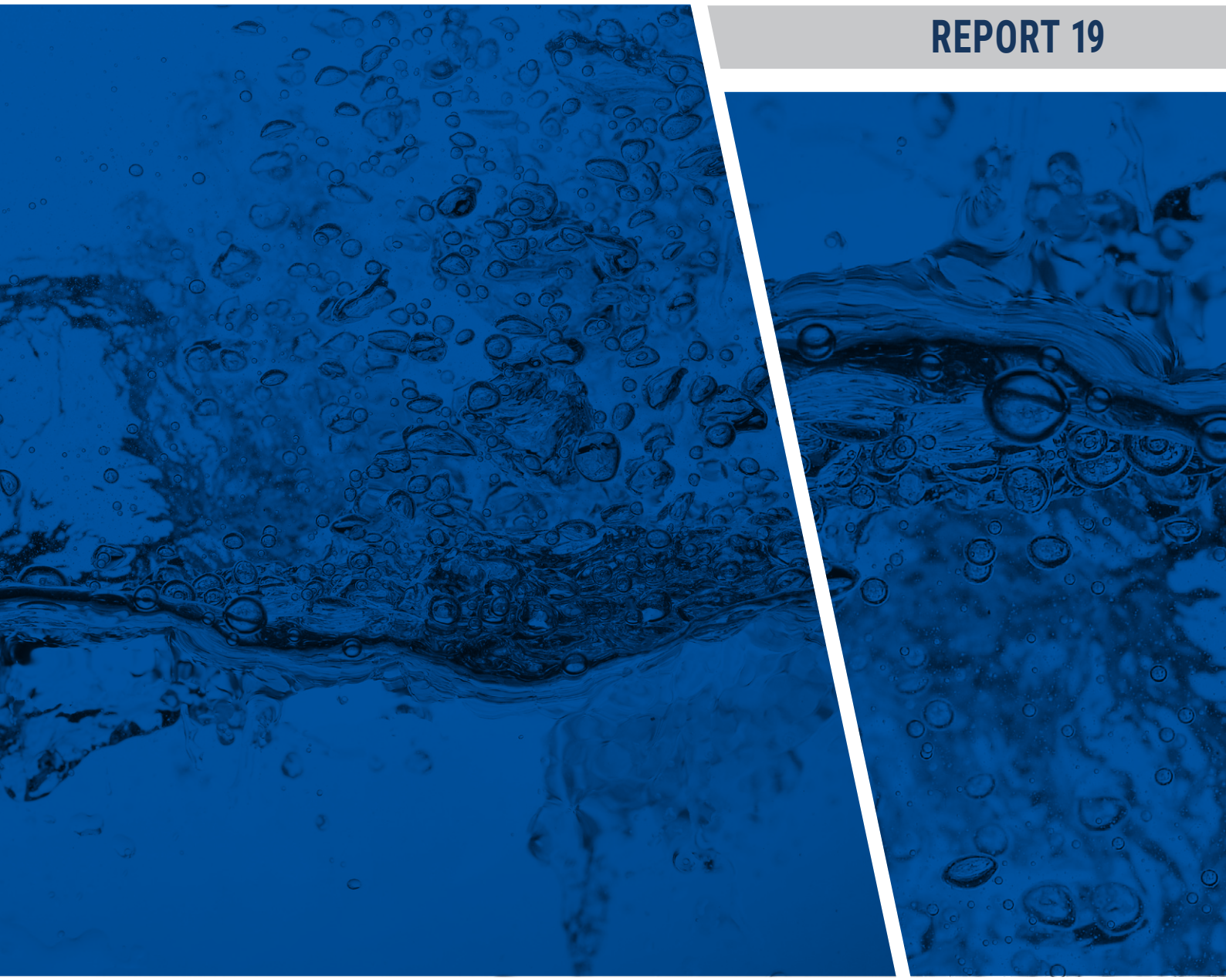
NATIONAL WASTEWATER DRUG MONITORING PROGRAM

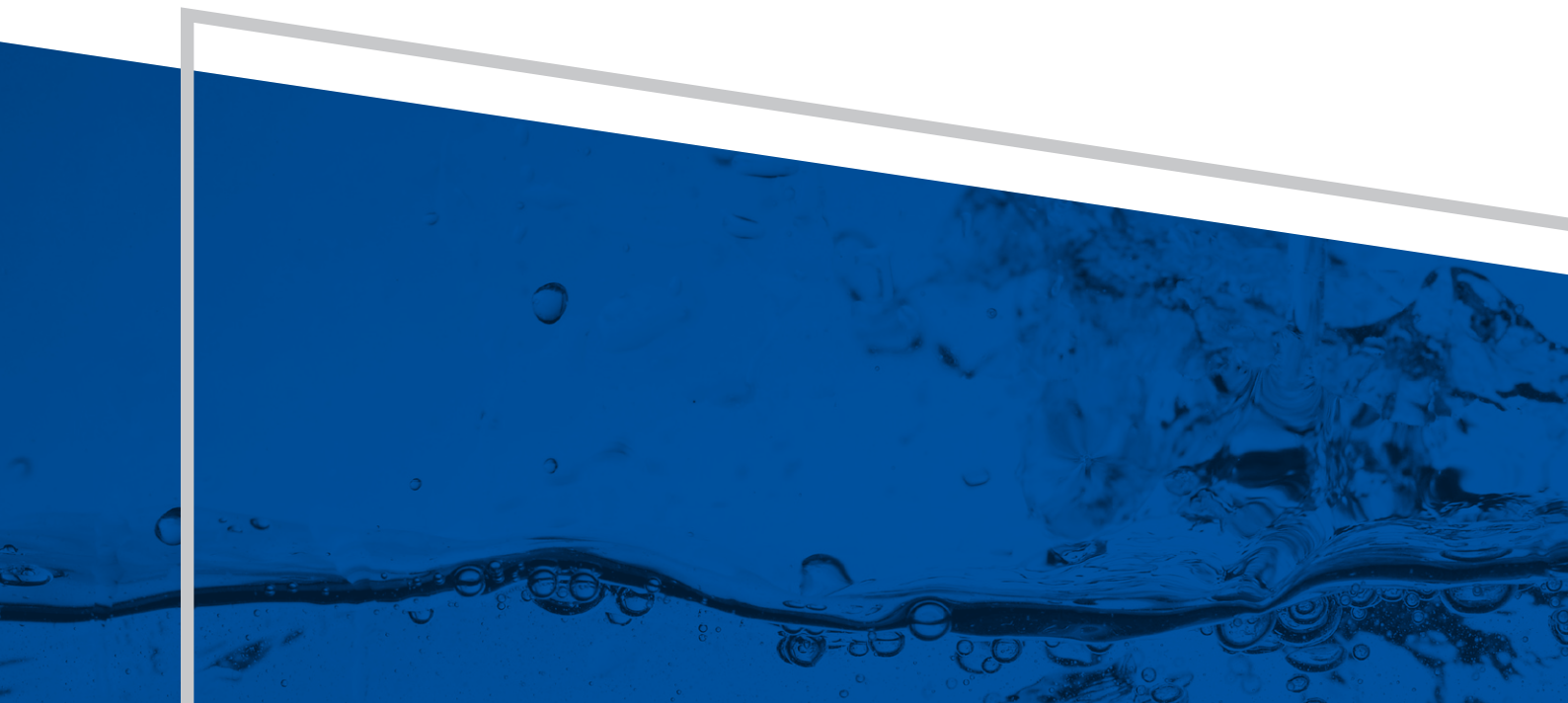
REPORT 19



AUSTRALIAN CRIMINAL INTELLIGENCE COMMISSION

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

University of South Australia



CONTENTS

CEO FOREWORD

I am pleased to present Report 19 of the National Wastewater Drug Monitoring Program (the Program). Wastewater analysis is one of the most cost-effective, least intrusive methods of measuring drug use at a population level.

This report is based on data collected in December 2022 and February 2023. In December 2022 the Program covered 55% of the Australian population. The findings are critical to the Australian Criminal Intelligence Commission (ACIC)'s insights on serious and organised criminal involvement in illicit drug trafficking. Much of the harm Australians suffer at the hands of organised crime is due to illicit drugs. There is some disturbing data in this report. Average consumption of methylamphetamine, cocaine, MDMA, MDA, fentanyl and ketamine has increased in both capital city and regional sites, despite large seizures of some of these drugs. This underlines the ongoing threat posed by serious and organised crime groups and their responsiveness to perceived market opportunities and the large illicit profits to be derived from Australian illicit drug users. This is underlined by the succession of large seizures and detections, offshore, at the border and domestically of major illicit drugs. Average consumption of heroin, oxycodone and cannabis decreased in capital city and regional sites, oxycodone to record low levels. While average consumption of nicotine and alcohol increased in capital city sites, it decreased in regional sites, to record low levels in December 2022. Alcohol consumption in capital cities also decreased to record low levels in February 2023.

The Program has been characterised by ongoing innovation and this report is no exception. For the first time, a reliable dose figure for cannabis has been determined and this permits cannabis consumption to be readily compared with other major illicit drugs, and the figure applied to historical data holdings going back to August 2018, when cannabis was first monitored by the Program. This report shows, nicotine and alcohol aside, cannabis is the most consumed drug by a large margin and its consumption has been at least double that of methylamphetamine throughout the time that both substances have been measured by the Program. Despite this, methylamphetamine remains the most harmful illicit drug in Australia.

Consumption of drugs other than cannabis and methylamphetamine has fluctuated throughout the life of the Program, albeit within a narrower range. There was a considerable increase in cocaine consumption between August and December 2022, following the record low level in August 2022. MDMA remains one of the lowest consumed drugs monitored by the Program, and in the current reporting period, heroin has been overtaken by cocaine and is now the fourth most consumed illicit drug. Consumption of fentanyl has been increasing since April 2022.

Section 5 of the report provides updated directly comparable 2022 data from the Sewage Core Group Europe (SCORE), which covered 161 cities from 28 countries in Europe, Asia, North America and Oceania. The results for March to May 2022 confirm the strong preference in world terms by Australian illicit drug users for illicit stimulants, where we ranked sixth of 28 participating countries. The results also highlight the domination of our domestic stimulant market by methylamphetamine. Australia had the third highest methylamphetamine consumption per capita compared with 24 other countries. Australia had relatively low consumption of other drugs compared with the remaining SCORE countries with the exception of cannabis, where we ranked sixth of 16 countries.

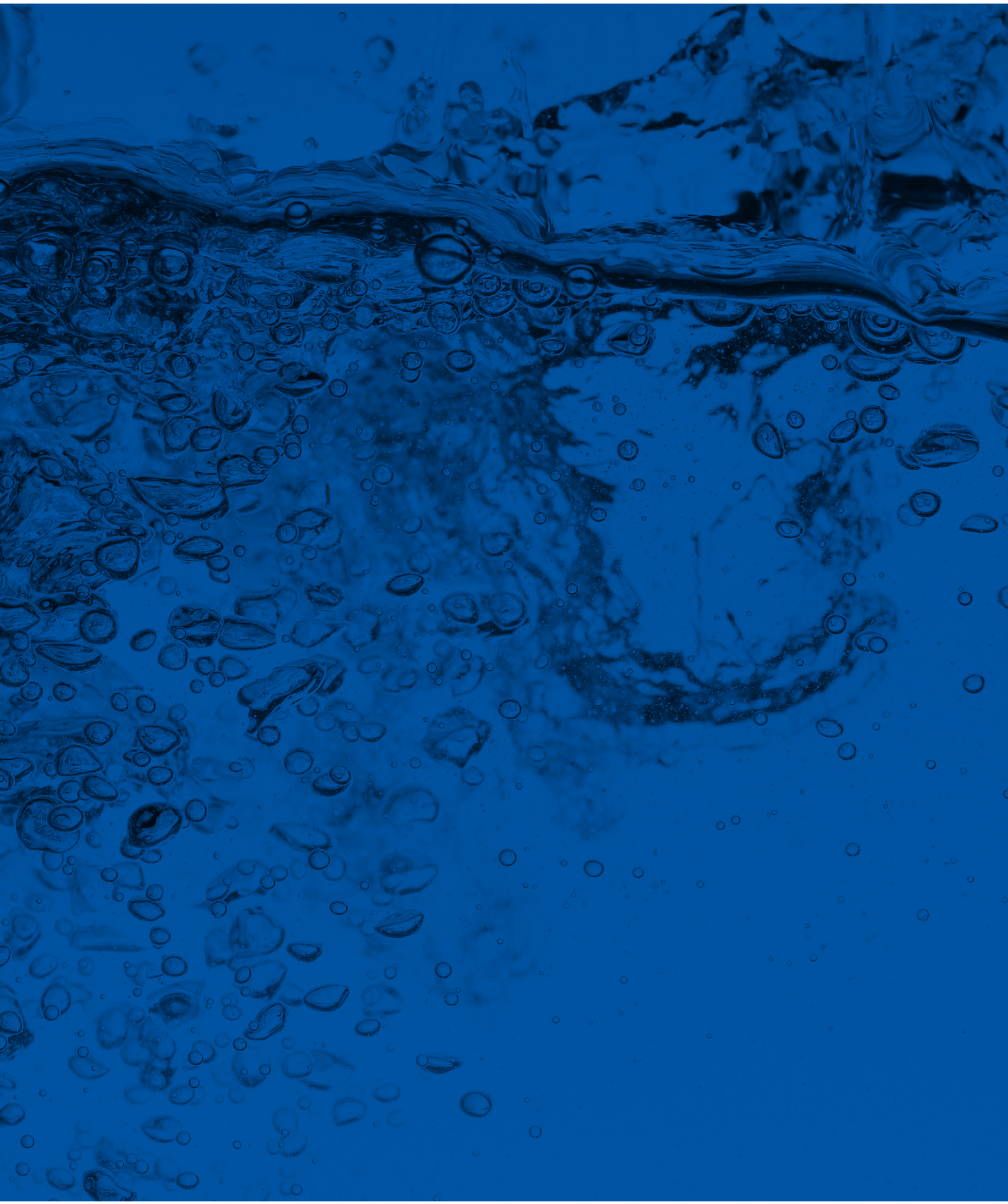
A multi-dimensional approach that targets supply, demand and harm reduction is critical to reducing drug use in Australia. Drug consumption estimates derived from wastewater data, when used in combination with other data—such as seizure, arrest, price, purity, health and availability data—provide the most comprehensive, empirically-based insights into Australian drug markets. In turn, these data reveal drug market resilience, but also points of vulnerability that present opportunities for coordinated strategies that improve the safety of the Australian community.

The ACIC remains committed to working with domestic and international law enforcement and intelligence partners to disrupt and dismantle serious organised criminal networks who continue to supply illicit drugs to Australian markets. Some law enforcement investigations are now conducted in conjunction with bespoke high intensity wastewater analysis so that the effectiveness of responses and the reaction of organised crime groups and drug consumers can be monitored.

ACKNOWLEDGEMENTS

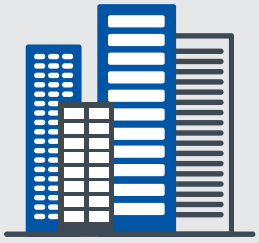
I would like to acknowledge the valuable support and expertise of The University of Queensland and the University of South Australia, which undertook the data collection and analysis underpinning this report, and the ACIC officers who contributed to the project.

Matthew Rippon
Acting Chief Executive Officer
Australian Criminal Intelligence Commission

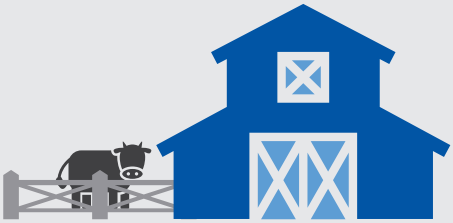


SNAPSHOT

The December 2022 collection covers around **55 per cent** of Australia's population—about **14 million Australians.**



Capital city **methylamphetamine, cocaine, MDMA, MDA, heroin** and **ketamine** average consumption exceeded regional consumption.



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

December 2022 and February 2023 highlights

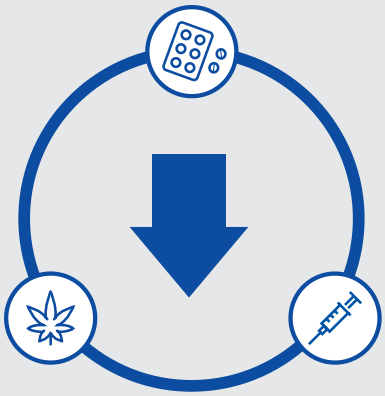
Record lows:

Oxycodone
regional (December)
capital city (February)

Alcohol
regional (December)
capital city (February)

Nicotine
regional (December)

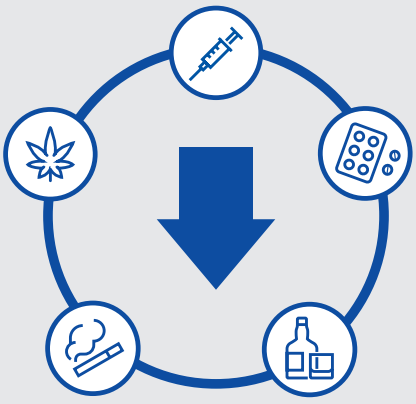
Between August and December 2022, the population-weighted average capital city consumption of:



heroin, oxycodone and cannabis **decreased**

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

Between August and December 2022, the population-weighted average regional consumption of:



alcohol, nicotine, heroin, oxycodone and cannabis **decreased**

methylamphetamine, cocaine, MDMA, MDA, fentanyl and ketamine **increased**

INTERNATIONAL DRUG COMPARISONS

Methylamphetamine consumption in Australia ranked **3rd** of 25 SCORE countries

Cocaine consumption in Australia ranked **18th** of 27 SCORE countries

MDMA consumption in Australia ranked **21st** of 27 SCORE countries

Cannabis consumption in Australia ranked **6th** of 16 SCORE countries

INTRODUCTION

This is the 19th report of the National Wastewater Drug Monitoring Program (the Program) to be publicly released by the Australian Criminal Intelligence Commission (ACIC). Report 19 presents data on Australia's drug consumption for 12 substances and includes data for December 2022 (capital city and regional sites) and February 2023 (capital city sites).

The Program is an Australian Government-funded initiative that assists in understanding drug use within populations, providing a measure of one important aspect of national health—the demand for a range of drugs. Illicit drugs and licit drugs with abuse potential are inherently harmful. Reliable drug consumption data are a key indicator of the level of harm experienced by the community. This is because the level of community harm is directly related to the quantity of substances consumed.

Findings presented in ACIC wastewater reports provide law enforcement, policy, regulatory and health agencies with additional, objective data on drug use. This data creates opportunities to shape responses to the demand and supply sides of illicit drug markets, particularly in high-use areas, and can inform harm reduction strategies. They inform priority-setting that is responsive to constantly evolving drug markets and broader world circumstances.

Longitudinal data captured by the Program increases our understanding of drug use nationally, in specific locations and over time. It provides valuable insights into trends and emerging issues in drug consumption across Australia and can identify new sources of risk.

IMPLEMENTATION

The ACIC 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, Program wastewater analysis measured the presence[1] of the following substances:

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

The ACIC continues to review the range of monitored substances with its partners, stakeholders and the universities.

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.

Both contracted universities monitor wastewater across Australia, covering all state and territory capital cities and a range of regional cities and towns. In December 2022, 57 wastewater treatment plants participated nationally (see Figure 1).[2] Sites were selected to permit the ACIC 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 2 universities.

Figure 1: The breakdown of sites by jurisdiction for December 2022.

Participation by all states and territories is vital to informing our understanding of the national picture of drug use and demand. Although the location of sites within and between states and territories may change over the life of the Program, the intention is to ensure site continuity.

2 Sampling also occurred in February 2023 in capital city sites, with 20 participating wastewater sites nationally, covering approximately 48 per cent of the Australian population.

REPORTING

Program reports are published 3 times a year. 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 ACIC. 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 ketamine (for which reliable dose figures are unavailable), 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.

EXPLOITATION OF PROGRAM DATA

The Program is based on a well-established, internationally recognised methodology. 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. Report 19 measures the drug use of approximately 55% of the Australian population. Population estimates were updated with Census 2021 population data and are reflected in the site data from April 2022.

Wastewater data are also particularly useful for identifying differences in levels of drug consumption in capital city and regional areas of Australia. The data reinforces different dynamics that apply to both capital city and regional markets and illustrate drug consumption variations that exist 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. Wastewater analysis also permits the ACIC to gain insight into the decision-making of serious and organised crime groups that supply illicit drug markets.

Regular wastewater reporting enables the ACIC and partners to detect and respond to increasing drug threats in a timely way. The number and diversity of regional sites that participate in the Program permit confident assessments to be made of drug trends outside of the capital cities that can be used to inform local responses. This is important because it allows wastewater data to complement a number of other Australian drug data collections that have limited regional coverage or are confined to capital cities. It also permits the ACIC and partners to speak with greater confidence about local drug threats.

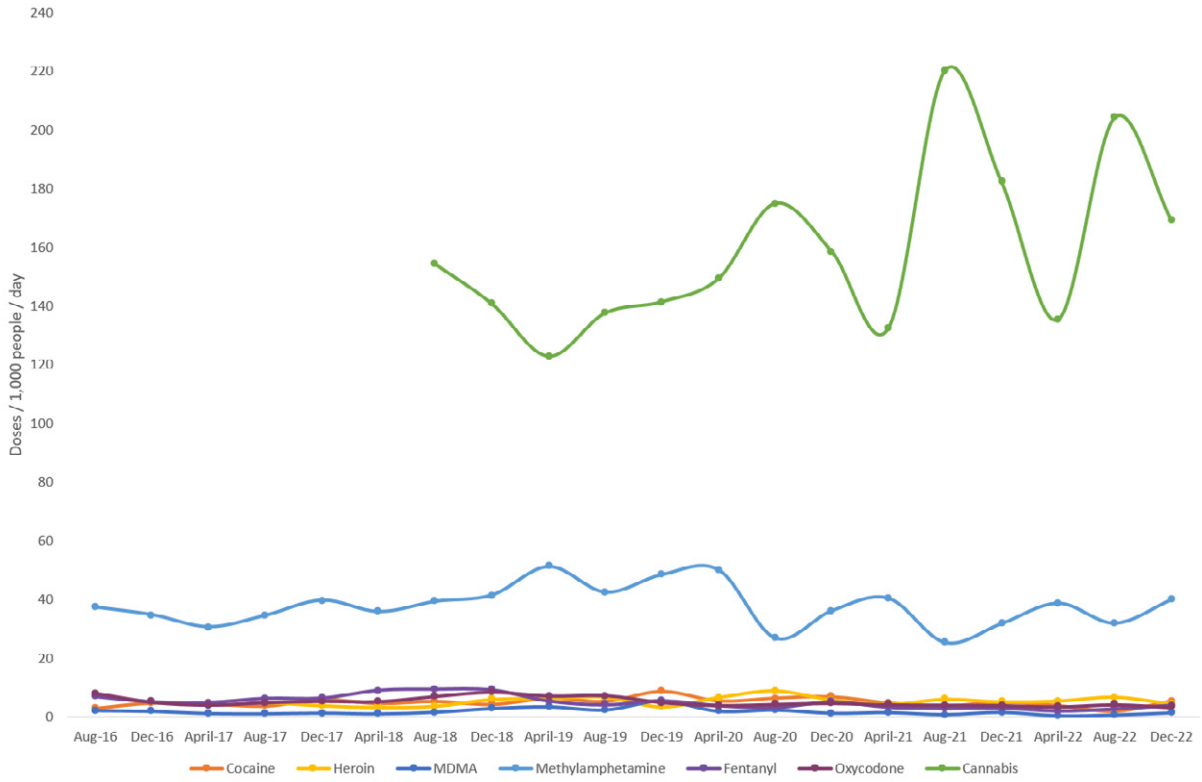
Triangulated data show that domestic drug markets are complex and vary between jurisdictions, with external influences affecting markets in different ways at different time periods. Other Program data illustrated that consumption of the respective drugs also varied considerably at different sites within jurisdictions. It is important that Australian drug datasets are interpreted holistically.

