurisdictions. Consistent with previous reports, findings show that of the substances monitored with known doses, nicotine and alcohol are the most consumed drugs in Australia, while methylamphetamine remains the most consumed illicit drug.[9]

METHYLAMPHETAMINE

When comparing data for August 2019 and December 2019, the population-weighted average consumption of methylamphetamine increased in both capital city and regional sites, with average capital city consumption in December 2019 the highest level recorded by the program. Regional average methylamphetamine consumption continues to exceed capital city average consumption. South Australia had the highest estimated average capital city consumption of methylamphetamine in December 2019, while Western Australia had the highest estimated average regional consumption.

COCAINE

When comparing data for August 2019 and December 2019, the population-weighted average consumption of cocaine increased in both capital city and regional sites, with average regional consumption in December 2019 the highest level recorded by the program. Average capital city cocaine consumption further increased from December 2019 to February 2020 to the highest level recorded by the program. Capital city average cocaine consumption continues to exceed regional average consumption. New South Wales had the highest estimated average cocaine consumption in both capital city and regional sites in December 2019.

3,4-METHYLENEDIOXYMETHYLAMPHETAMINE (MDMA)

When comparing data for August 2019 and December 2019, the population-weighted average consumption of MDMA increased in both capital city and regional sites to the highest levels recorded by the program. Regional average MDMA consumption continues to exceed capital city average consumption. New South Wales had the highest estimated average capital city consumption of MDMA in December 2019, while Queensland had the highest estimated average regional consumption.

3,4-METHYLENEDIOXYAMPHETAMINE (MDA)

MDA is a metabolite of MDMA. When comparing data for August 2019 and December 2019, MDA excretion in both capital city and regional sites increased. Regional average MDA excretion continues to exceed capital city average excretion. New South Wales had the highest estimated average MDA excretion in capital city sites in December 2019, while Queensland had the highest estimated average regional consumption.

9 Throughout this report, unless otherwise stated, all comparisons on the consumption of different drugs are based on doses consumed rather than drug mass.

HEROIN

When comparing data for August 2019 and December 2019, the population-weighted average consumption of heroin decreased in both capital city and regional sites, with average regional consumption the lowest level recorded by the program. Capital city average heroin consumption continues to exceed regional average consumption. Victoria had the highest estimated average capital city consumption of heroin in December 2019, while New South Wales had the highest estimated regional consumption.

CANNABIS

When comparing data for August 2019 and December 2019, the population-weighted average consumption of cannabis increased in capital city sites to the highest level recorded by the program, while consumption in regional sites decreased. Regional average cannabis consumption continues to exceed capital city average consumption. Tasmania had the highest estimated average capital city consumption of cannabis in December 2019, while the Northern Territory had the highest estimated average regional consumption.

OXYCODONE

When comparing data for August 2019 and December 2019, the population-weighted average consumption of oxycodone decreased in both capital city and regional sites. Regional average oxycodone consumption continues to exceed capital city average consumption. Tasmania had the highest estimated average capital city consumption of oxycodone in December 2019, while Victoria had the highest estimated average regional consumption.

FENTANYL

When comparing data for August 2019 and December 2019, the population-weighted average consumption of fentanyl increased in both capital city and regional sites. Regional average fentanyl consumption continues to exceed capital city average consumption. New South Wales had the highest estimated average capital city consumption of fentanyl in December 2019, while South Australia had the highest estimated average regional consumption.

NICOTINE

When comparing data for August 2019 and December 2019, the population-weighted average consumption of nicotine increased in both capital city and regional sites, with average regional consumption the highest level recorded by the program. Average capital city nicotine consumption further increased from December 2019 to February 2020 to the highest level recorded by the program. Regional average nicotine consumption continues to exceed capital city average consumption. The Northern Territory[10] had the highest estimated average capital city and regional consumption of nicotine in December 2019.

ALCOHOL

When comparing data for August 2019 and December 2019, the population-weighted average consumption of alcohol decreased in capital city sites and increased to a record level in regional sites. Regional average alcohol consumption exceeded capital city average consumption. Tasmania had the highest estimated average alcohol consumption in capital city sites in December 2019, while the Northern Territory[11] had the highest estimated consumption in regional sites.

10 As the Northern Territory only had two participating sites, results may not be representative of the Territory as a whole.
11 Ibid.

MEPHEDRONE

Consistent with previous reporting periods, mephedrone was mostly detected below the level at which it could be reliably quantified. The number of national detections of mephedrone decreased, from 38 in August 2019 to 24 in December 2019, with the number of detections in capital city sites exceeding the number of detections in regional sites. The number of sites where mephedrone was detected decreased, from 12 in August 2019 to 8 in December 2019. Mephedrone was detected in New South Wales, Queensland, South Australia and Western Australia, with New South Wales reporting the highest number of detections in December 2019.

METHYLONE

Consistent with previous reporting periods, methylone was mostly detected below the level at which it could be reliably quantified. The number of national detections of methylone increased, from 24 in August 2019 to 39 in December 2019, with the number of detections in capital city sites exceeding the number of detections in regional sites. The number of sites where methylone was detected increased, from 8 in August 2019 to 16 in December 2019. Methylone was detected in all states and territories with the exception of Tasmania and the Australian Capital Territory. Queensland reported the highest number of methylone detections in December 2019.

INTERNATIONAL COMPARISONS (SCORE)

There are a number of factors that influence drug consumption, including but not limited to different drug preferences and drug availability. This concept is illustrated in the SCORE data and the notable differences in stimulant drug preferences. Noting that SCORE data in many cases relate to a single or small number of sites per participating country, of the 30 countries with comparable reported data for stimulant drugs (amphetamine, methylamphetamine, MDMA and cocaine), Australia ranks fourth highest after Czechia, the United States of America and the Netherlands for total estimated stimulant consumption. Stimulant consumption in Australia continues to be primarily driven by methylamphetamine use. In comparing the individual stimulant drug components, of the countries with comparable consumption data Australia ranks third for methylamphetamine and MDMA, and sixteenth for cocaine.

NEXT REPORT

The eleventh report of the National Wastewater Drug Monitoring Program is scheduled for public release in October 2020.