The ACIC engages with academic institutions, industry and public sector agencies to identify further data applications. Identified opportunities included 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. The Program is sufficiently flexible to allow for bespoke collection activity in different geographic locations and at varying intervals in response to identified needs and objectives.

DRUG CONSUMPTION SNAPSHOT

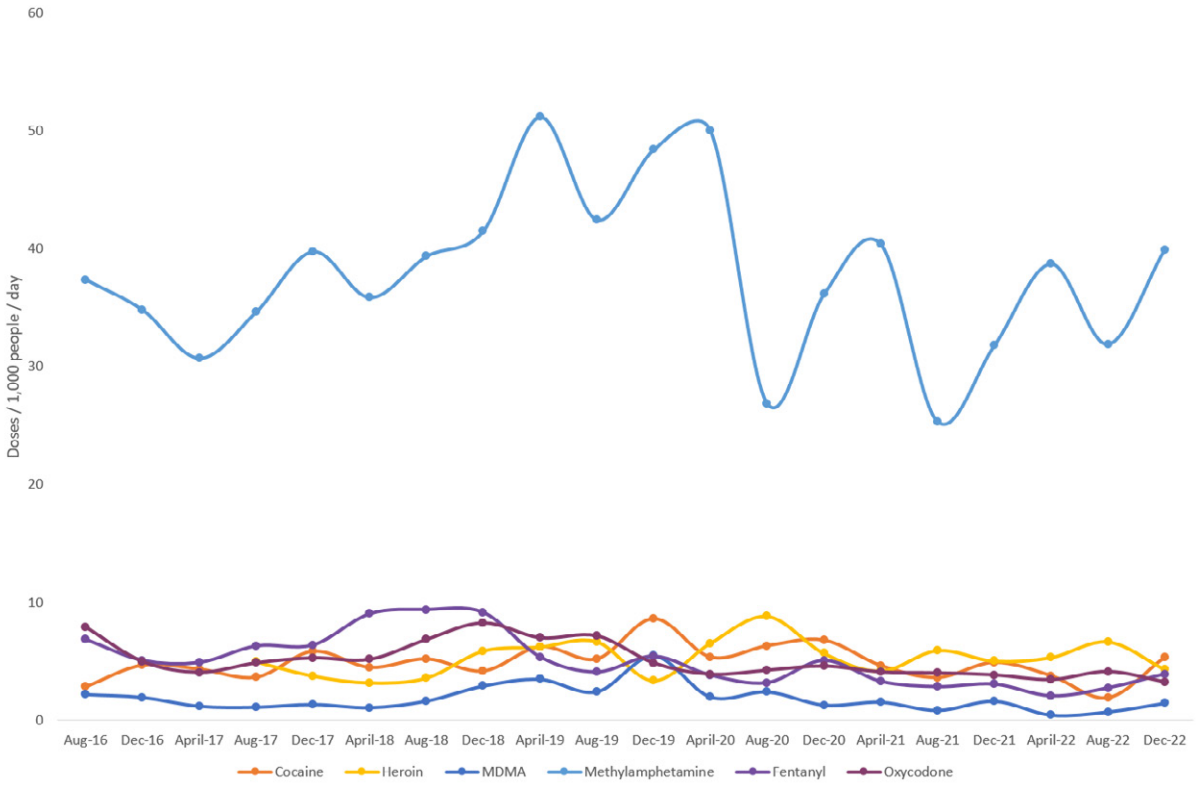
The calculation of a reliable dose figure for cannabis permits us to compare use of the drug with use of other drugs with available dose data. Nicotine and alcohol aside, cannabis is the most consumed drug by a large margin, despite substantial fluctuations (Figure 2). Cannabis consumption has been at least double the consumption of methylamphetamine throughout the time that both substances have been monitored by the Program, with consumption of methylamphetamine being less variable.

Figure 2: National average drug consumption of cannabis, methylamphetamine, cocaine, MDMA, heroin, oxycodone and fentanyl.



Consumption of drugs other than cannabis and methylamphetamine has also fluctuated throughout the life of the Program, albeit within a narrower range. There has been a considerable increase in cocaine consumption since the record low level in August 2022. Despite an increase in MDMA consumption, it remains one of the lowest consumed drugs monitored by the Program. In the current reporting period, heroin has been overtaken by cocaine and is now the fourth most consumed illicit drug. Consumption of fentanyl exceeded oxycodone for the first time since April 2021, with consumption of fentanyl increasing since April 2022. There was record low consumption of oxycodone in regional areas in December 2022 and in capital cities in February 2023.

Figure 3: National average drug consumption of methylamphetamine, cocaine, MDMA, heroin, oxycodone and fentanyl.



INTERNATIONAL COMPARISON

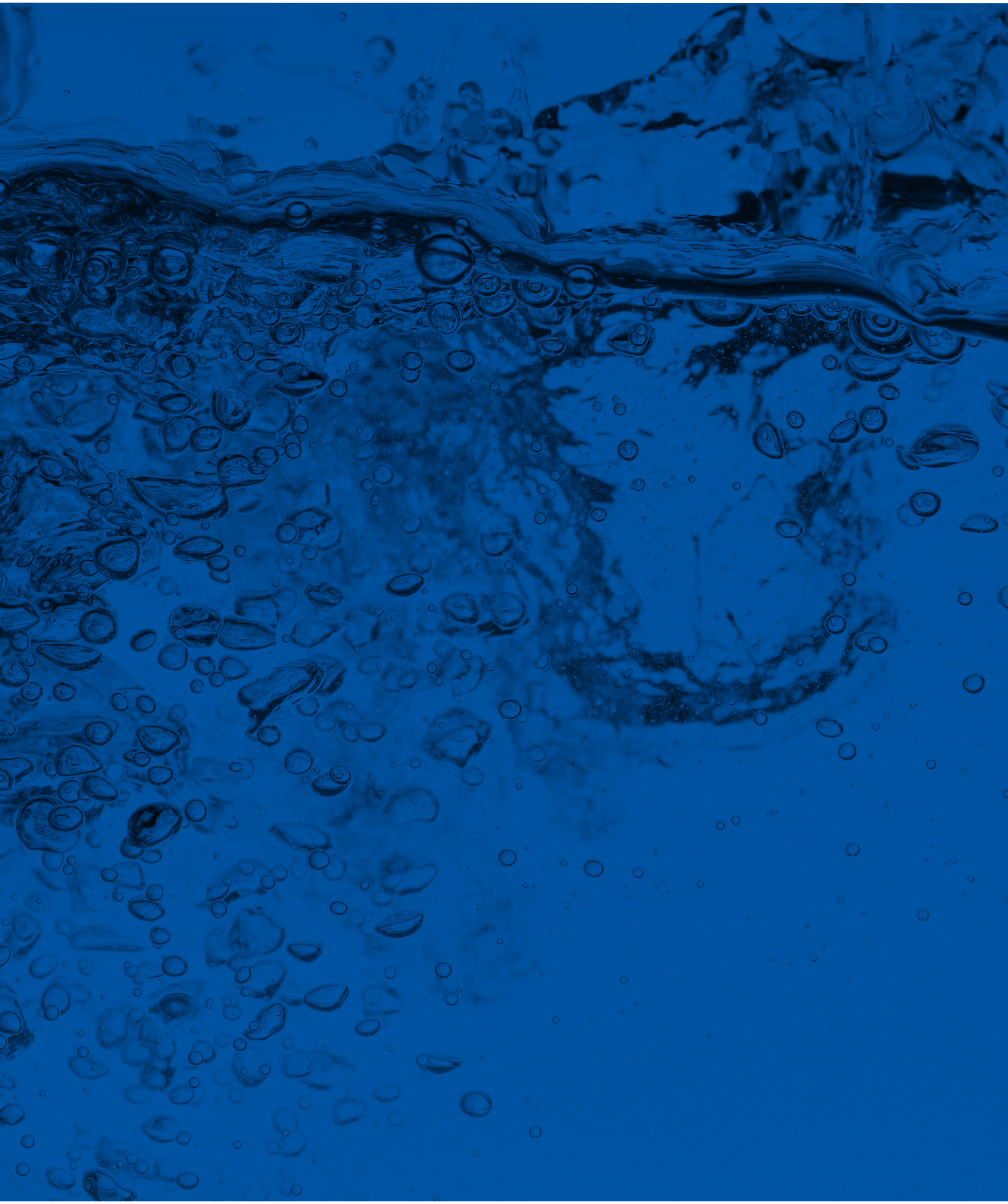
One of the advantages of wastewater analysis is that the process has been standardised by a European network of laboratories called SCORE[3]. The SCORE network permits comparison between analytical results obtained in 2022 from 161 cities in 28 countries in Europe, Oceania, North America and Asia. These results confirm the considerable per capita consumption of illicit stimulants in Australia, even in world terms, and that our illicit stimulant consumption is dominated by methylamphetamine.

EVOLUTION OF THE PROGRAM

Wastewater data are an important part of the national suite of datasets that increase understanding of drug consumption, demand and supply in Australian cities and regional locations. Ensuring Program data are publicly available assists understanding and informs the national conversation on drug markets, including their supply, the harm they cause and appropriate policy responses. Report 19 builds on national drug consumption data contained in the 18 preceding reports to identify trends over at least 6 years in drug use across states, territories and the nation.

3 SCORE is the Sewage Core Group Europe.

The ACIC's wastewater work extends far beyond the Program. We are exploiting new technology developed by our university partners to take sampling to an increasing variety of sites beyond wastewater treatment plants. Innovation in the range of chemicals that can be reliably detected and quantified in wastewater is also occurring, with these advances having application for law enforcement, health and broader community harm reduction purposes. Moreover, wastewater analysis now routinely extends to a broader range of drugs than is reported in the Program for research and development purposes, which aids future understanding of emerging drug market issues and responses.



RESEARCH FINDINGS

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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
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
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-tetrahydrocannabinol (THC-COOH).

1: EXECUTIVE SUMMARY

The Australian Criminal Intelligence Commission (ACIC)'s National Wastewater Drug Monitoring Program (NWDMP or the Program) reports on selected substances of concern in most populated regions of Australia since August 2016. The current version of the NWDMP focuses on 12 licit and illicit drugs, including nicotine, alcohol, the stimulants methylamphetamine, amphetamine, cocaine, MDMA (ecstasy) and MDA, as well as the opioids oxycodone, fentanyl and heroin. Cannabis and ketamine make up the remaining number. Estimates of drug consumption in a population are determined from measured concentrations of drug metabolites (excreted into the sewer system after consumption) in wastewater samples and results are used to monitor trends in drug consumption 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 the Program. Each site has been allocated a unique code which is assigned to each WWTP throughout the course of the Program. Site names are not included in this report to maintain treatment plant confidentiality.

For Report 19, wastewater samples were collected for up to 7 consecutive days during weeks in December 2022 and February 2023. The December 2022 collection involved regional and capital city sites, while February 2023 included capital city sites only. A total of 57 sites participated in the Program for the December 2022 period, consisting of 20 capital city WWTPs and a further 37 regional WWTPs, covering a population of 13.9 million Australians. Data from this report equates to coverage of approximately 55 per cent of Australia's population for December 2022 and 48 per cent for February 2023 (capital city sites only).

A total of 525 new samples have been added to the 9,075 already reported previously, bringing the total number since the beginning of the Program to 9,600. The collected samples provide comprehensive, Australia-wide baseline data against which subsequent results can be compared to ascertain both spatial and temporal trends. The snapshot of the scale of drug consumption over a week in December 2022 was compared with historical data included in previous reports. The December 2022 dataset was used for the spatial comparison as it was more comprehensive, including both capital city and regional sites. The temporal comparison includes the latest capital city collection data for February 2023.

Cannabis use has been expressed for the first time since its inclusion in the Program as daily doses per 1,000 people. This enables cannabis to be scaled against other drugs in the report. When drugs were expressed in average dose amounts, alcohol and nicotine consistently ranked as the highest consumed drugs in all states and territories in December 2022. However, cannabis was the most consumed illicit drug across the country, followed by methylamphetamine. Other psychoactive substances included in the report, whether legally prescribed or not, were mostly consumed at levels well below the 4 drugs already mentioned.

The average consumption of nicotine was slightly higher in regional areas in December 2022 compared to capital cities, but there was record low consumption of nicotine nationally in December 2022. Consumption was variable between sites, particularly regional parts of the country. Aside from the Australian Capital Territory, specific sites in every state and the Northern Territory had above average nicotine consumption in the current period. The Northern Territory and Tasmania have generally been the areas with highest overall nicotine consumption over the life of the Program.

Alcohol consumption in regional areas was also higher than that in the capital cities in December 2022. The regional site in the Northern Territory and a capital city site in Tasmania had the highest

alcohol consumption. There was a decrease in average alcohol consumption in capital city and regional sites in February 2023 and December 2022 respectively to the lowest levels recorded by the Program.

Population weighted average methylamphetamine consumption was higher in the capital cities than in regional Australia in December 2022. Capital city sites in almost every state had above average consumption of the drug. Several regional sites across the country also recorded well above average consumption in December 2022. On a jurisdictional level, the recent findings show that methylamphetamine consumption was highest in South Australia and Western Australia. Nationally, consumption of the drug continues to fluctuate.

Cocaine consumption in Australia in December 2022 was much higher in the capital cities than in regional areas. There was above average consumption of the drug in capital city sites in New South Wales and Victoria, and in regional sites in New South Wales and Queensland. This caused an overall increase at a national level from record low consumption in August 2022.

MDMA consumption remains at the low end of the scale compared to levels thus far in the Program, however has been on an increasing trajectory since April 2022. Use of the drug in capital cities was marginally higher than in regional Australia in December 2022. A capital city site in New South Wales and regional site in Queensland had very high consumption. MDMA use in the current reporting period was tangibly higher than during the previous collection. However, the changes reflect relatively small actual amounts of drug, considering the low level of use compared to other illicit stimulants nationally. MDA, being a stimulant in its own right as well as a metabolite of MDMA, was excreted at relatively low levels. Population weighted average excretion was highest in the capital cities, with sites in New South Wales and Western Australia recording use well above any other sites.

Oxycodone and fentanyl are prescription pharmaceutical opioids with abuse potential. The average consumption of oxycodone and fentanyl was considerably higher in regional parts of the country in December 2022 compared to capital city sites. In the case of oxycodone, the difference was almost double. Nationally, oxycodone consumption appears to have reached a plateau at historically low levels, with small short-term variability. Fentanyl consumption increased in several jurisdictions in the current collection period. Since April 2022 fentanyl consumption has increased in the capital cities and regional areas.

Population weighted heroin consumption in the capital cities was more than triple that in regional Australia in December 2022. Consumption of the drug was highest in capital city and regional sites in Victoria. In contrast, heroin use in many other regional parts of Australia is too low to measure using current methods.

Cannabis consumption was twice as high in regional Australia as in the capital cities in December 2022. Use of the drug in some parts of regional South Australia was the highest in the nation, although sites in several other states had well above average consumption of the drug. Cannabis consumption in the capital city of the Northern Territory declined sharply, but there were high levels of consumption in some regional sites in the Northern Territory, Queensland and South Australia.

In addition to its use in pain management, ketamine is a compound of emerging concern over its abuse potential. Consumption of ketamine has been increasing in capital city and regional sites since April 2022. On average, capital city excretion levels were higher than the regional averages in December 2022. Some capital city sites in the eastern states recorded very high levels and large

differences across the collection week. The regional site in the Northern Territory also had ketamine excretion at relatively high levels. Nevertheless, compared to other drugs excreted amounts were relatively low.

The Australian consumption data from the NWDMP were also compared to an international dataset from March to May 2022 for cities from 24 countries in Europe, as well as one city in the United States of America (USA), 4 in New Zealand and one in Korea. Australia ranked sixth highest in terms of combined stimulant use (cocaine, meth/amphetamines and MDMA), behind the USA, Czechia, Sweden, Belgium and the Netherlands. The proportion of each stimulant was different among nations, with cocaine and amphetamine being the dominant stimulant in most European countries, while methylamphetamine was dominant in Australia, Korea, USA, New Zealand and a few countries in Eastern Europe. Australia was third highest in methylamphetamine consumption, and at the mid to lower end of cannabis, MDMA and cocaine consumption compared to the other countries.

2: INTRODUCTION

2.1 PREAMBLE

Wastewater analysis is a technique for monitoring the 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 3-year program from 2016 to 2019, including 9 public reports. The universities have been re-commissioned to provide data for an ongoing program. Wastewater treatment sites have been assessed, bimonthly in the case of capital city sites and every 4 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 consumption across Australia to establish trends. This latest NWDMP report compares consumption data from previous reports with results obtained subsequently from all sites in December 2022 and capital cities in February 2023. The report presents patterns of substance consumption across Australia, showing differences in levels between capital cities and regional centres, within and between states and territories, and nationally.

Compounds of concern include nicotine from nicotine intake (cigarettes, gum, patches, e-cigarettes, etc.), ethanol from alcohol consumption, pharmaceutical substances with abuse potential such as oxycodone, fentanyl and ketamine, as well as illicit substances including methylamphetamine, MDMA, MDA, cocaine, cannabis and heroin.

Some drugs share a common clearance pathway from the body. Methylamphetamine is partially metabolised and excreted as amphetamine, while part of a MDMA dose is converted to MDA. The pharmacokinetics of these 4 compounds have been documented and have been accounted for in this report (Pizarro et al. 2002; Khan & Nicell 2011). MDA is 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 and expressed as mg excreted per 1,000 people per day (daily mass load). Due to the lack of information of MDA elimination following MDA ingestion, consumption estimates cannot be calculated.

Cannabis results in previous reports were expressed as the amount consumed per day per 1,000 people. In this report, a revised excretion factor and dose have been applied in the back-calculation to estimate consumption so that the scale of cannabis use can be compared to other drugs. More information is provided in Appendix 1. MDA and ketamine results continue to be reported as the amount (mg) of drug excreted per day per 1,000 people due to the absence of clear information available in the scientific literature around suitable factors to estimate consumption of the substances in wastewater.

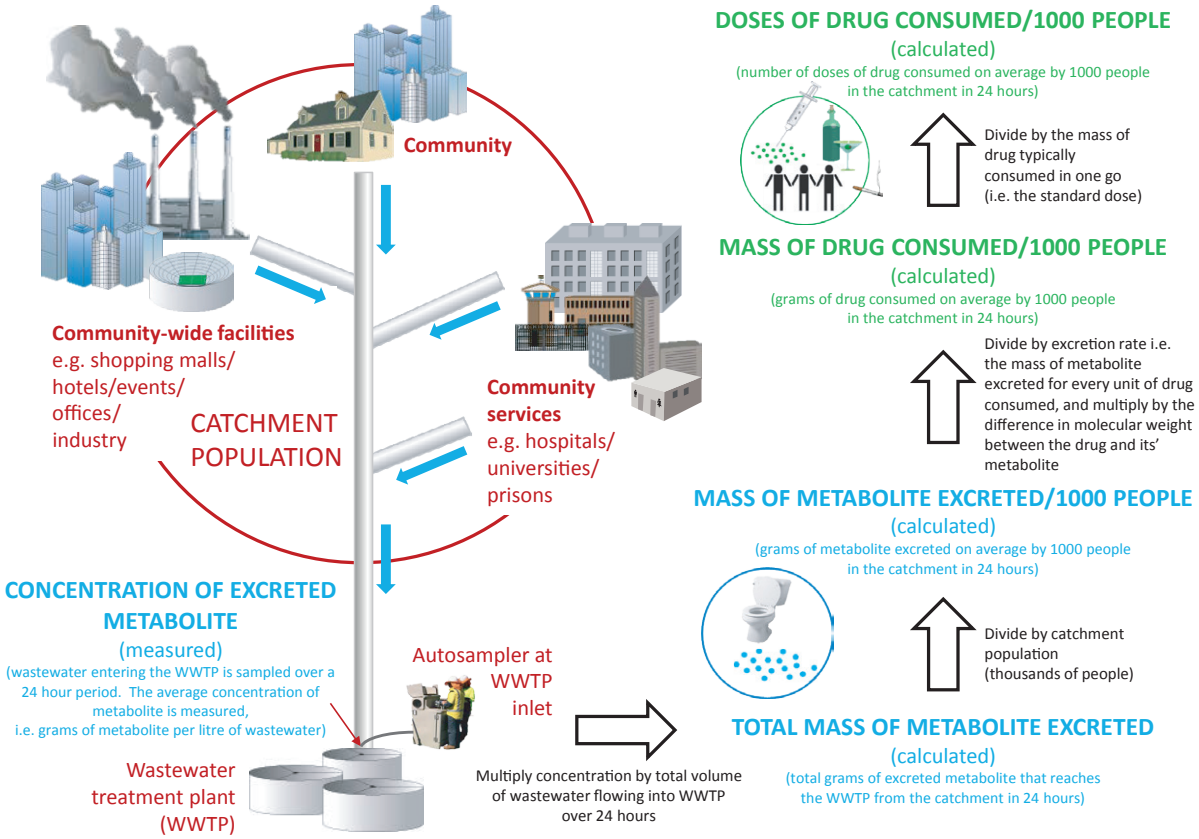
3: METHODS

The method underlying wastewater-based monitoring of drug consumption in a given population is based on the principle that any given compound 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 referred to as a metabolite. Once the excreted compound or metabolite is flushed, it will enter the sewer system, assuming the toilet forms part of a wastewater catchment.

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.[4] 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 4). The method is non-invasive and is done on a population-scale level, so individuals are not targeted, and privacy is respected.

4 Information in relation to heroin appears in Report 3.

Figure 4: 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. Apart from a few sites in regional Western Australia, operators have been collecting a second daily influent sample with sodium metabisulphite (0.5% m/v) as preservative from August 2018 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 these 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). 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.

3.1 PARTICIPATING WASTEWATER TREATMENT PLANTS (WWTPs)

Fifty-seven WWTPs across Australia participated in the NWDMP for the December 2022 collection period (Figure 5). Of these, 20 sites were located in capital cities and a further 37 in regional areas, covering a wide range of catchment population sizes. Sites were selected in consultation with the ACIC. 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 for the course of the Program. Only site codes are presented in the results.

Figure 5: Participating WWTPs in December 2022 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.

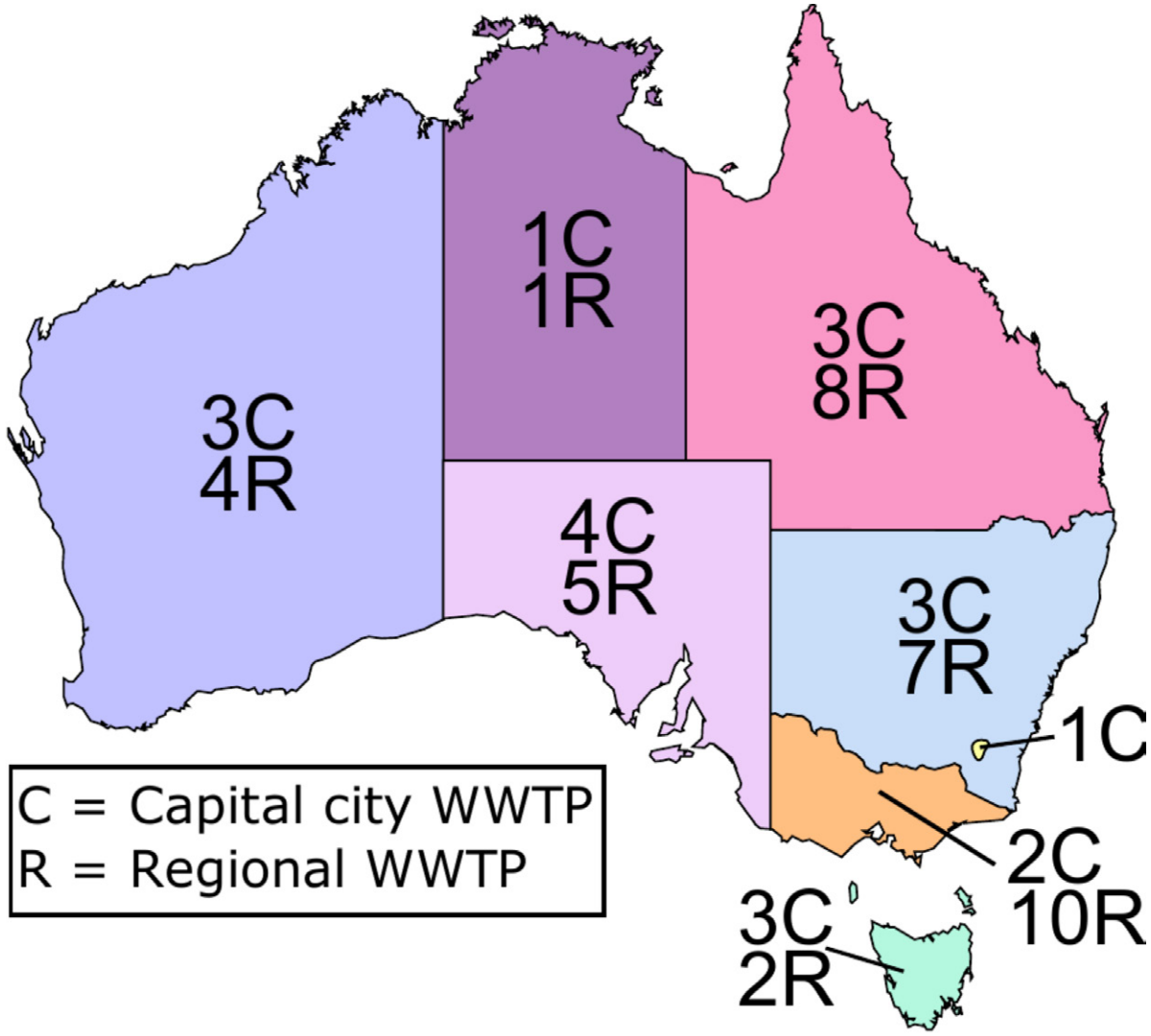


Table 1: Number of participating WWTPs for the periods covered in this report. One collection period aims to collect data from both capital city (C) and regional (R) sites, while the other collection period aims to collect data from capital city sites only.

State/territory	Dec 2022 Capital	Dec 2022 Regional	Feb 2023 Capital
ACT	1	0	1
NSW	3	7	3
NT	1	1	1
Qld	3	8	3
SA	4	5	4
Tas	3	2	3
Vic	2	10	2
WA	3	4	3
Sites	**20**	**37**	**20**
Population (millions) C & R	**12.1**	**1.8**	**12.1**
% of Australian population	**47.6**	**7.1**	**47.6**
Total population (millions)	**13.9**		**12.1**
% of Australian population	**54.7**		**47.6**

Estimates have been rounded to the nearest 0.1 million. Census 2021 population used (25,422,788) for population percentage estimates.

3.2 SAMPLE COLLECTION AND PREPARATION

Daily composite samples were collected by treatment plant staff on 7 consecutive days, or where 7 days was not feasible, across as many consecutive days as possible. Weekend samples in many of the Tasmanian sites were not available. Small revisions may be made to historical data when more accurate data become available, for example, when updated flow measurements supplied by wastewater treatment authorities or population estimates become available, such as the Census 2021 figures. 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 numbers, 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 the 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 6. This includes information on interpreting the consumption data presented on the vertical axes in all graphs in this report. To improve readability of graphs with higher results in one site, we have reduced the graph height and labelled the higher value on the bar (values obtained from the left axis). 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. This is similar for ketamine. From Report 19, cannabis results are presented as doses per day per 1,000 people in addition to the mg per day per 1,000 people, similar to most other drugs included in the report. This has to be considered when referring to historical reports where results were shown only as daily mass load consumed per 1,000, and the calculation of cannabis used a different excretion rate which was revised in Report 19. From Report 19 all current and historical data have been revised and are comparable within the report.

Bubble charts are included to represent the relative extent of consumption in capital city and regional areas for each jurisdiction. See Figure 7 for a description of how to interpret the bubble charts.

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)[5] 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.

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

Weekly pattern of drug use: The pattern of drug consumption 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 the maximum, minimum and average (for individual sites as illustrated in Figure 6) and only population-weighted average values for all other graphs. Consistent patterns of drug consumption in Australia from previous wastewater-based epidemiology studies indicate that some substances such as cocaine, MDMA and alcohol have high variation in weekly consumption rates, with higher consumption on weekends. 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).

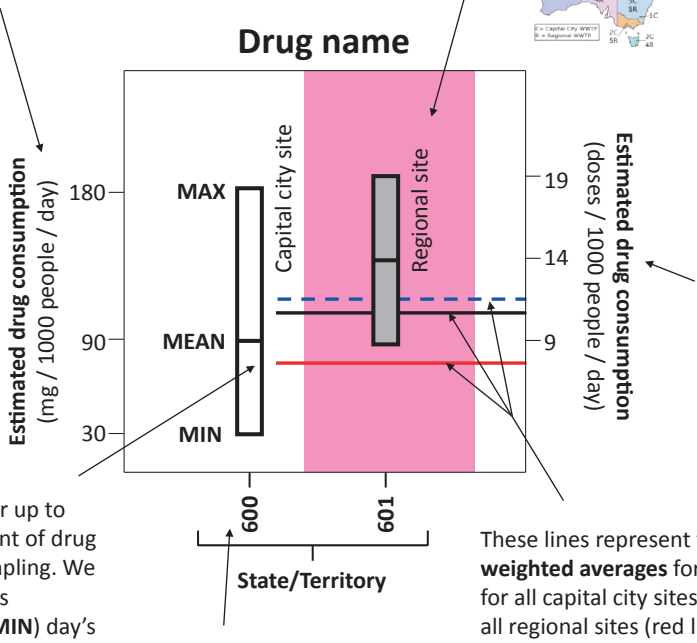
Figure 6: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

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.

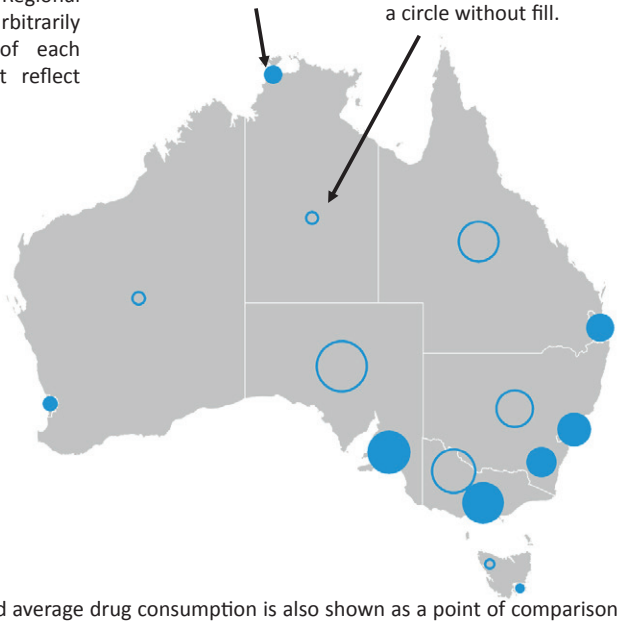
Figure 7: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

Bubbles:
Capital city site averages are drawn over the capital city of a jurisdiction and the regional site averages are drawn in the middle of the State or Territory. Regional bubbles are drawn arbitrarily close to the centre of each jurisdiction and do not reflect location of sites.

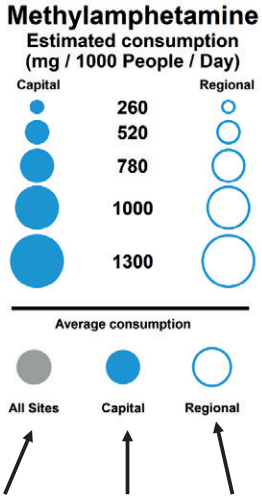
This type of plot gives a rough overview of drug consumption per jurisdiction. The other temporal and spatial comparison graphs give greater resolution to compare between locations and over time, and should be used for analysis.

Capital city average:
Population-weighted average of all capital sites tested per jurisdiction. Capital sites are indicated by a filled circle.

Regional city average:
Population-weighted average of all regional sites tested per jurisdiction. Regional sites are indicated by a circle without fill.



Legend:
The population-weighted average drug consumption for each jurisdiction is represented as a scaled circle. Representative consumption estimates are shown at the right of the bubble plot. Each bubble is scaled individually based on the consumption level.



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.

4: RESULTS

Estimated drug consumption data are presented in several different ways in the following sections to allow comparisons of drug consumption at the individual site level (section 4.1), temporal trends for states and territories for the past 2 years (section 4.2) and within each state and territory (section 4.3). December 2022 data were used for section 4.1, which compares the individual sites 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. It is not always possible to coordinate collection of the same week of the month at all sites, so sampling weeks may not correspond in all instances. A list of the detection frequency for each drug can be found in Appendix 3. 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 2022

4.1.1 NICOTINE AND ALCOHOL

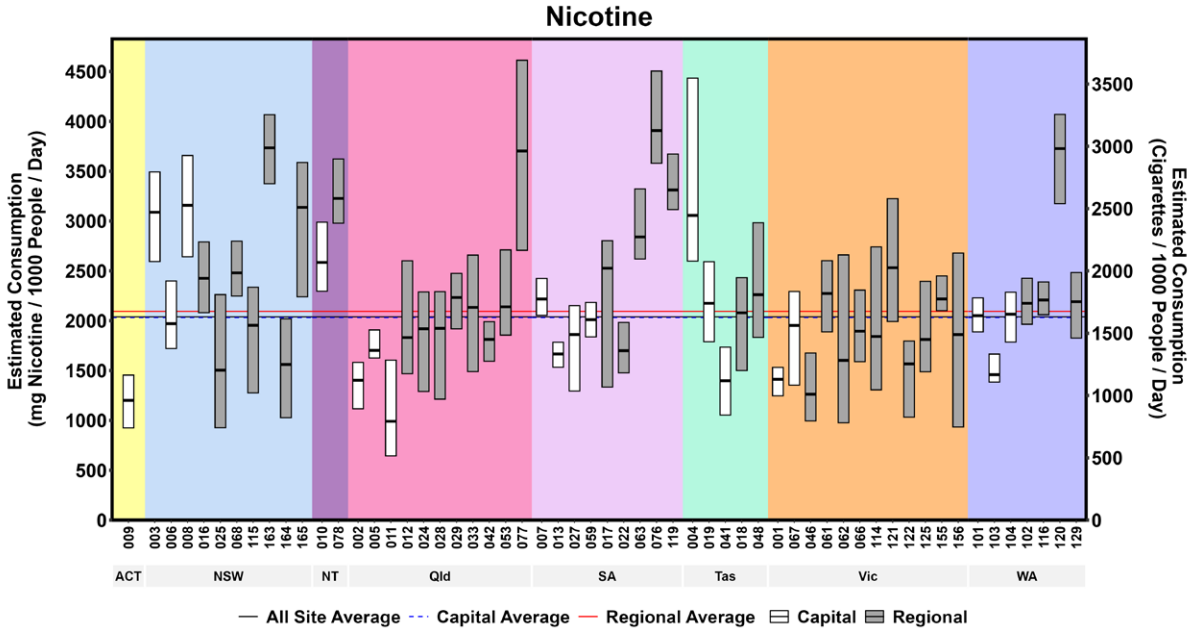
Nicotine is the main psychoactive substance present in tobacco leaves, some vaping products and treatments aimed at discouraging smoking behaviour. Two nicotine metabolites, cotinine and hydroxycotinine, were used to estimate the consumption of nicotine. The estimate is expressed as nicotine in this report as the method cannot distinguish between nicotine intake from tobacco, electronic cigarettes and nicotine replacement therapies such as patches and gums.

Nicotine consumption estimates during the December 2022 collection week show large variability across the country (Figure 8). The regional average was higher than in the capital cities (red horizontal and dotted blue lines, respectively). Specific sites in several states consumed nicotine at levels well above the respective averages. Nicotine consumption showed large fluctuations over the sampling week at some sites, indicated by longer bars.

The specific marker of ethanol consumption, ethyl sulphate, was used to determine the scale of alcohol use across the country. The December 2022 averages show that alcohol consumption was higher in regional areas than in capital cities (Figure 9). Apart from a regional site in the Northern Territory and a capital city site in Tasmania, the variability between sites was less than observed for nicotine. Very large differences between days of the week were observed in many parts of the country, reflected by the length of the bars in the graph. In most cases this is due to higher consumption of alcohol on weekends. Some regional sites in Tasmania only provided weekday samples, which may have affected the pattern in that state.

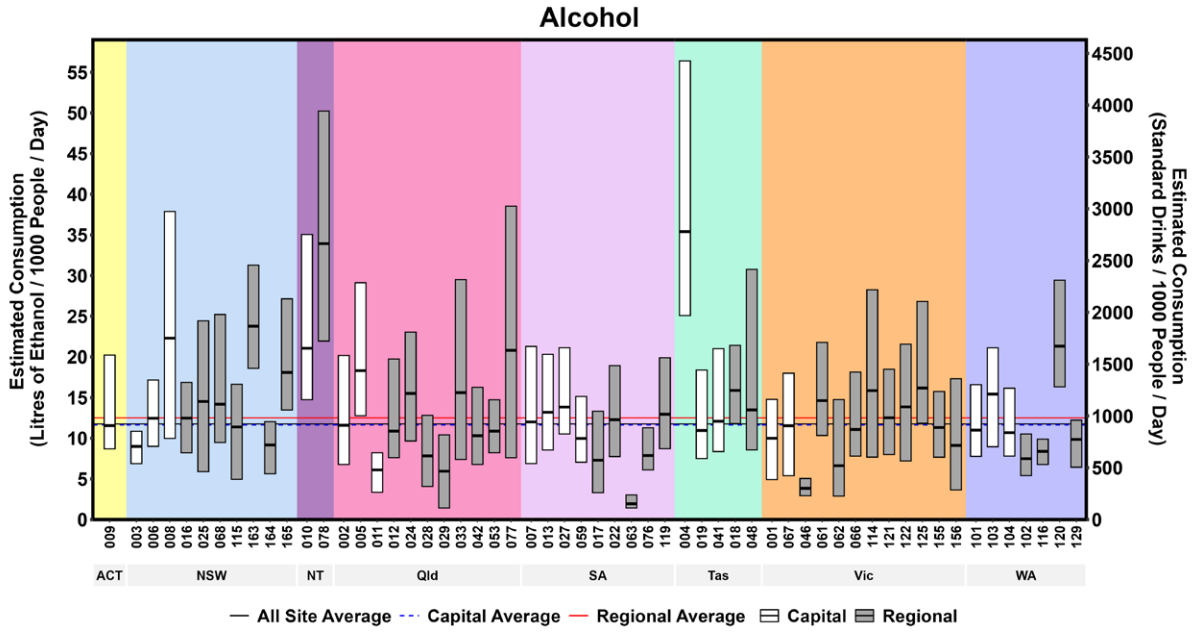
Relative consumption levels can be represented by showing the scale of consumption of nicotine (Figure 10) and alcohol (Figure 11) as capital city or regional ‘bubbles’ for each state and territory. The above average consumption of nicotine and alcohol in regional parts of the Northern Territory is evident from the size of the bubbles in that region. These findings need to be understood in the context of there being only one regional site included for this jurisdiction. The capital city use of nicotine is spread more evenly, while that of alcohol is higher in the Northern Territory and Tasmania.

Figure 8: Estimated nicotine consumption for December 2022 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 to 7.



- Higher regional average
- Large differences across Australia

Figure 9: Estimated alcohol consumption for December 2022 in litres consumed per day (left axis) and standard drinks per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- Higher regional average
- Wide weekly spread a common feature

Figure 10: Estimated average nicotine consumption per jurisdiction for December 2022 in number of cigarettes per day per thousand people. The number of collection days varied from 5 to 7.

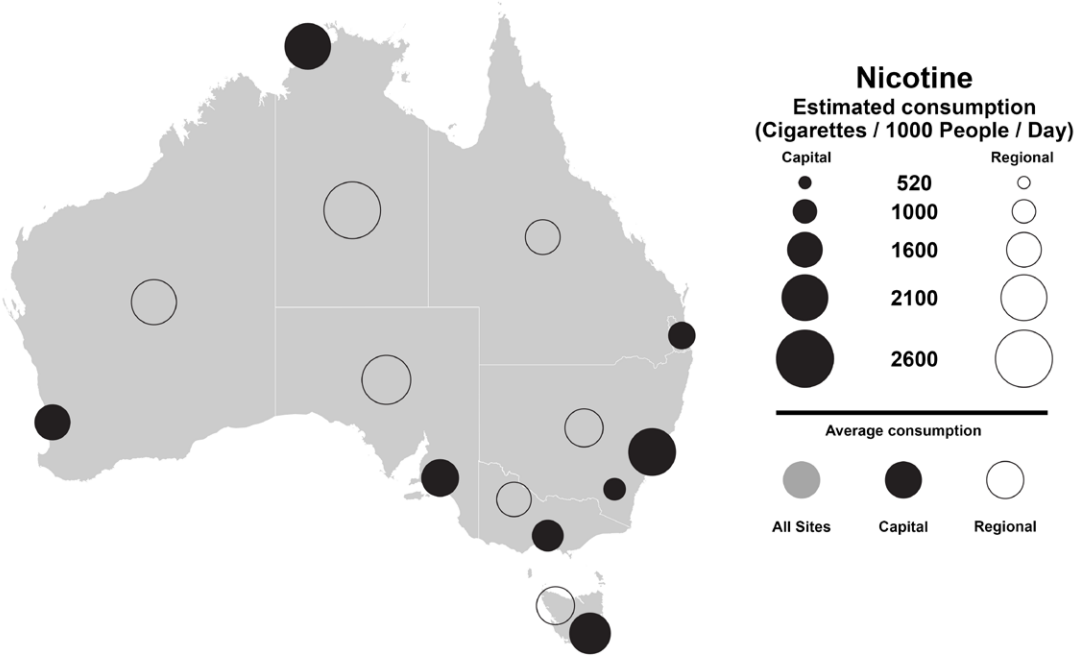
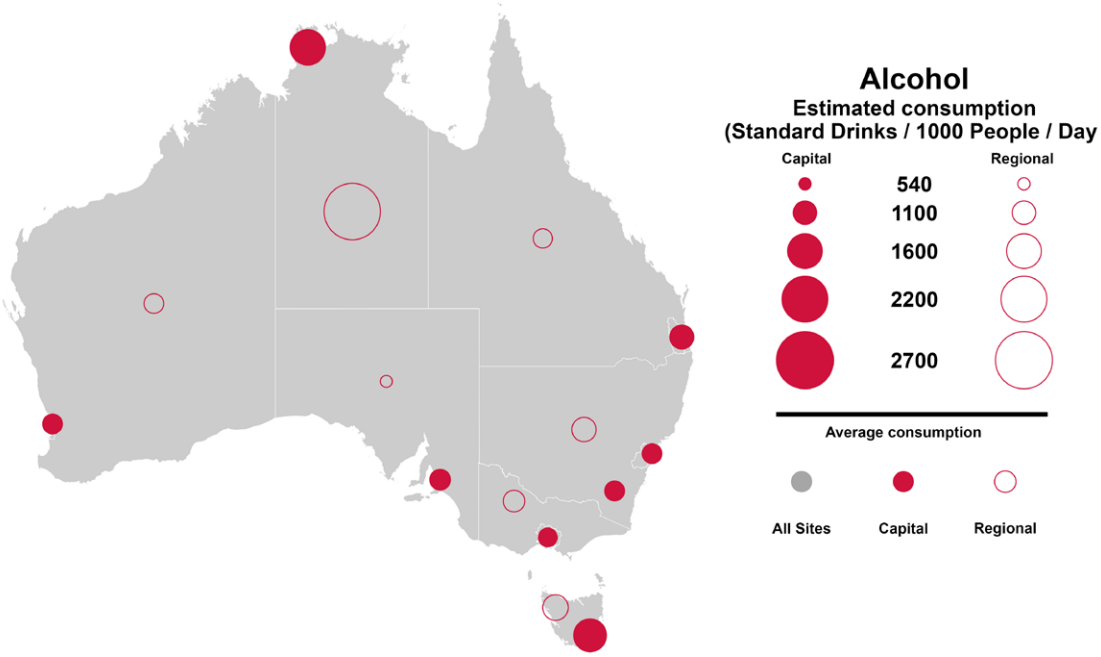


Figure 11: Estimated average alcohol consumption per jurisdiction for December 2022 in number of standard drinks per day per thousand people. The number of collection days varied from 5 to 7.



4.1.2 STIMULANTS

4.1.2.1 METHYLAMPHETAMINE

Methylamphetamine consumption was variable across Australia in December 2022 (Figure 12). The regional average was lower than that of the capital cities, although that was not necessarily the case at a jurisdictional level. The difference in consumption between days of the week was generally smaller than for MDMA and MDA. The Australian Capital Territory, Northern Territory and Tasmania were some of the lowest consumers of methylamphetamine on an overall jurisdictional level.

4.1.2.2 AMPHETAMINE

The measured concentration of amphetamine in the December 2022 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 largely in agreement with our previous findings (see Appendix 4 of Report 1). The levels of amphetamine in wastewater samples can be largely attributed to the metabolism of methylamphetamine. However, the drug is also prescribed for some behavioural disorders and the method cannot differentiate between medical and illicit use.

4.1.2.3 COCAINE

Benzoylecgonine, the specific metabolite of cocaine, was used to estimate the consumption of the stimulant (Figure 13). On average, the capital city cocaine consumption was more than double that of regional areas. Cocaine use was very low in some regional catchments and dropped to below quantification limits on some days. The difference between days of the week was generally larger in the capital cities, reflected by the longer bars in the graph. A site in New South Wales had particularly high cocaine consumption. Overall, New South Wales consumption of cocaine was well above any other jurisdiction.

4.1.2.4 MDMA (3,4-METHYLENEDIOXYMETHYLAMPHETAMINE)

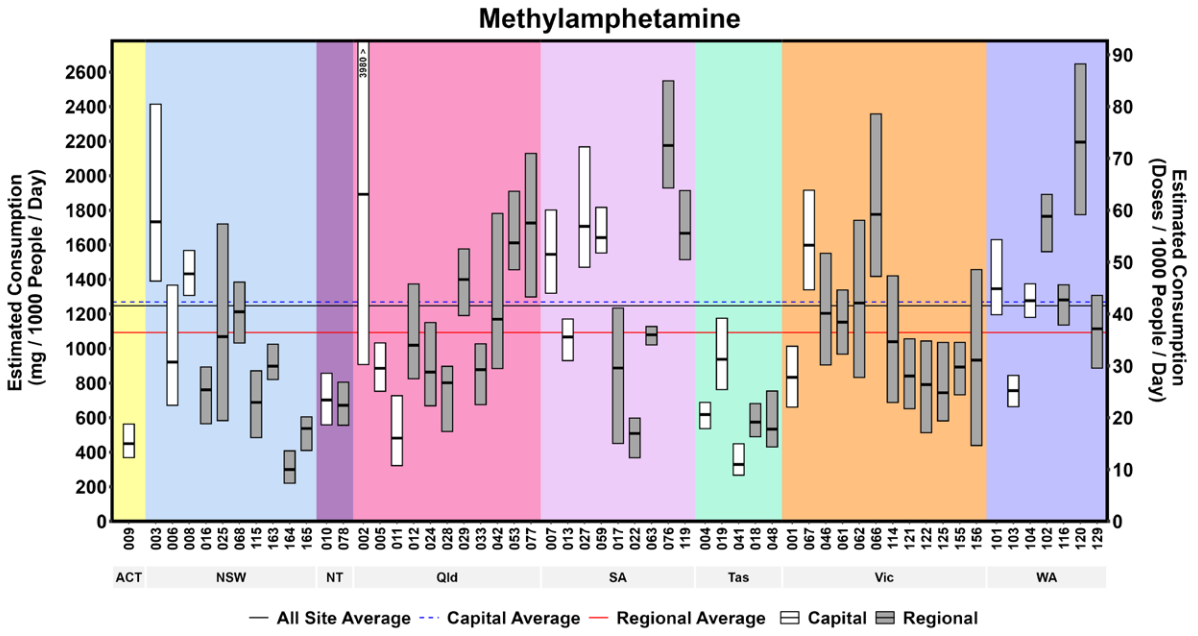
The average consumption of MDMA in Australia was much lower than methylamphetamine and cocaine (Figure 14). A site in each of New South Wales and Queensland had relatively high levels compared to elsewhere. Average regional consumption of MDMA was below the capital city average in December 2022.

4.1.2.5 MDA (3,4-METHYLENEDIOXYAMPHETAMINE)

Excretion levels of MDA were relatively consistent across most jurisdictions, with the exception of a site in New South Wales and several sites in Western Australia (Figure 15). A. New South Wales capital city site had the highest MDA use. The national capital city average was slightly higher than the national regional average.

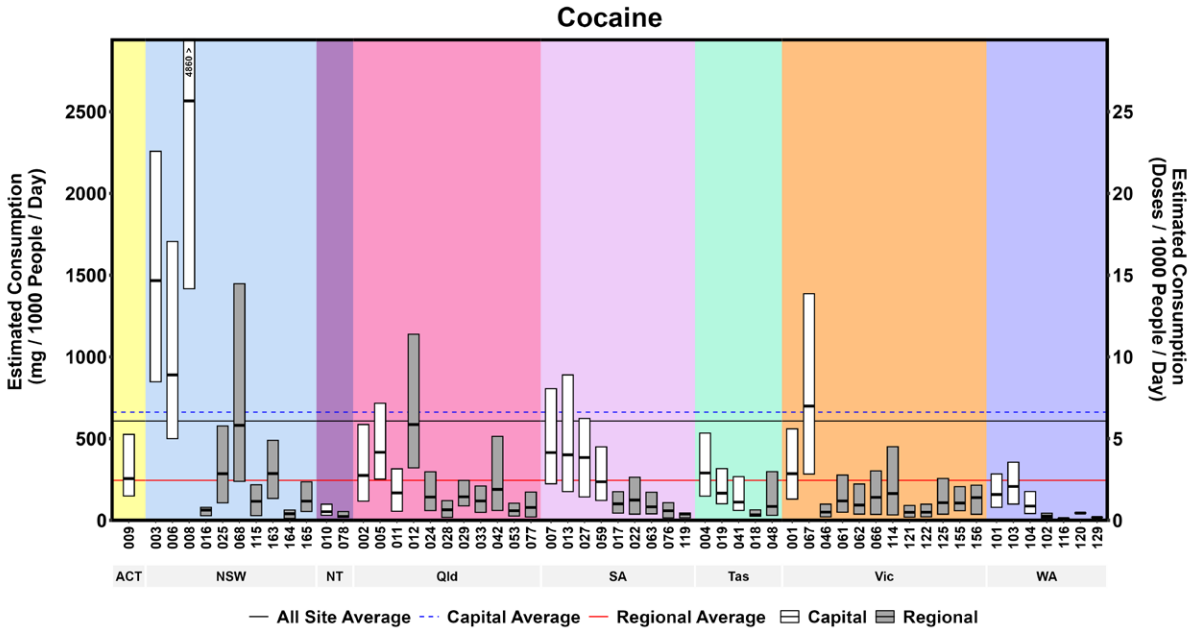
The scale of consumption is expressed as a bubble graph to compare regional and capital city consumption of methylamphetamine (Figure 16), cocaine (Figure 17), MDMA (Figure 18) and MDA (Figure 19) across the country. Higher consumption of methylamphetamine was evident in most mainland capital cities, while cocaine on the south-eastern seaboard and MDA on the west coast were very apparent.

Figure 12: Estimated methylamphetamine consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



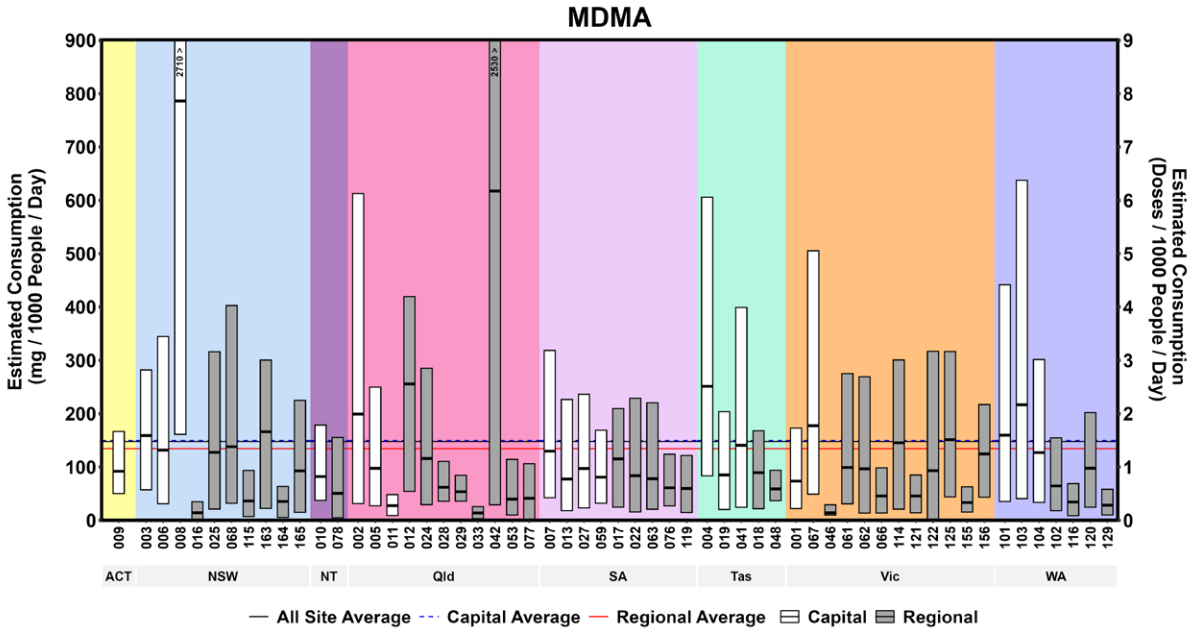
- Lower regional consumption
- High variability across the country

Figure 13: Estimated cocaine consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



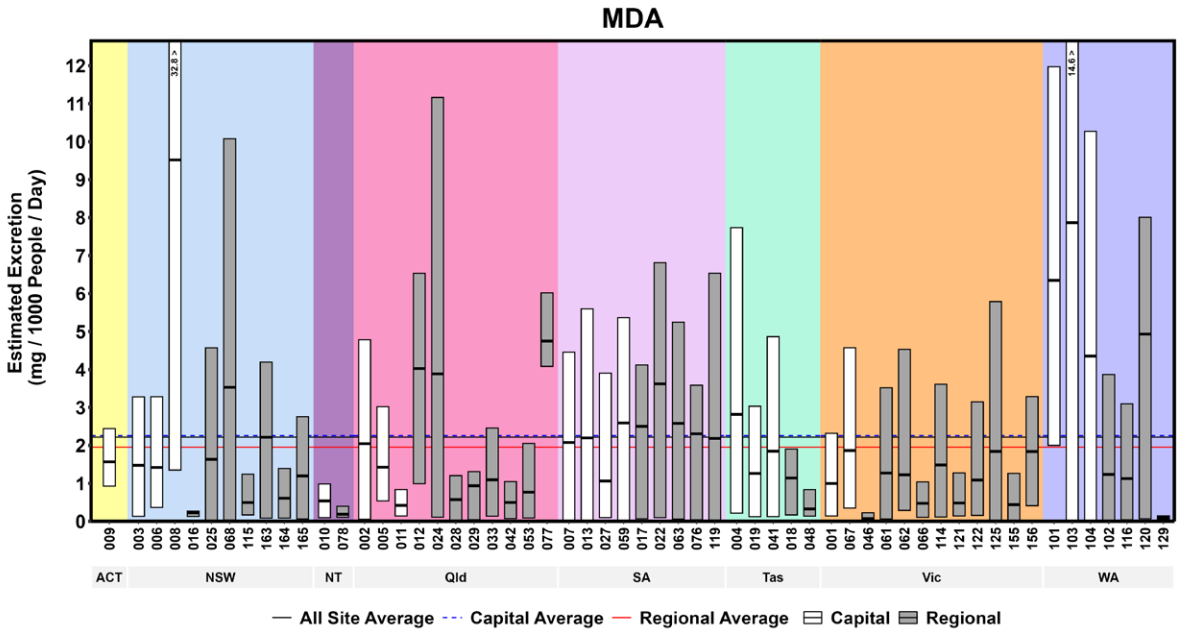
- Higher capital city consumption
- High overall consumption in New South Wales

Figure 14: Estimated MDMA consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- Mostly low consumption nationally
- Localised spikes in consumption

Figure 15: Estimated MDA excretion for December 2022 in mass excreted per day per thousand people. The number of collection days varied from 5 to 7.



- Relatively low use
- Some sites well above average

Figure 16: Estimated average methylamphetamine consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

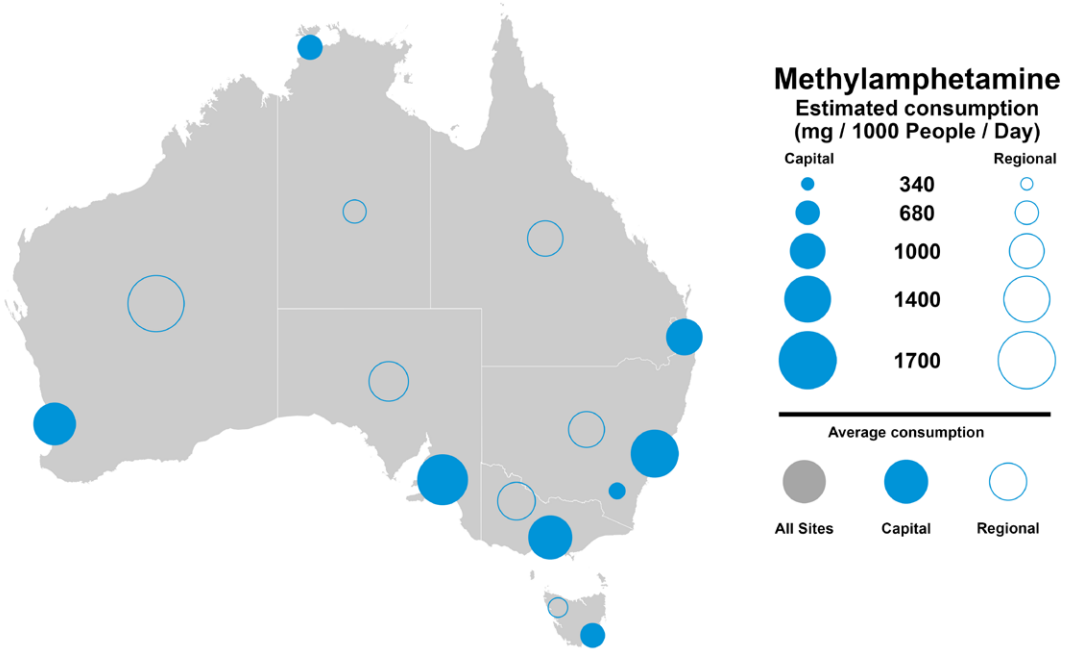


Figure 17: Estimated average cocaine consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

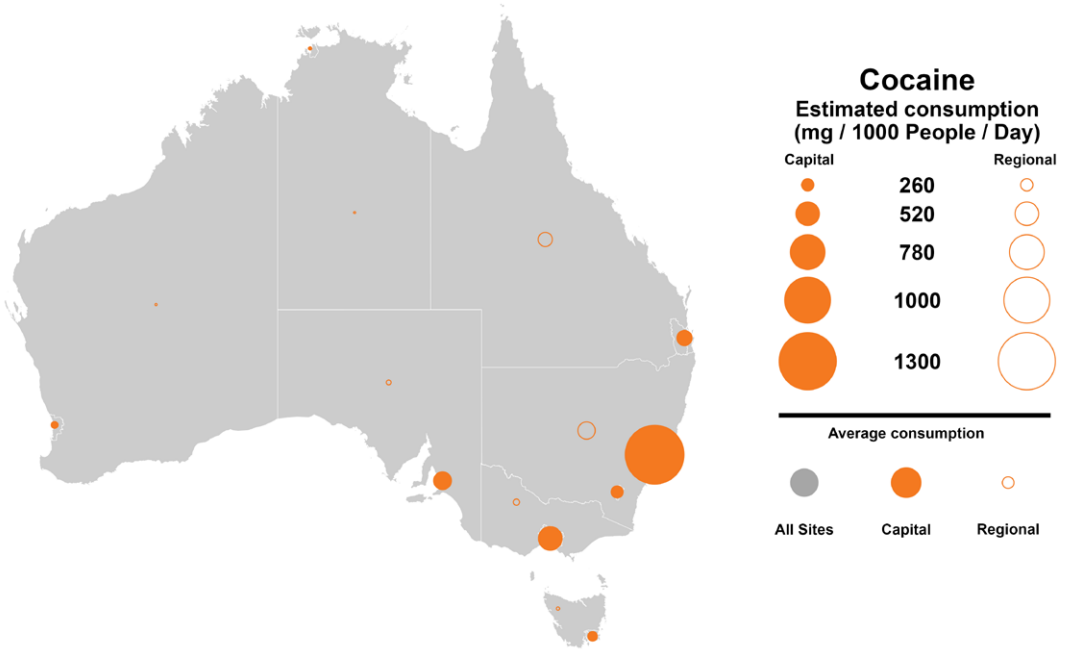


Figure 18: Estimated average MDMA consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

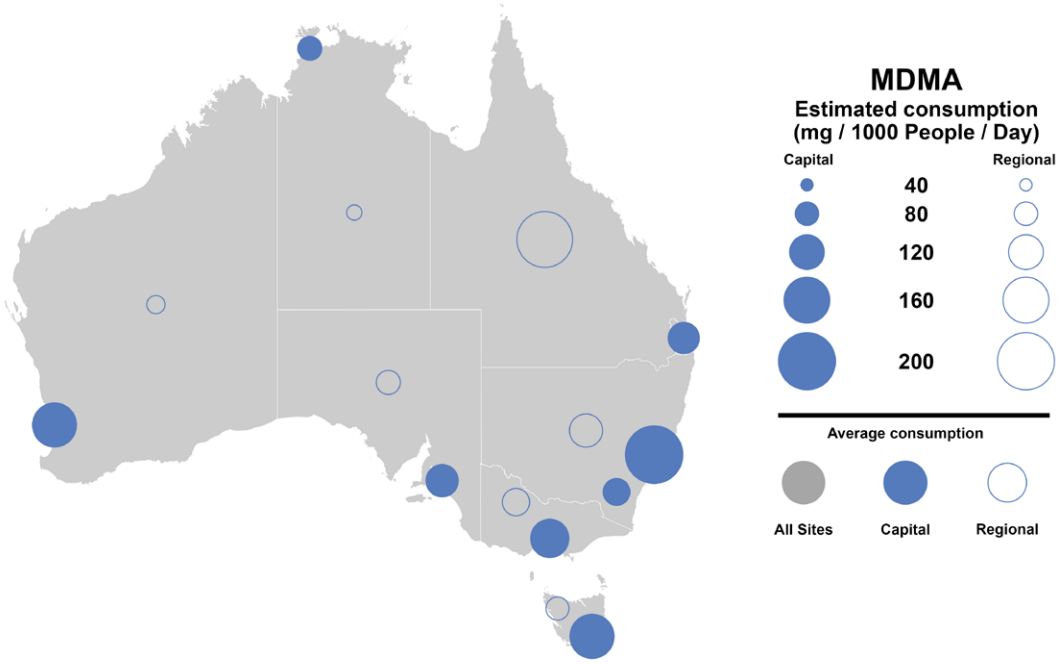
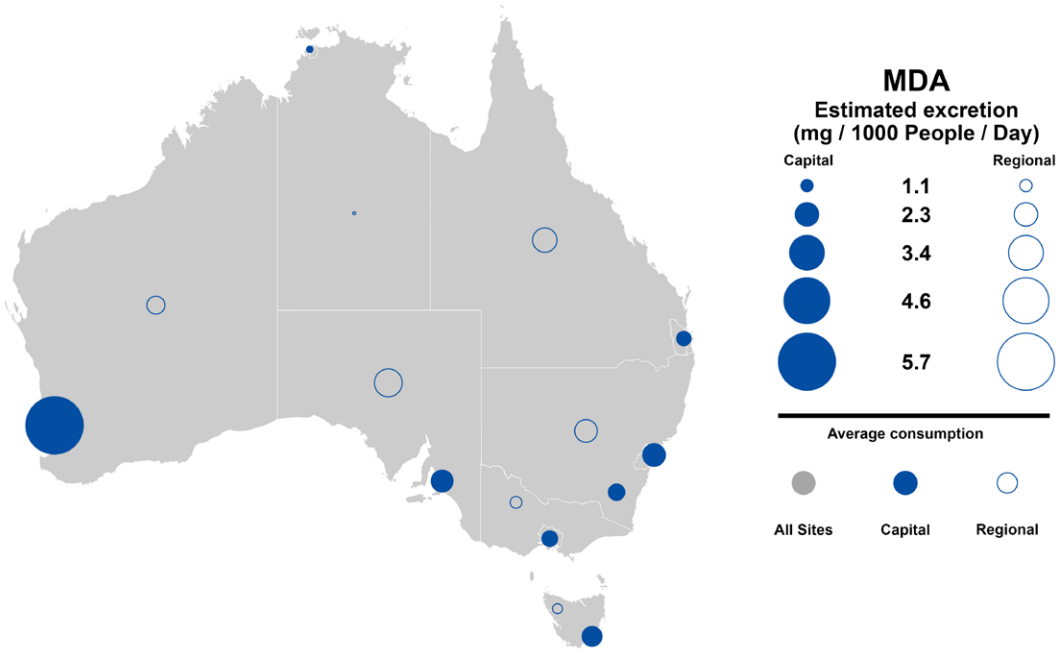


Figure 19: Estimated average MDA excretion per jurisdiction for December 2022 in mg excreted per day per thousand people. The number of collection days varied from 5 to 7.



4.1.3 OPIOIDS

Two prescription opioids are included in the report, as well as heroin, an illicit drug. Oxycodone and fentanyl are legally prescribed pharmaceuticals to alleviate pain. Although wastewater analysis cannot differentiate between prescribed use and consumption for non-medical purposes, these substances remain of interest due to their abuse potential.

4.1.3.1 PHARMACEUTICAL OPIOIDS

The metabolism and excretion profiles of oxycodone and fentanyl are well established. The main metabolites (noroxycodone, and norfentanyl) were measured to estimate their consumption.

Use of oxycodone in the December 2022 collection week was highly variable with distinctly higher average consumption in regional areas, compared with capital cities (Figure 20). Oxycodone consumption varied between sites. There was more variability between sites in regional parts of the country and also a greater spread over the collection week in many cases compared to the capital cities.

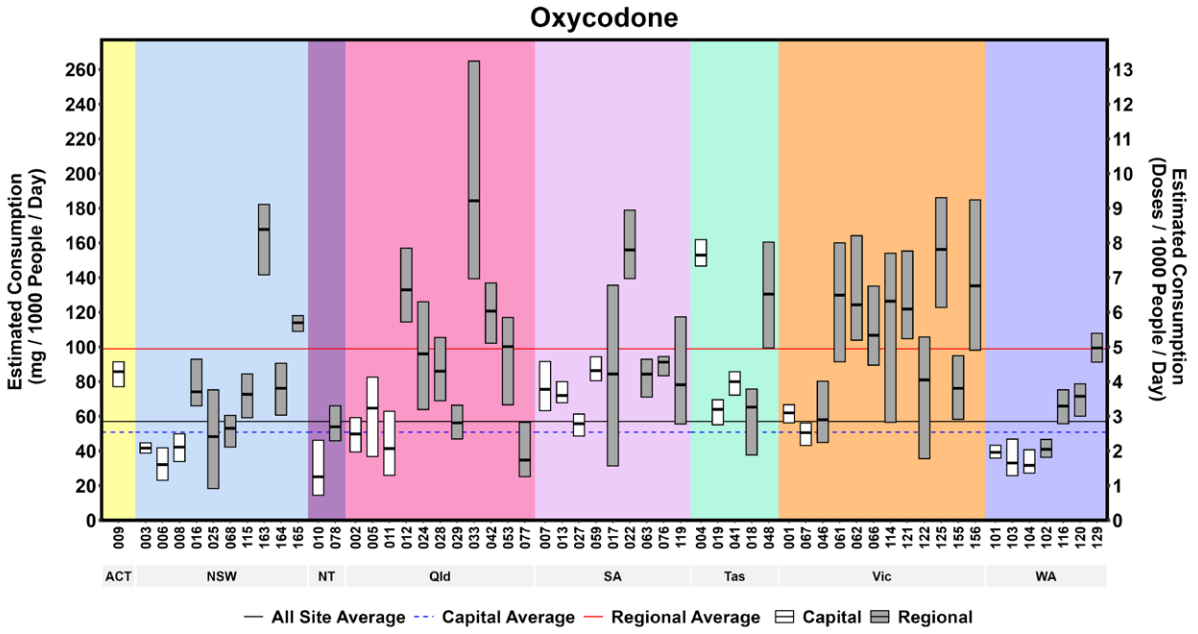
Fentanyl consumption was similarly substantially higher on average in regional Australia (Figure 21). The spatial difference between capital city and regional areas was less apparent in Western Australia. As with oxycodone, there was a wider spread in use over the course of the sampling week in regional areas. The highest consumption of fentanyl was found at some sites in regional New South Wales and South Australia, while a site in Tasmania had the highest capital city levels.

The relative scale of oxycodone and fentanyl consumption was apparent when results were aggregated by jurisdiction and capital city or regional area and presented in bubble graph form. Higher pharmaceutical opioid consumption was particularly evident in regional areas in the eastern states and South Australia (Figures 22 and 23).

4.1.3.2 HEROIN

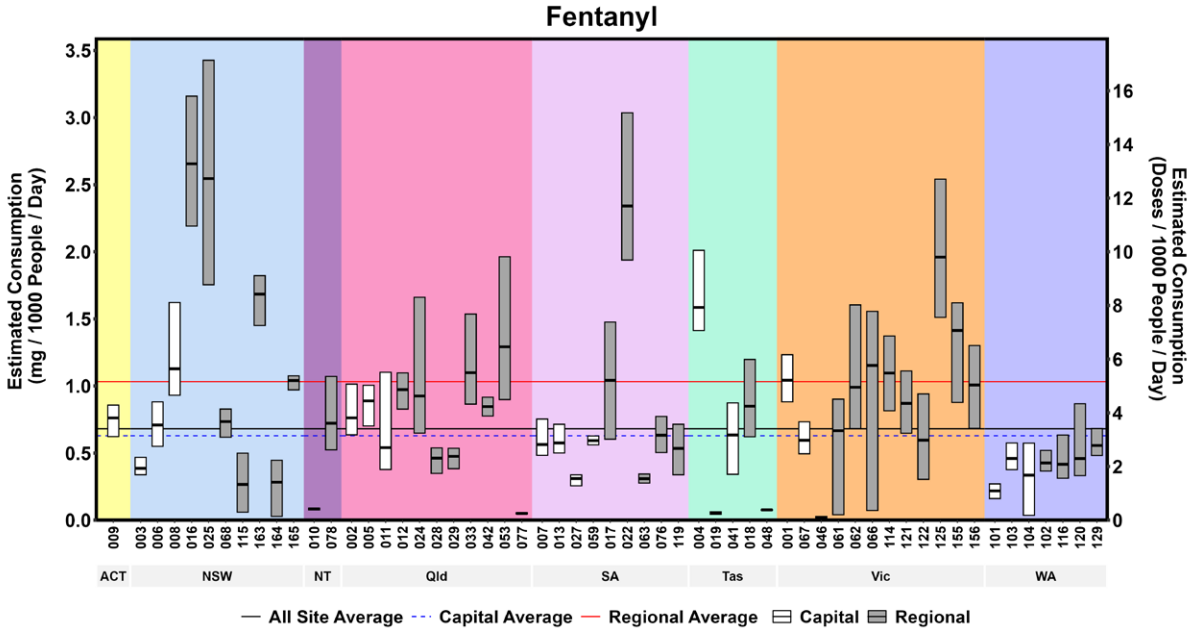
The heroin marker, 6-monoacetylmorphine (6-MAM), was used to determine consumption of the drug. Since the compound is characteristic of heroin metabolism, it can be used to distinguish heroin from other opioids such as morphine and codeine. The December 2022 collection week showed substantially higher consumption of heroin in various sites in Victoria compared to anywhere else (Figure 24). Site 46 in regional Victoria in particular had high average consumption. In contrast, heroin consumption fell below the method quantification limits in many regional sites in other states and territories. This was reflected in the low national regional average compared to the capital cities. The elevated heroin consumption in Victoria and, to a lesser extent, New South Wales is clearly evident from the bubble graph (Figure 25).

Figure 20: Estimated oxycodone consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- Higher regional average
- Tasmania highest of the capitals

Figure 21: Estimated fentanyl consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- Higher regional average
- Large variability across jurisdictions

Figure 22: Estimated average oxycodone consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

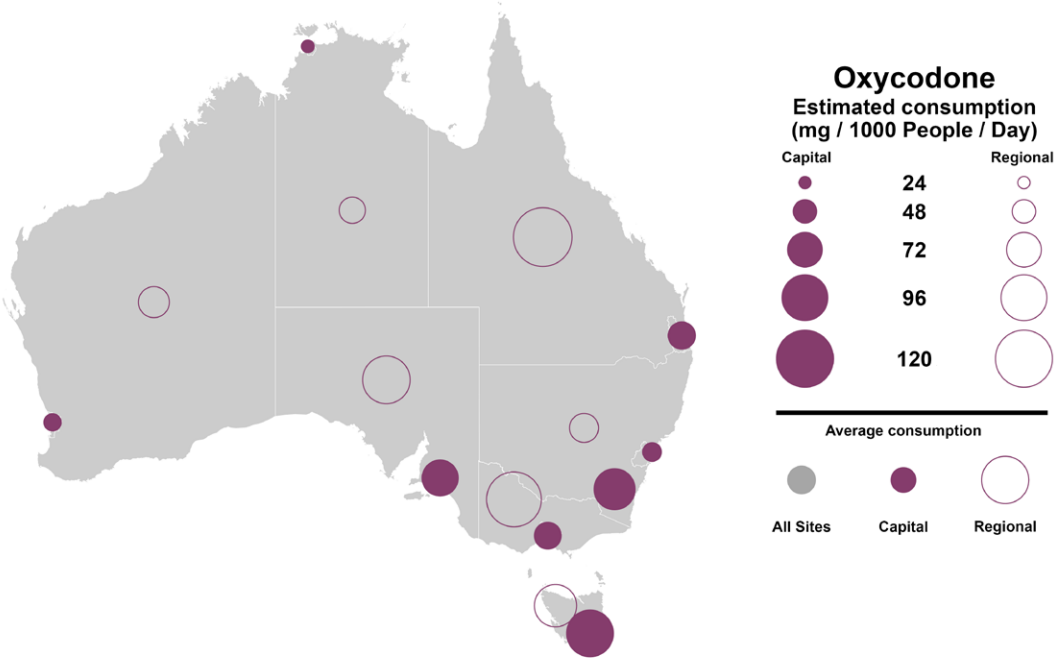


Figure 23: Estimated average fentanyl consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

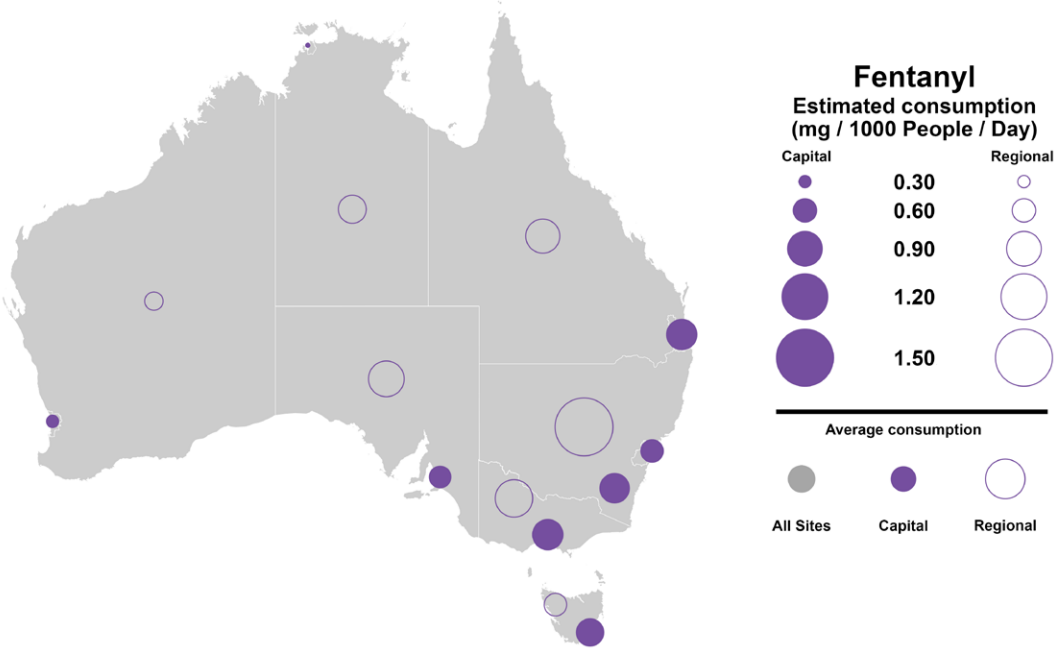
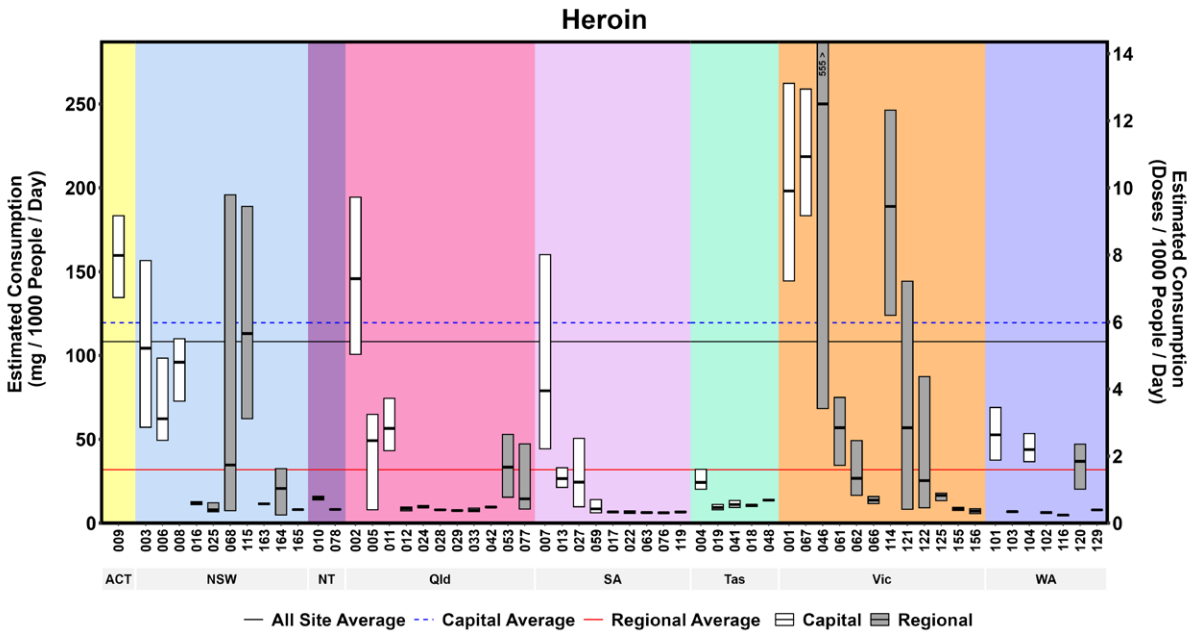
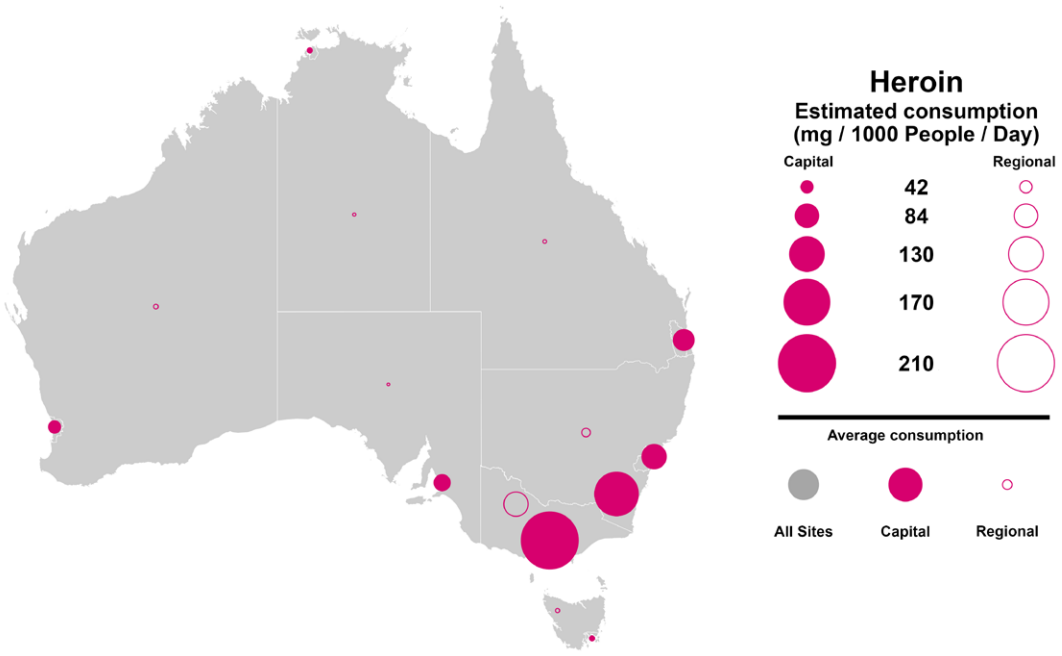


Figure 24: Estimated heroin consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- Lower regional consumption, often not quantifiable
- Highest consumption in Victoria

Figure 25: Estimated average heroin consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.



4.1.4 CANNABIS

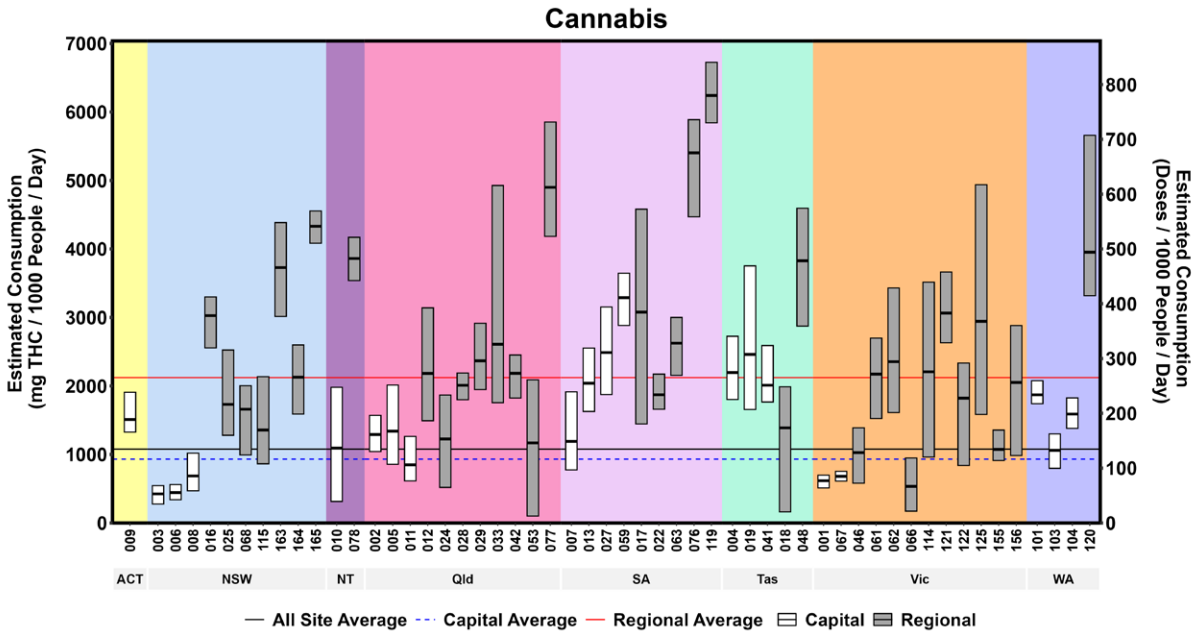
Tetrahydrocannabinol (THC) is the main psychoactive compound found in cannabis. The compound is metabolised and largely cleared through the gastrointestinal tract. A small proportion is excreted through the kidneys as 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH). The latter is known to adsorb to various surfaces, including sewer infrastructure and particulates suspended in the wastewater (e.g. Pandopulos et al 2022 and Campos-Manas et al 2022). 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. Accordingly, any spatial comparisons should be made with caution. Upon collection, samples require preservation 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, except in some sites in regional Western Australia where this is not possible.

Cannabis consumption is being expressed for the first time in this report as daily doses of the ingested active ingredient (THC) consumed per 1,000 people. Previous reports described consumed daily mass amounts in milligrams (mg). The change has been made possible by new research coming to light on the behaviour of the cannabis marker, THC-COOH, in wastewater from around Australia. The dose amount (8mg) has been suggested based on the desired effect on an average user of the active ingredient, regardless of the route of administration, e.g. inhaled smoke, part of a plant being used or oral ingestion through edible forms (Freeman and Lorenzetti, 2020).

Large spatial differences were evident across Australia, with regional cannabis consumption being much higher than in the capital cities (Figure 26). Capital city sites in South Australia and Tasmania generally had the highest cannabis use, while regional sites with above-average consumption were spread over much of the country. In contrast, capital city sites in New South Wales and Victoria had relatively low cannabis consumption levels.

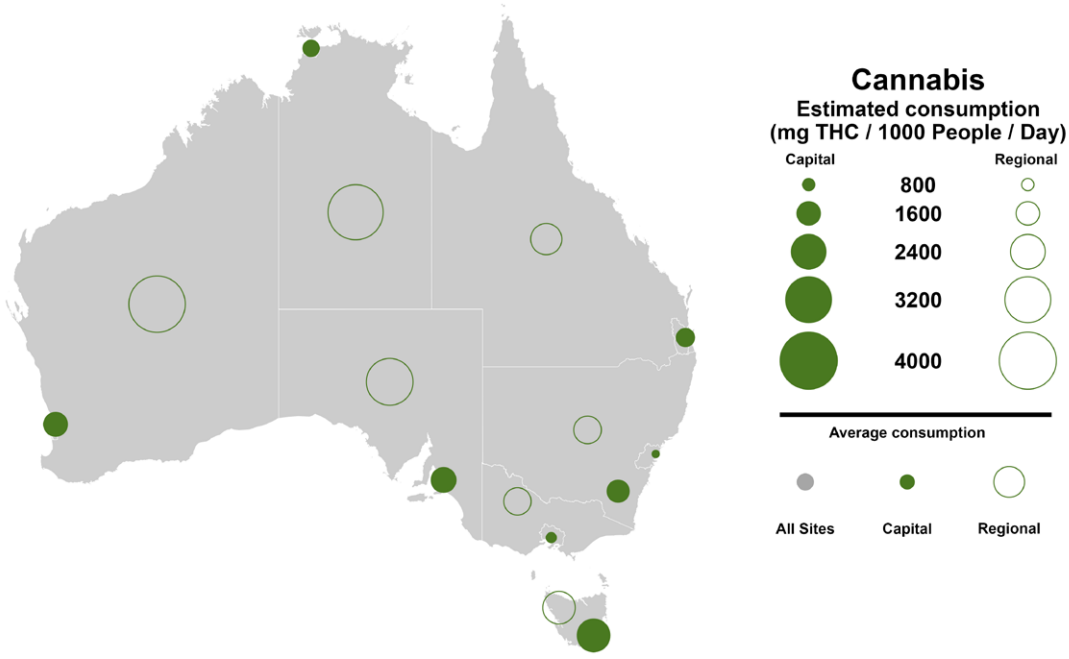
The bubble plot and jurisdictional differences in cannabis consumption across Australia show the generally higher consumption in regional areas (Figure 27).

Figure 26: Estimated cannabis consumption for December 2022 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7.



- High regional consumption
- Variable consumption across the country

Figure 27: Estimated average cannabis consumption per jurisdiction for December 2022 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

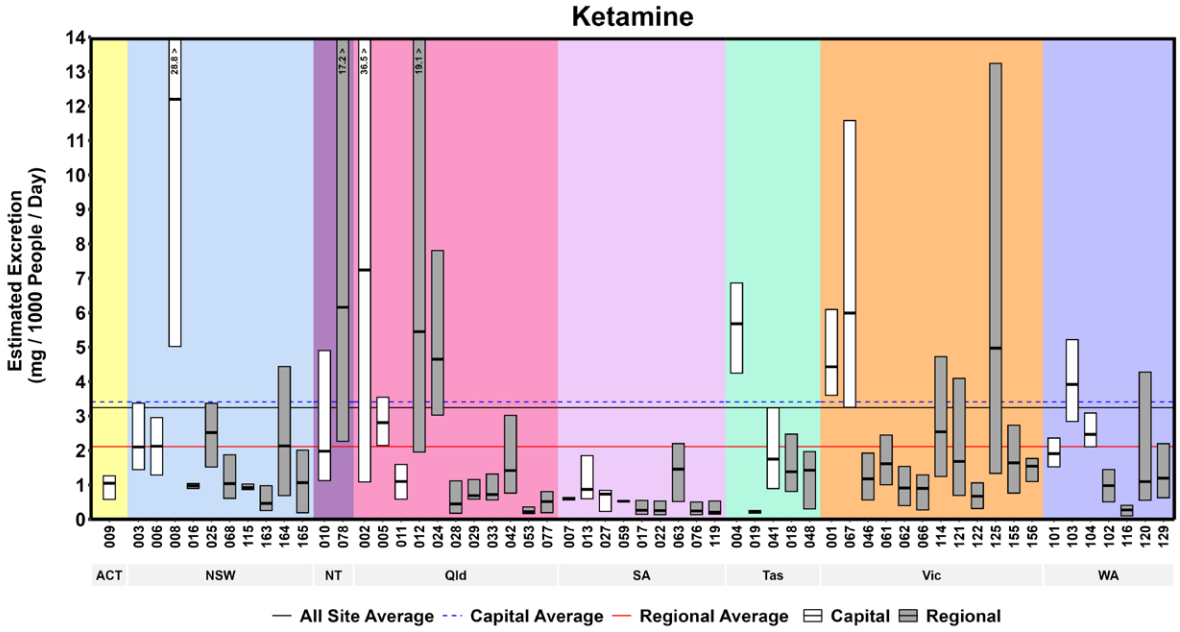


4.1.5 KETAMINE

Ketamine, measured as its metabolite, norketamine, is used medically for the management of acute pain, often associated with surgery or trauma. Ketamine has veterinary applications as well, although this may have less relevance in terms of wastewater monitoring due to the separation of stormwater and agricultural run-off from the sewer network in most Australian catchments. Due to its sedative and hallucinogenic effects, the drug has been associated with illicit substance abuse and is listed as a new psychoactive substance by the United Nations Office on Drugs and Crime. The reported proportions of ketamine and its metabolites in wastewater leave some doubt as to an appropriate factor to convert excreted amounts to consumed amounts. Therefore, similar to MDA, measured levels are being shown here as excreted daily mass loads.

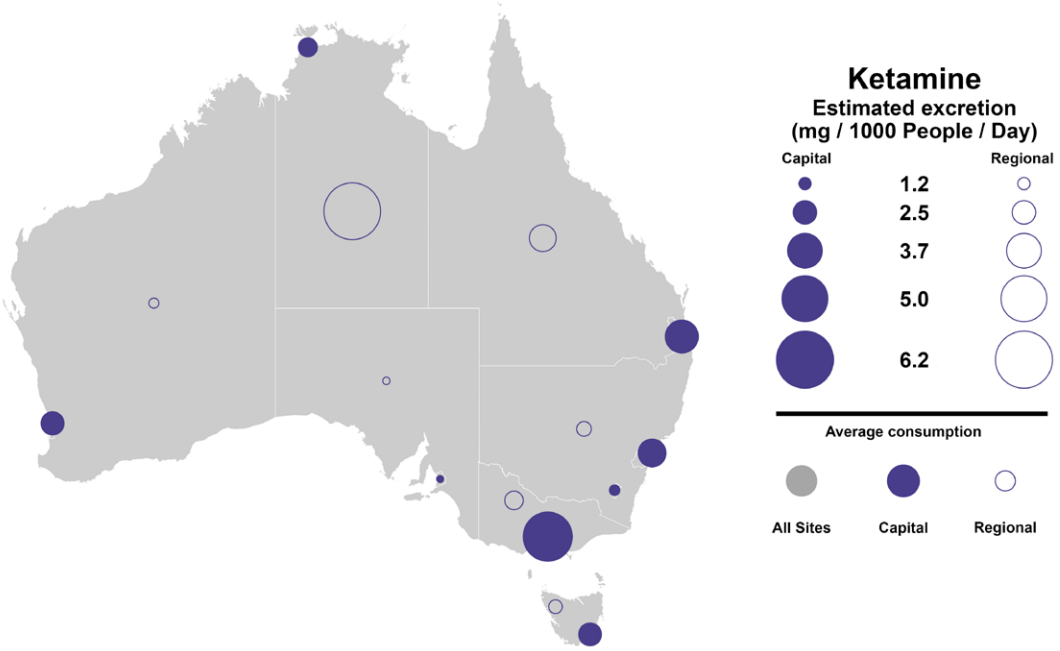
The regional average excretion of ketamine was lower than the capital cities, compounded by some results falling below the method quantification limits on certain days at several sites (Figure 28). Relatively high average excretion levels were recorded across a number of jurisdictions. The bubble plot shows the relative scale of ketamine excretion across Australia, with the regional site in the Northern Territory and capital city Victoria being the most prominent contributors when ketamine excretion was averaged across sites in the respective jurisdictions (Figure 29).

Figure 28: Estimated ketamine excretion for December 2022 in mass excreted per day (left axis) per thousand people. The number of collection days varied from 5 to 7.



- **Lower regional average**
- **High excretion in several sites**

Figure 29: Estimated average ketamine excretion per jurisdiction for December 2022 in mg excreted per day per thousand people. The number of collection days varied from 5 to 7.



4.2 TEMPORAL CHANGES IN DRUG CONSUMPTION ESTIMATES BY JURISDICTION

The per capita consumption of each drug outlined in the following figures compares data acquired for this report to previous collection periods on a state or territory basis. The data relating to capital cities in this section have been updated to include both the December 2022 and February 2023 collections, while regional areas were updated for December 2022. This needs to be considered when comparing results between sections 4.1 and 4.2. Ketamine was included in the Program for the first time in Report 13, so has fewer data points than the other substances.

Although every effort has been 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). Due to the larger number of data points collected by the Program, the current report presents the last 2 years of data. Prior data dating back to 2016 for each substance of interest is available on the ACIC website by jurisdiction.

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 for each substance. Updated changes to the graphs relating to this report are the two most recent bars consisting of capital cities (December 2022 and February 2023) and the single most recent bar for regional areas (December 2022). Some temporal changes reflected in these bars may be a consequence of updated populations used in the calculations, see Appendix 4 of Report 17 for the difference in populations for the 2016 and 2021 Census for each catchment.

4.2.1 NICOTINE AND ALCOHOL

Temporal changes in nicotine consumption across Australia reflect the differences between parts of the country since the Program commenced in August 2016, with regional averages well above that of the capital cities (Figure 30). Comparing the respective averages with the current reporting period shown in section 4.1.1, it is apparent that the gap between capital cities and regional Australia is closing. Clear differences in trends are emerging in the various jurisdictions. Results in the current reporting period (December 2022 and February 2023) are consistent with a gradual decreasing pattern in the capital cities of the Australian Capital Territory and Tasmania, while the current findings in the capital cities of South Australia and Western Australia are indicative of general increasing consumption over the past 2 years. Consumption is also decreasing in the Northern Territory and regional parts of several states. Nicotine consumption has been relatively steady in other parts of the country, or too variable to draw meaningful conclusions.

Overall alcohol consumption in the current collection period also reflects localised changes (Figure 31). Consumption has decreased in several jurisdictions in the current reporting period, most notably in the capital city of the Northern Territory. The difference in alcohol consumption in regional areas compared to the capital cities is less pronounced than for nicotine, but like nicotine has been higher in regional areas since the start of the Program.

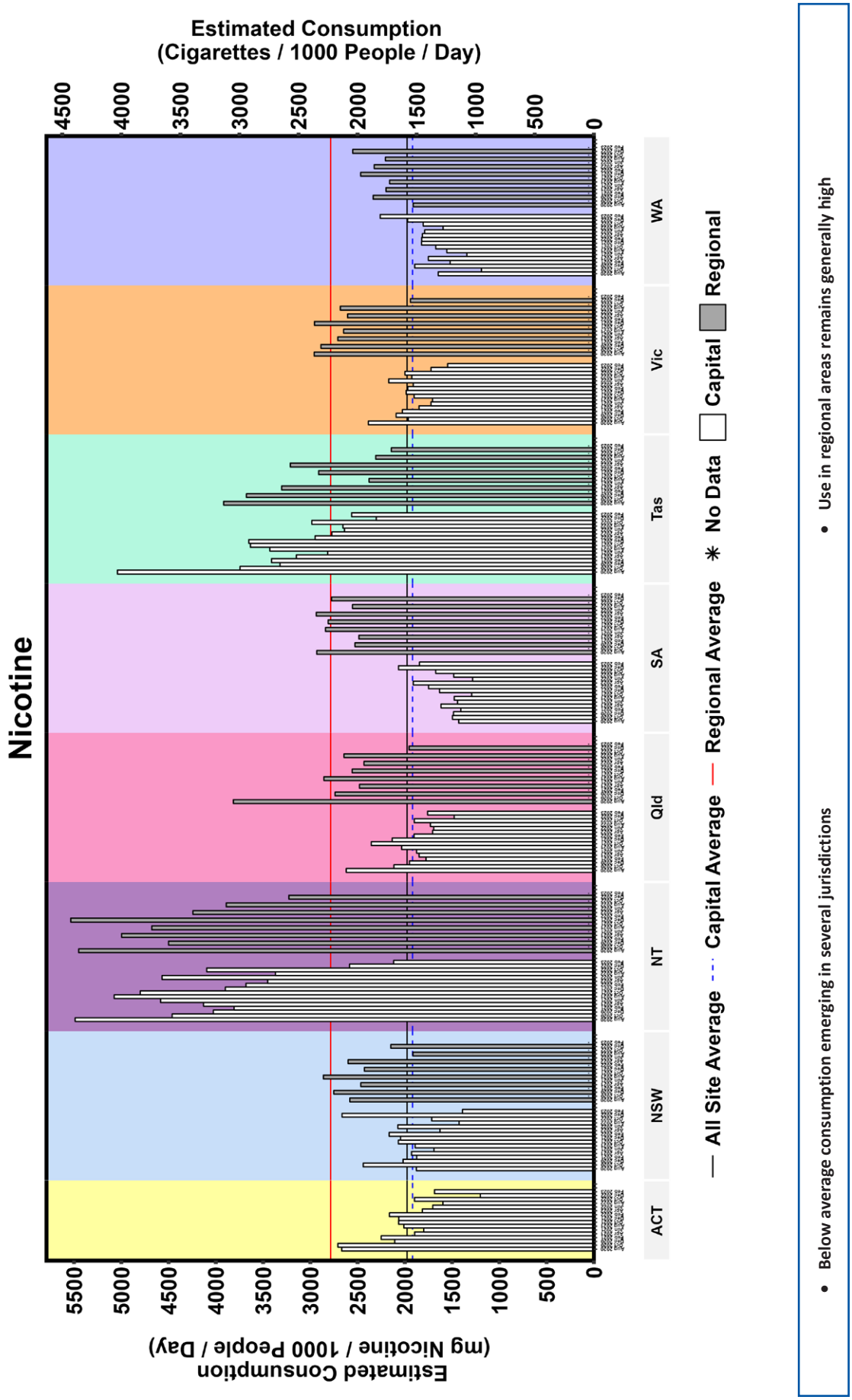
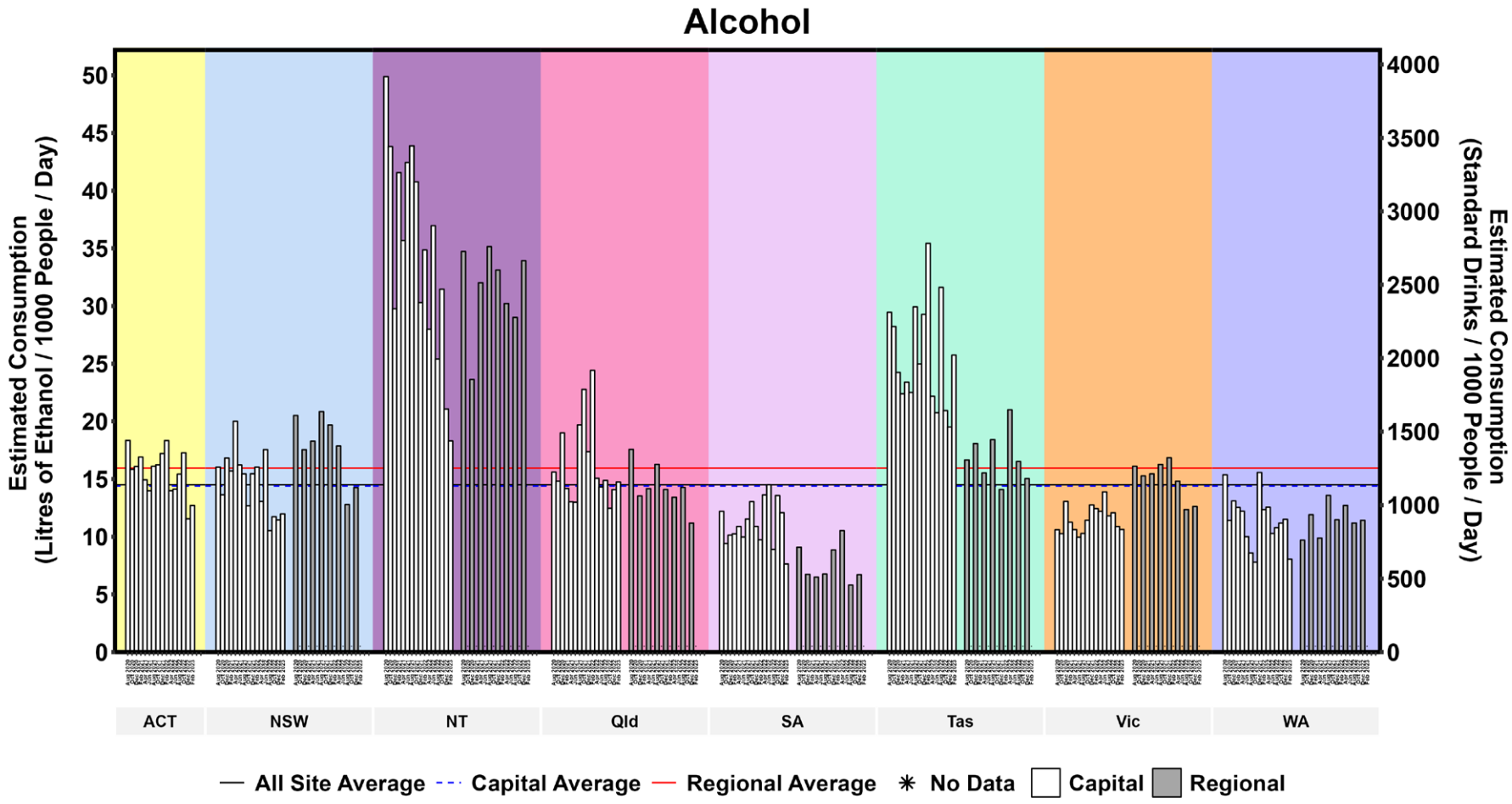


Figure 30: Estimated average consumption of nicotine by state/territory, August 2020 to February 2023, where 1 cigarette provides 1.25 mg of nicotine.

Figure 31: Estimated average consumption of alcohol by state/territory, August 2020 to February 2023. A standard drink is 10.0 g, or 12.6 mL.



- Mostly lower alcohol consumption in current period
- Regional consumption exceeds capital city consumption

4.2.2 STIMULANTS

Temporal changes in the consumption of methylamphetamine have been variable, with short term fluctuations a prominent feature (Figure 32). Several jurisdictions, including Queensland, Tasmania and Western Australia, had consumption levels towards the higher end of those recorded over the past 2 years. Nationally, the regional running average has been higher than that of the capital cities, which is opposite to the current result reported in section 4.1.2.1. Western Australia and South Australia had the highest capital city consumption of methylamphetamine in February 2023 and regionally in December 2022. Sites where data have been available from before the start of the NWDMP show that while methylamphetamine consumption is currently at high levels compared to the past 2 years, levels are still mostly below historical highs in the context of the Program (Figure 33 and Figure 34).

Cocaine consumption has been showing large decreases in almost all jurisdictions over the past 2 years (Figure 35). Compared to the previous reporting period, results are currently higher in almost every capital city and regional centre of the country. The long-term averages show that regional use of cocaine is well below that of the capital cities.

MDMA consumption across Australia has been decreasing since December 2019, but this trend has reversed since April 2022 and in the current reporting period (Figure 36). Current levels of MDMA consumption have mostly been below the long-term averages, with regional use exceeding that of the capital cities.

MDA excretion is also showing a decrease over the last 2 years (Figure 37). No clear patterns are emerging and fluctuations are all within a relatively small range. The long-term average regional excretion has been higher than in the capital cities, so it is notable that the trend has reversed in the current reporting period (section 4.1.2.5).

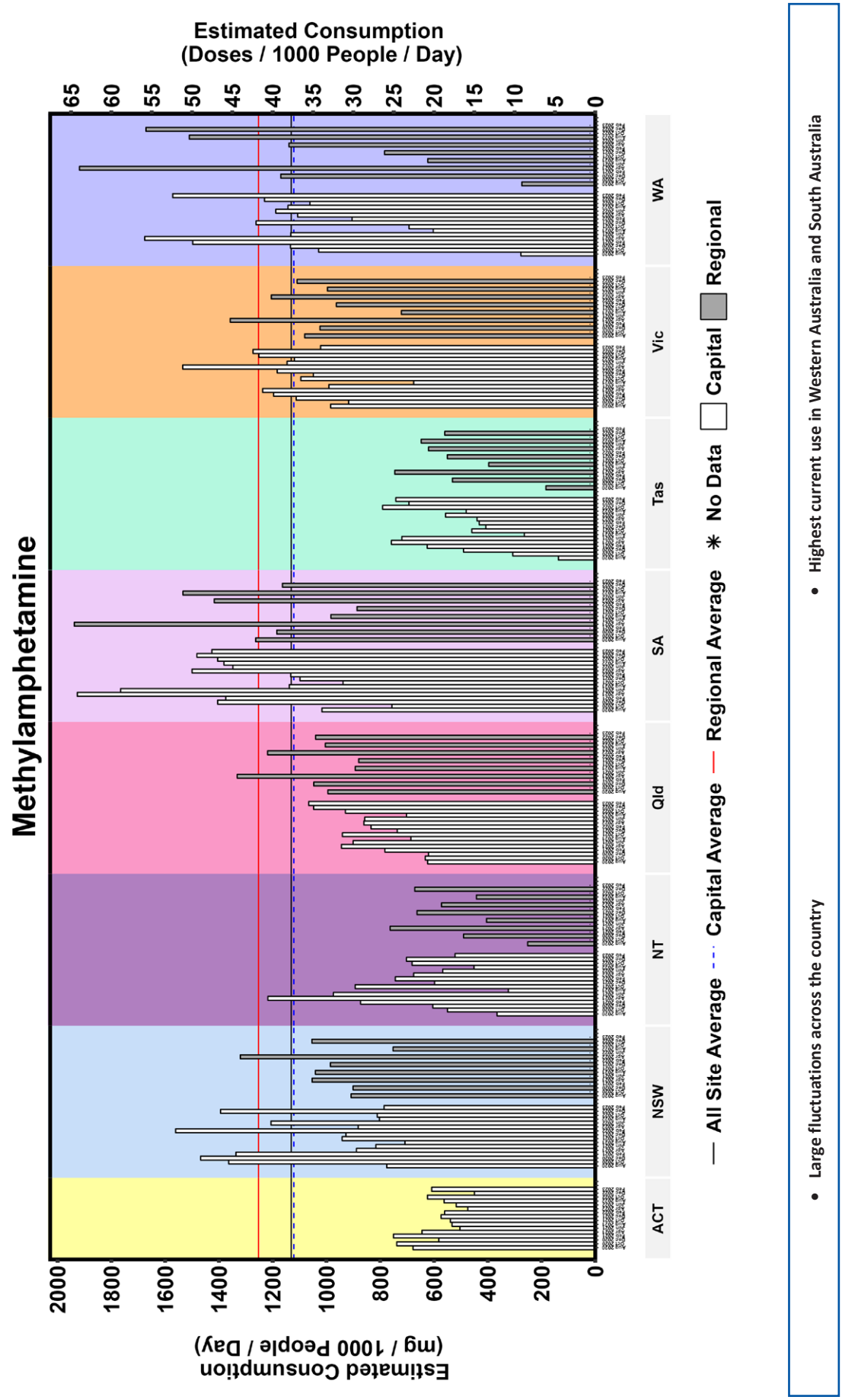


Figure 32: Estimated average consumption of methylamphetamine by state/territory, August 2020 to February 2023.

Figure 33: Change in methylamphetamine consumption for sites in Queensland and South Australia with historical data.

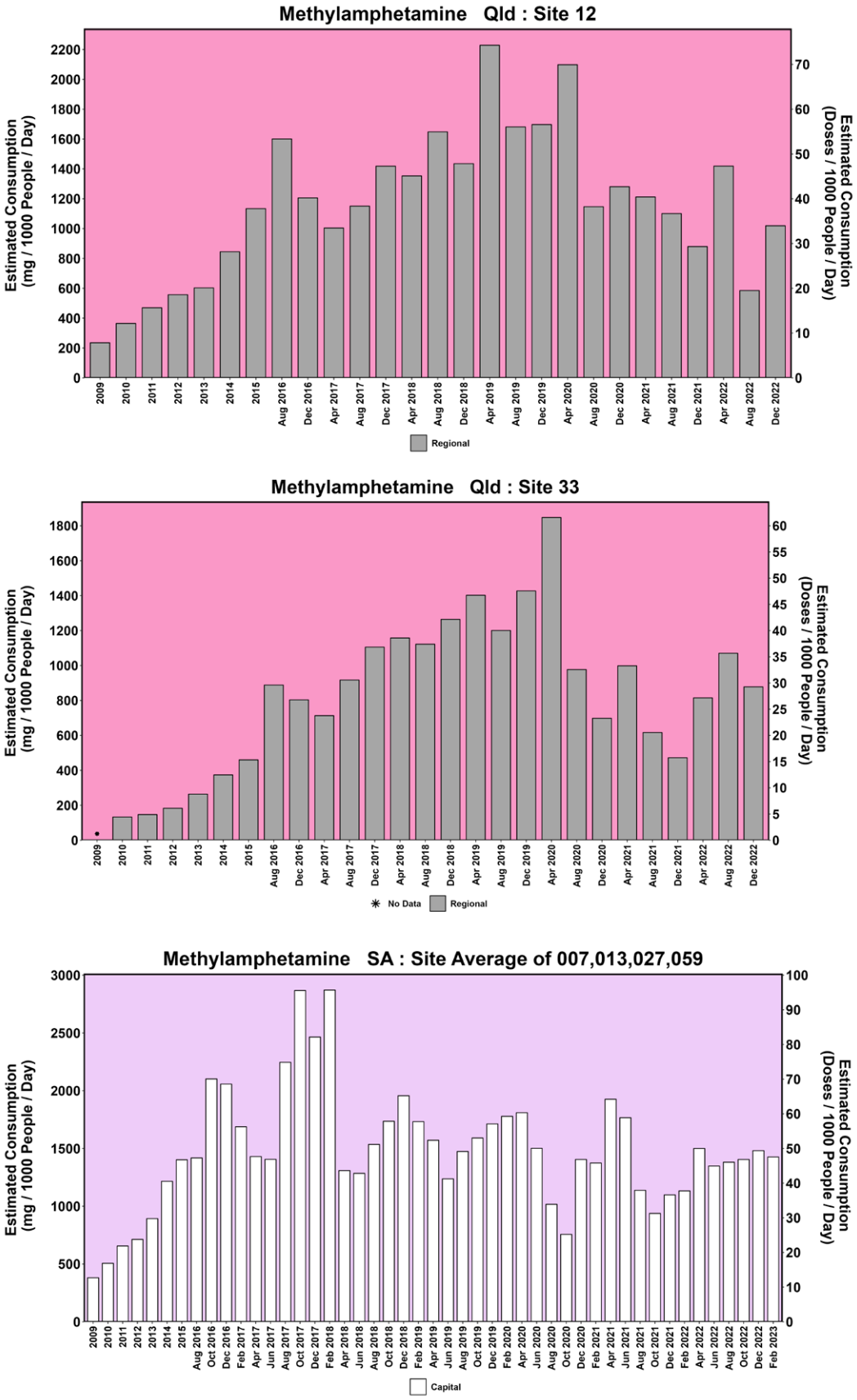
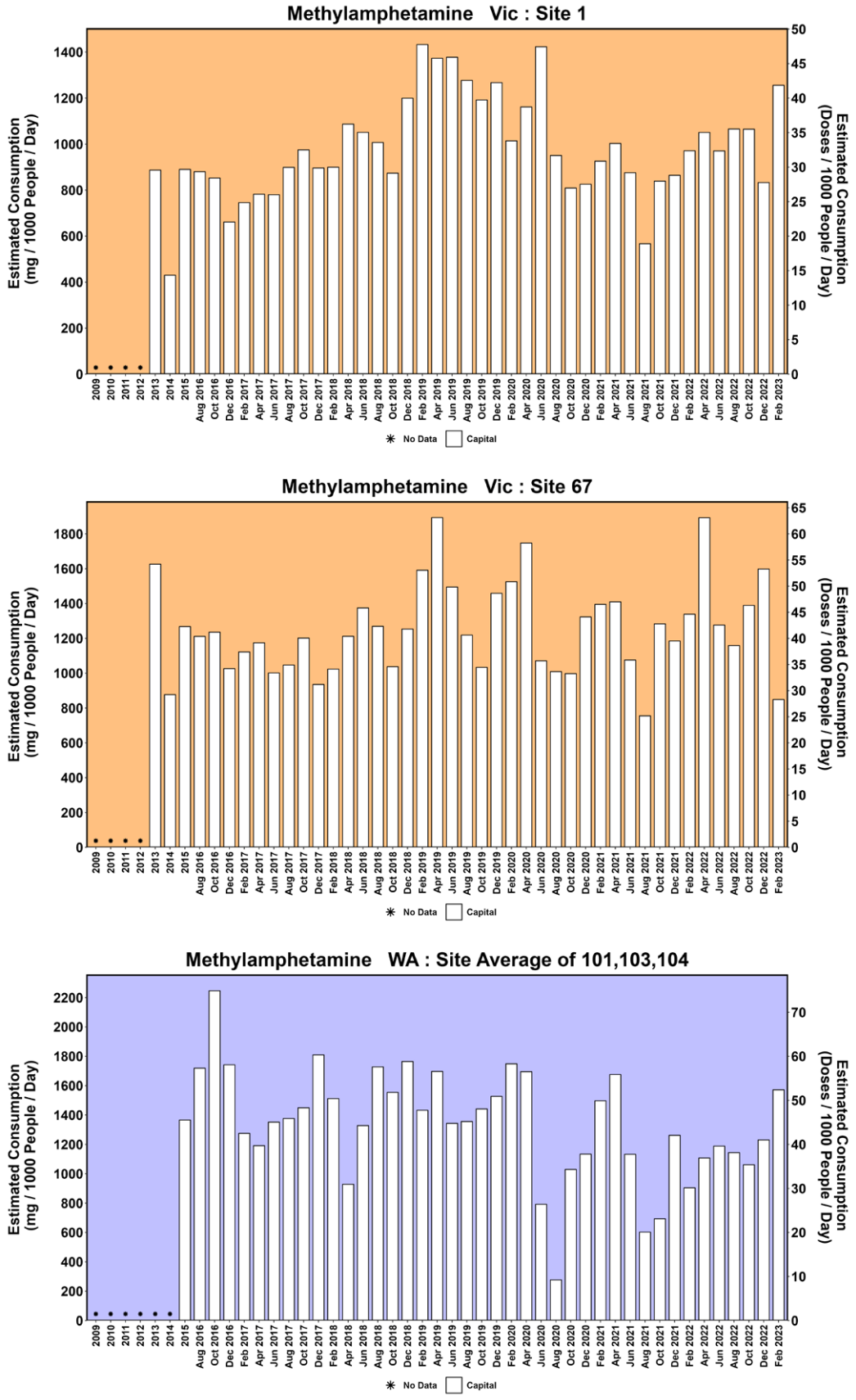


Figure 34: Change in methylamphetamine consumption for sites in Victoria and Western Australia with historical data. Both Victorian sites were the average of one week per year in 2013, 2014 and 2015.



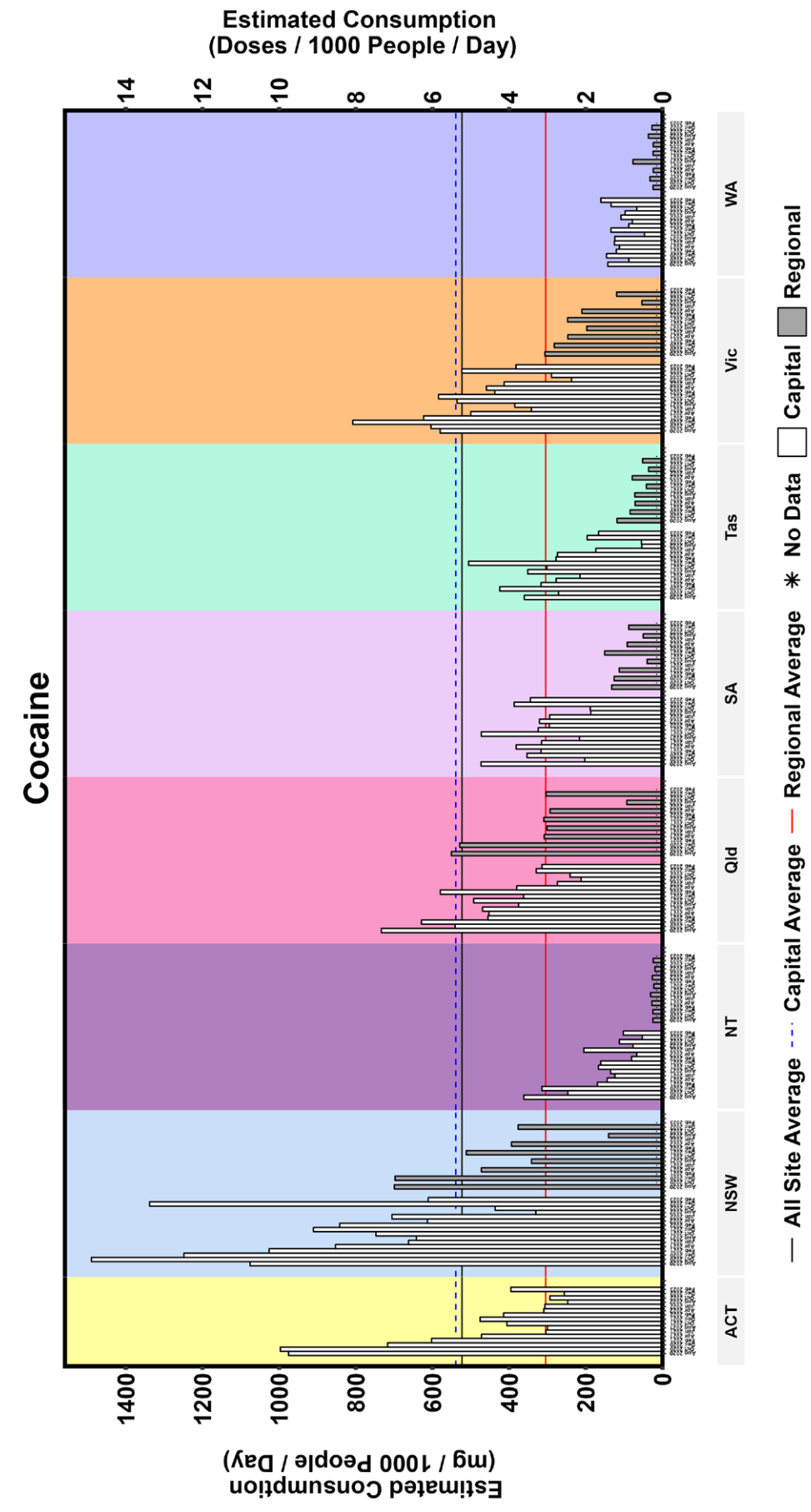


Figure 35: Estimated average consumption of cocaine by state/territory, August 2020 to February 2023.

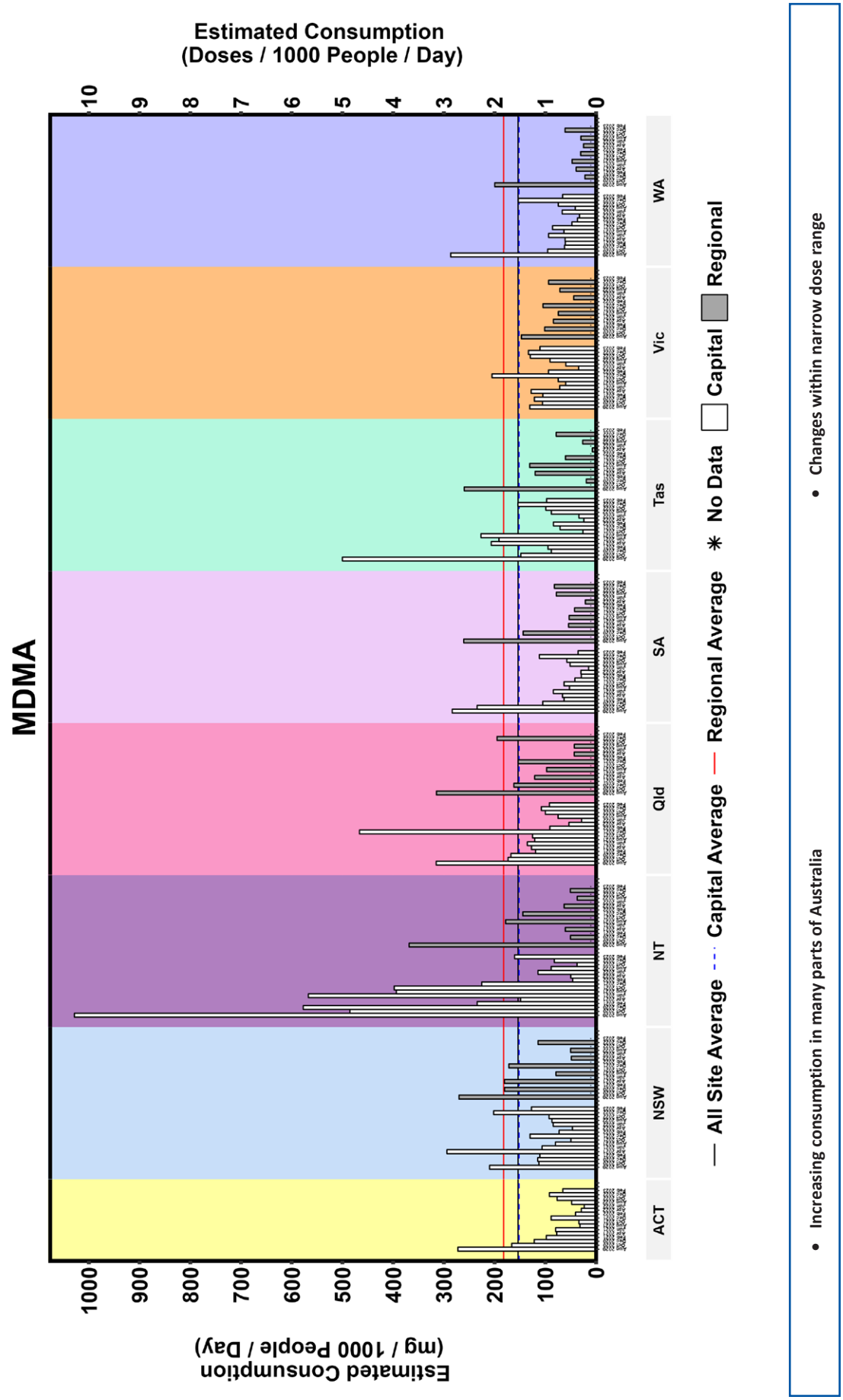


Figure 36: Estimated average consumption of MDMA by state/territory, August 2020 to February 2023.

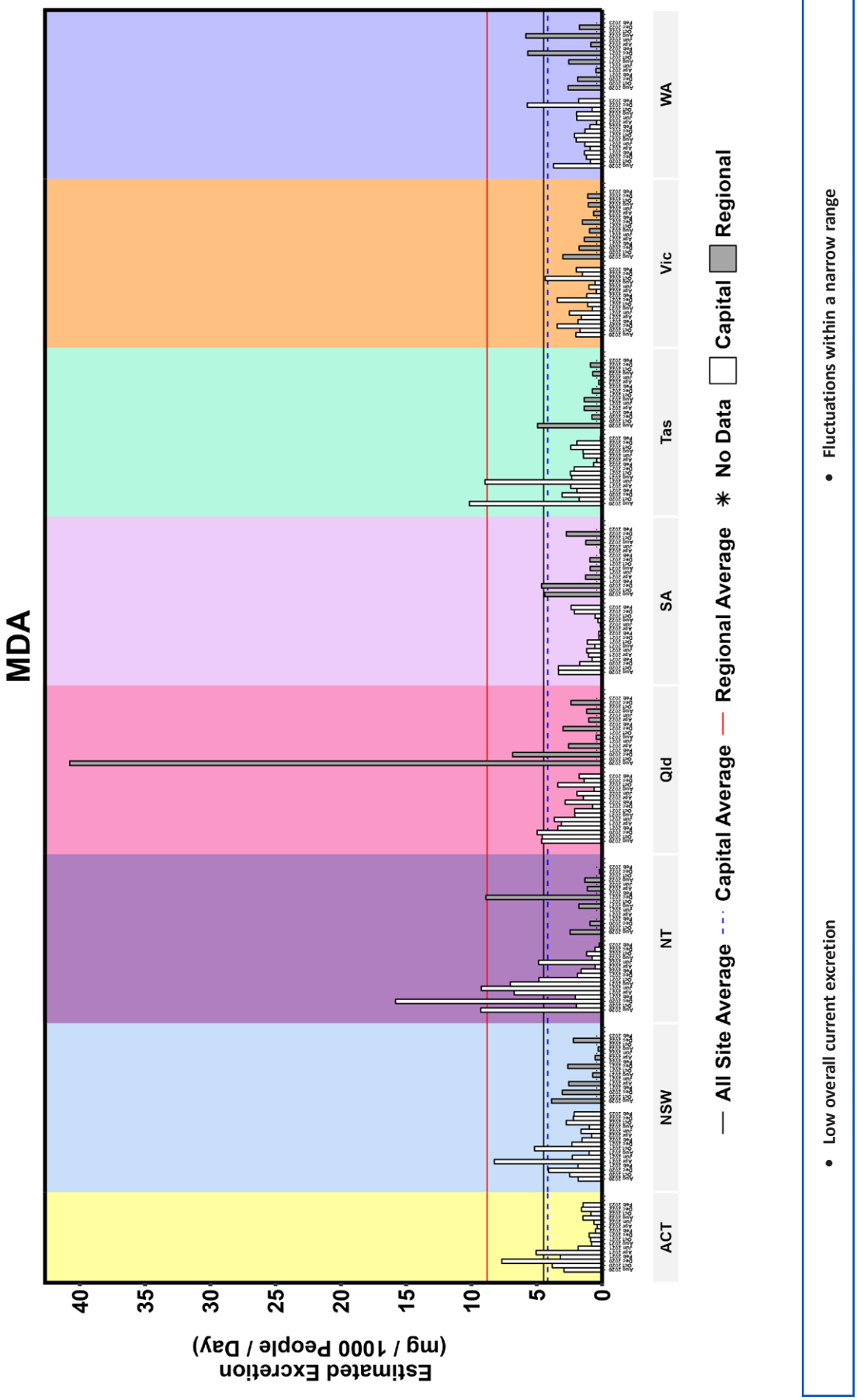


Figure 37: Estimated average excretion of MDA by state/territory, August 2020 to February 2023.

4.2.3 OPIOIDS

Oxycodone consumption in Australia has been decreasing over the past 2 years in many parts of the country and, Western Australia excepted, the trend has been maintained in the current reporting period (Figure 38). Average per capita regional oxycodone consumption is much higher than in the capital cities. The capital city of Tasmania and regional parts of Queensland and Victoria are currently the highest consumers of oxycodone on a population basis.

Fentanyl consumption has been increasing in many jurisdictions since April 2022 (Figure 39). On a national scale, the rolling average regional consumption of fentanyl remains higher than in the capital cities.

In contrast to the pharmaceutical opioids, heroin is mostly consumed in the capital cities (Figure 40). Current levels of heroin consumption have decreased in some parts of the country or remained relatively stable when compared to the previous report. Consumption of heroin remains high in Victoria and New South Wales compared to other parts of the country. Outside of these 2 states, regional consumption of heroin is at very low levels.

Heroin consumption has been measured in capital city South Australia since 2013 (Figure 41). A gradual, long-term decrease in heroin consumption was evident from 2013 to early 2019, followed by an increase towards the end of that year. Over the past year, heroin consumption in the capital city has been relatively stable.

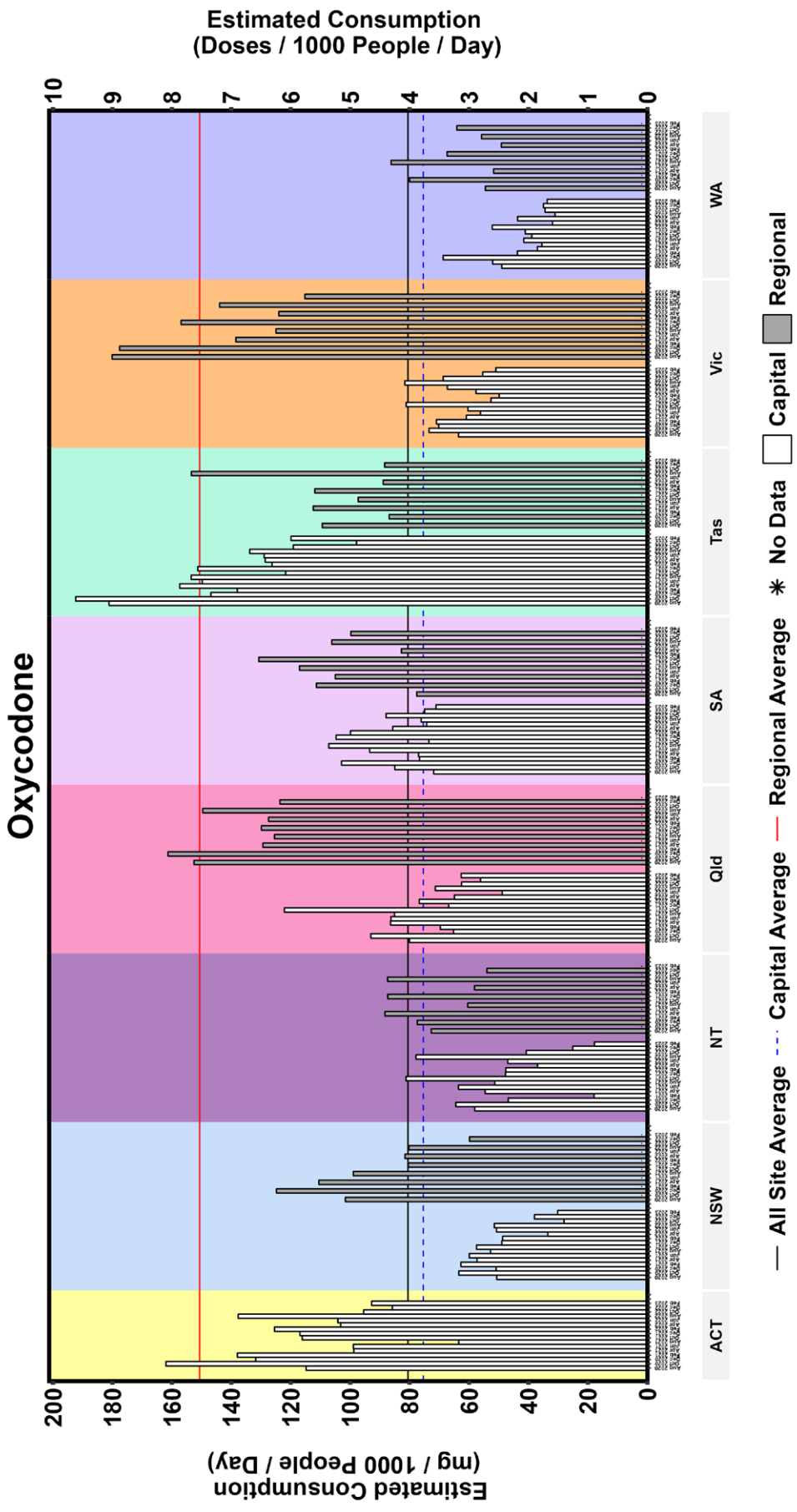


Figure 38: Estimated average consumption of oxycodone by state/territory, August 2020 to February 2023.

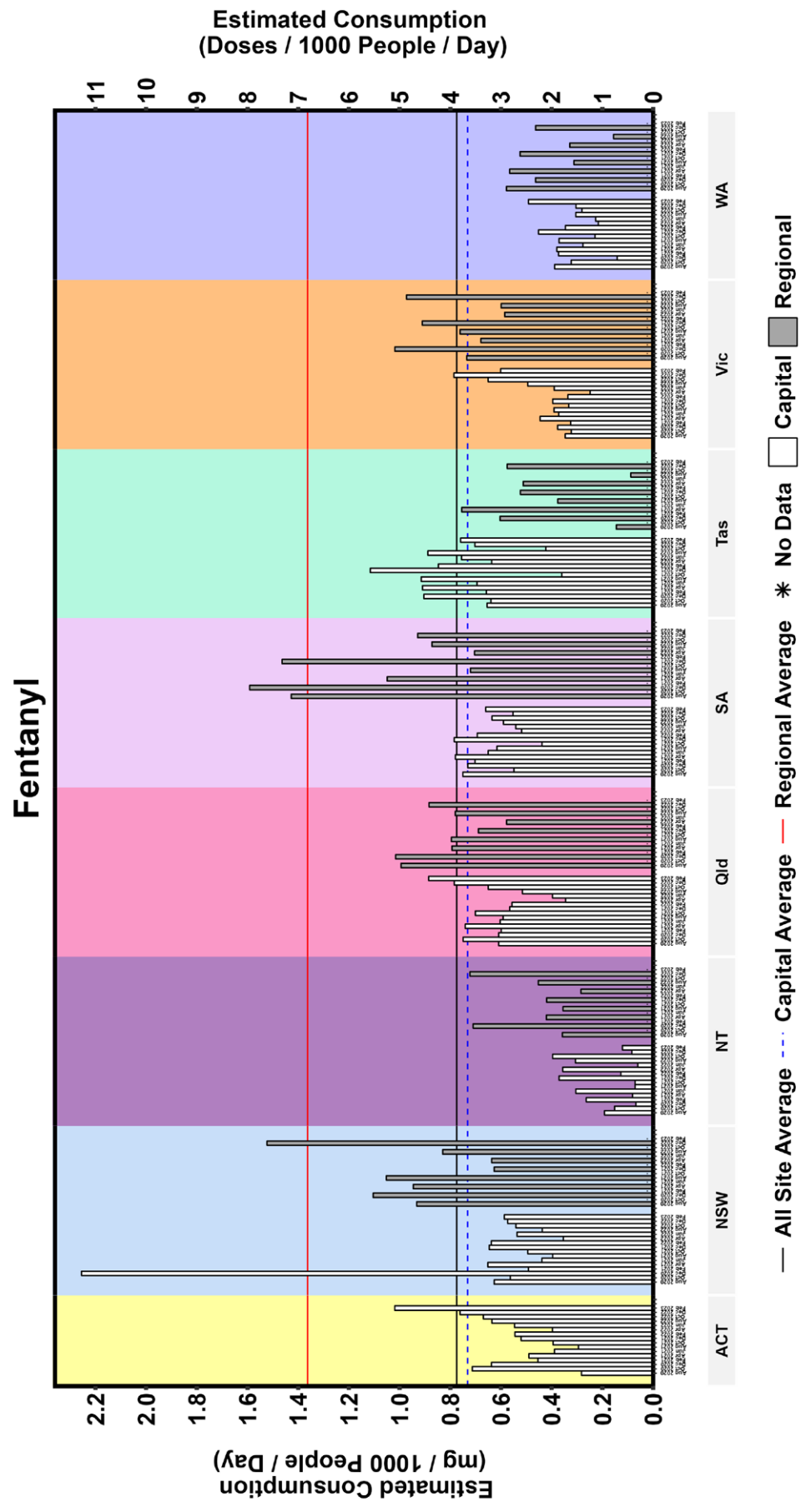


Figure 39: Estimated average consumption of fentanyl by state/territory, August 2020 to February 2023.

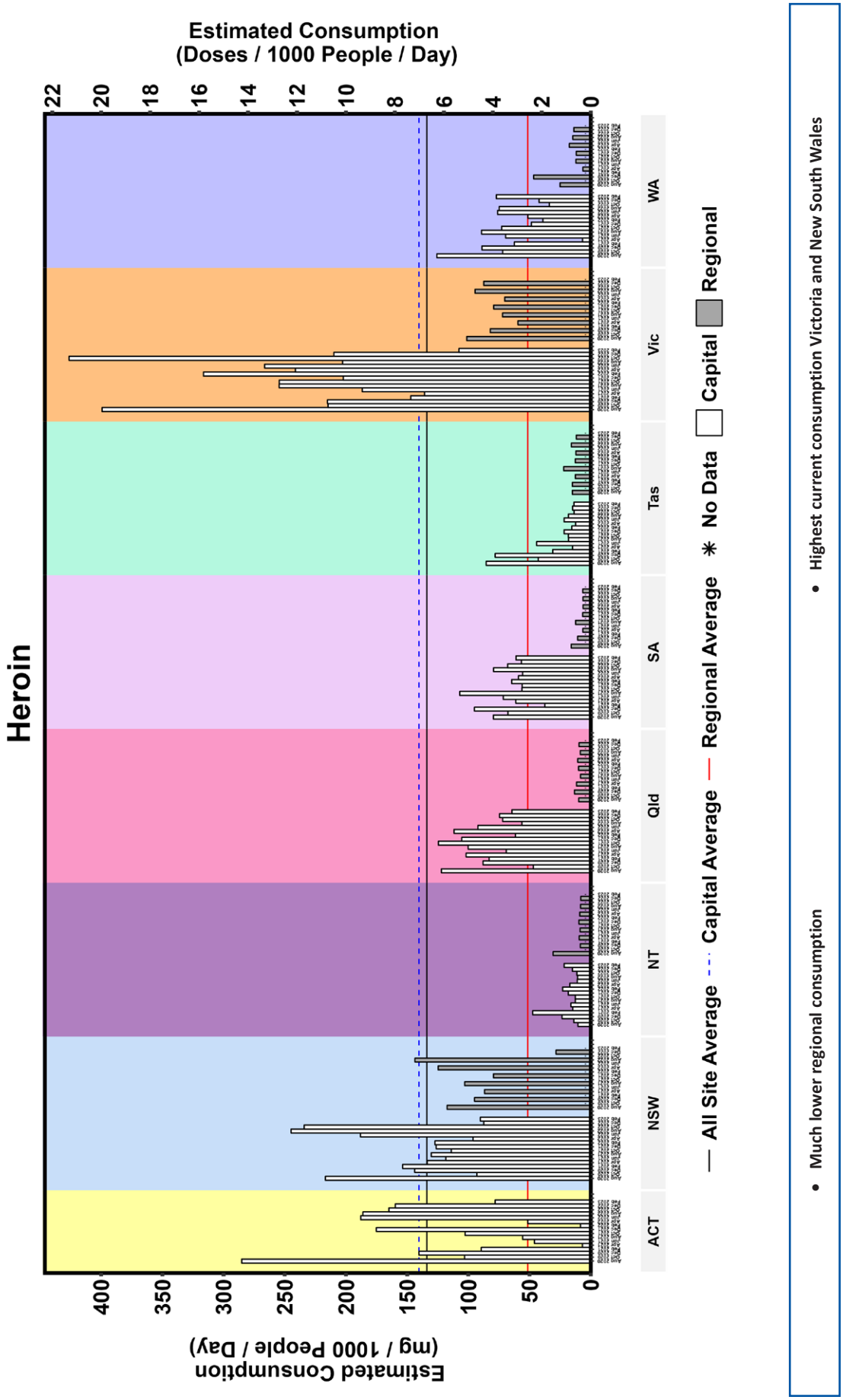
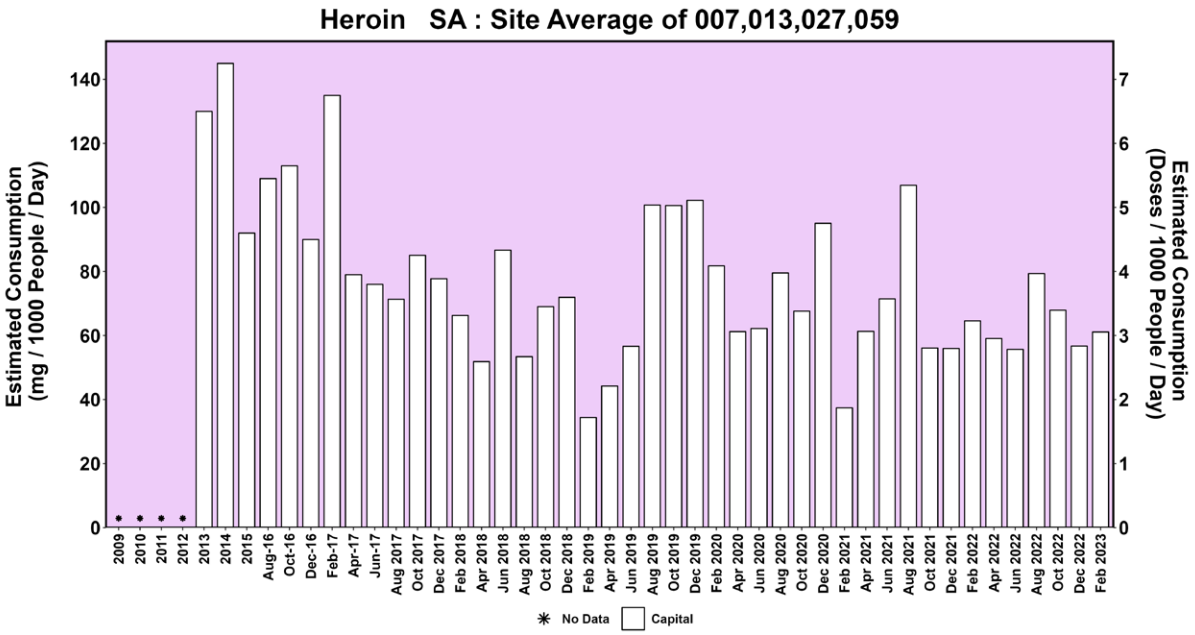


Figure 40: Estimated average consumption of heroin by state/territory, August 2020 to February 2023.

Figure 41: Change in heroin consumption for capital city sites in South Australia with historical data.



4.2.4 CANNABIS

Tasmania excepted, cannabis consumption in regional Australia has generally been higher than in the capital cities (Figure 42). Large decreases in the current reporting period were evident in several jurisdictions, including the capital cities of the 2 territories and Victoria. Regional Western Australia showed a substantial increase in cannabis use and currently has the highest consumption of the drug, together with regional parts of the Northern Territory and South Australia. Average cannabis consumption in capital city sites in New South Wales and Victoria consistently shows lower consumption levels than in the smaller capital cities.

Cannabis consumption has been monitored in capital city South Australia since 2011. An overall increasing trend in consumption was observed until August 2021 (Figure 43). Since then, consumption of the drug in the capital of the state has slowly decreased.

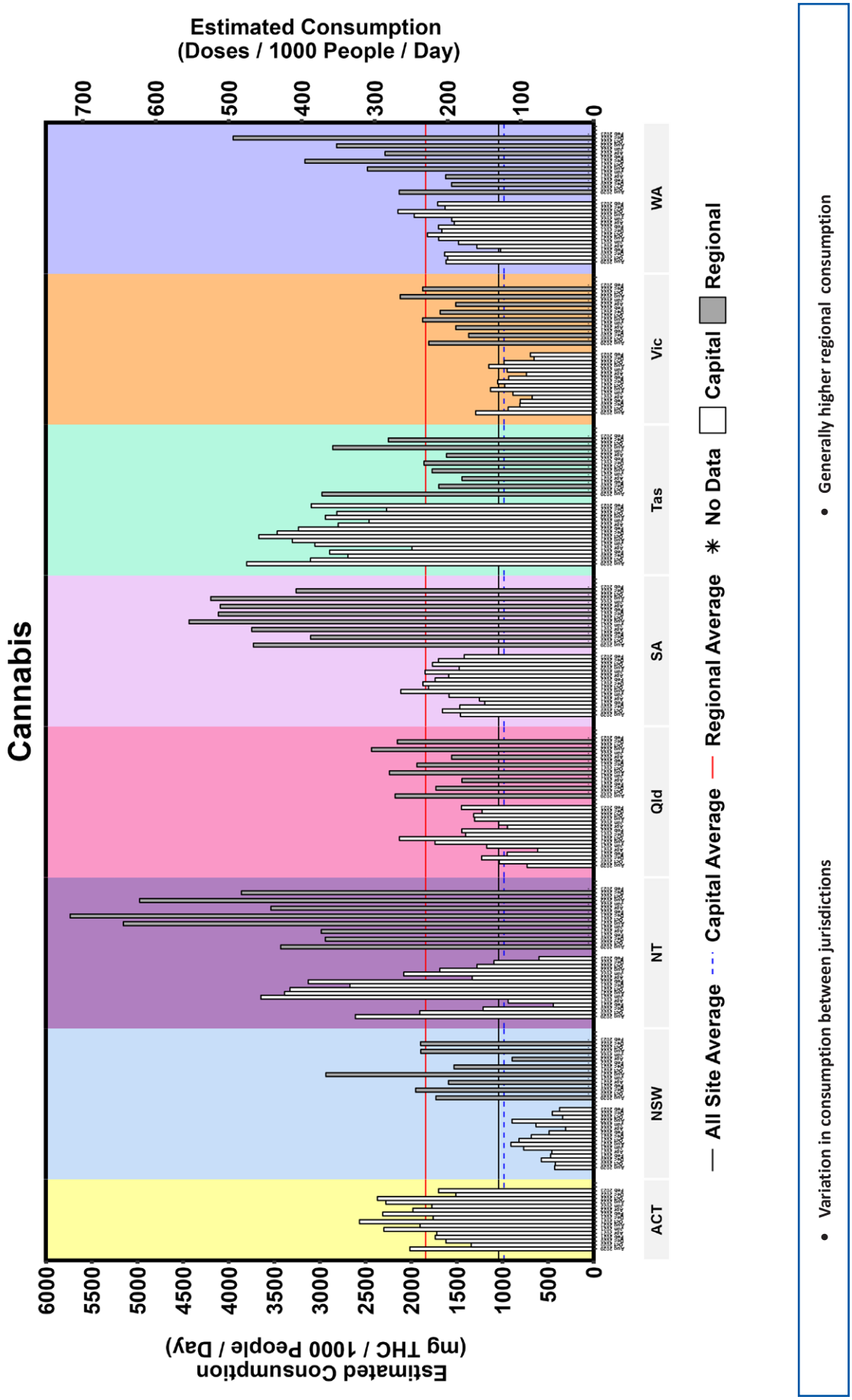
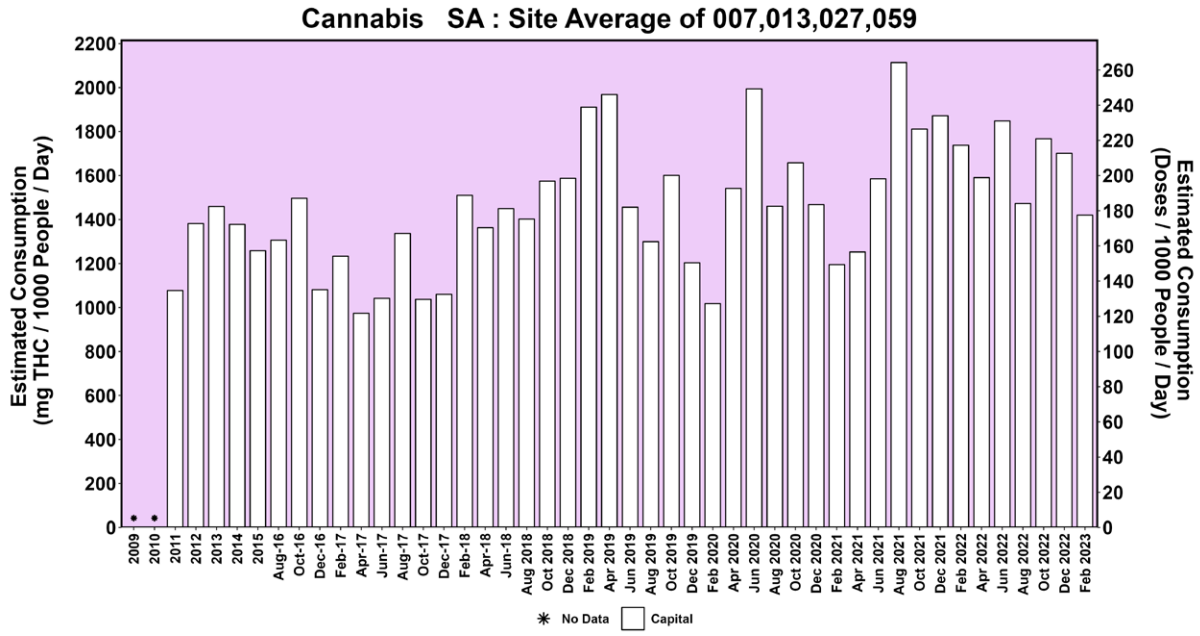


Figure 42: Estimated average consumption of cannabis by state/territory, August 2020 to February 2023.

Figure 43: Change in cannabis consumption for sites in capital city South Australia with historical data. Cannabis is detected via the THC metabolite, THC-COOH.



4.2.5 KETAMINE

Only 2 years of data has been collected for ketamine so far in the Program and the data is reported as amounts excreted, until an appropriate urinary elimination rate is selected to calculate back to consumption. The rolling averages suggest that capital city consumption levels exceed those in regional areas, but there have been some exceptions (Figure 44). The Northern Territory capital city site shows large variability between collection periods compared to other jurisdictions. Capital city sites in Victoria currently have the highest excreted amounts of ketamine in the country, whereas South Australia has had the lowest recorded excretion. Current levels across the country do not follow specific trends and vary within a relatively small range.

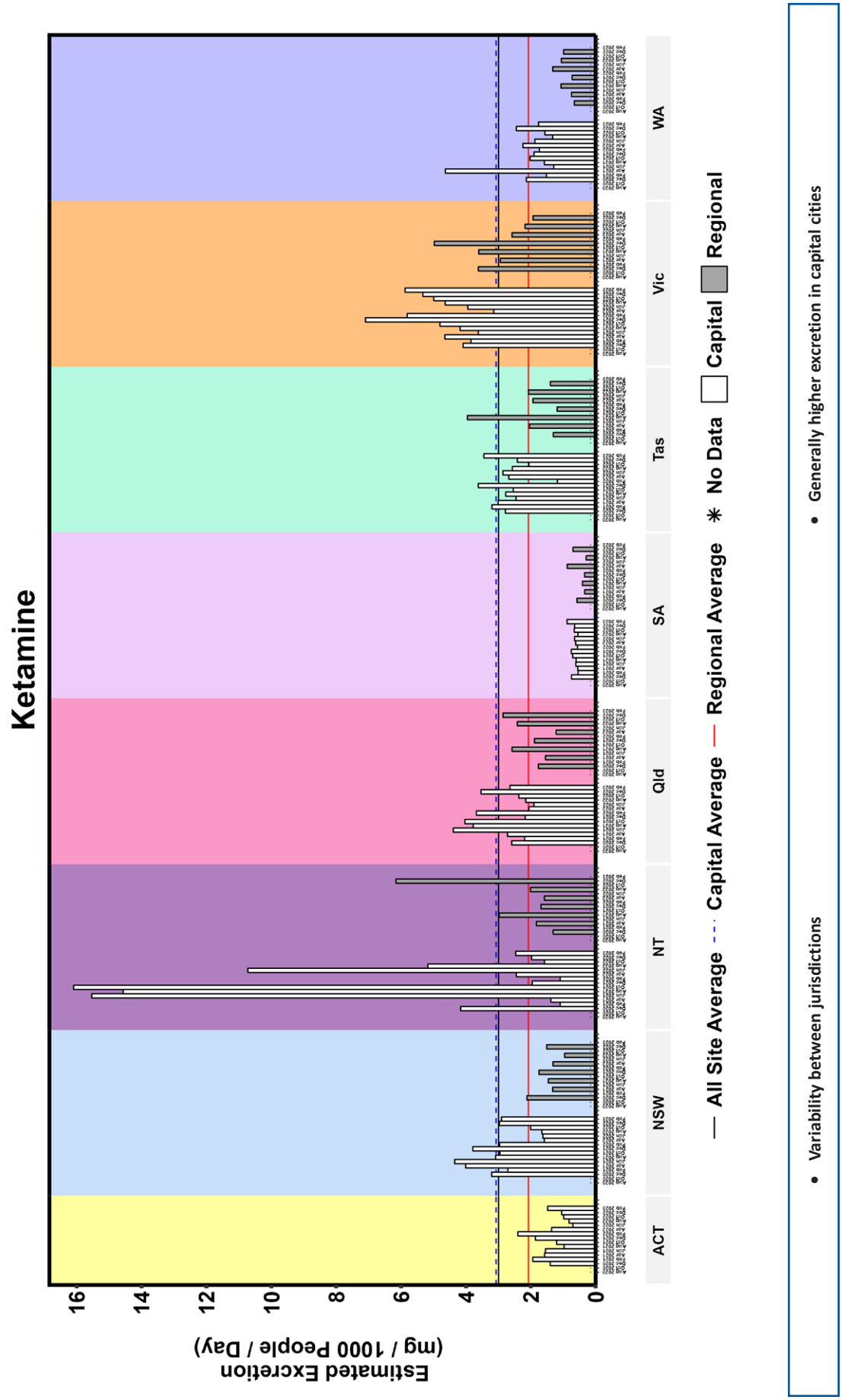


Figure 44: Estimated average excretion of ketamine by state/territory, August 2020 to February 2023.

4.3 NATIONAL CAPITAL CITY AND REGIONAL AVERAGES

In order to show the national trends of the individual substances, all capital city and regional sites were combined for each substance (Figure 45 to Figure 50). Fewer sites were able to be sampled in October 2016 and this is highlighted as such in the respective figures.

Nicotine consumption has fluctuated within a relatively narrow range since the start of the Program (Figure 45). Consumption has decreased in regional areas of the country since August 2021. Consequently, population weighted regional nicotine use, which once tended to be well above city levels, has now become very similar. There was record low nicotine consumption in regional areas in December 2022.

Alcohol consumption appeared relatively stable until August 2021, since when consumption has decreased in regional areas. There has been no particular long-term trend in the capital cities. Consumption of alcohol in the current reporting period has reached its lowest levels since the Program commenced, in capital cities in February 2023 and in regional areas in December 2022. Regional alcohol consumption remains slightly above that of the capital cities.

Overall methylamphetamine consumption gradually increased until April 2020, since when a trend appears to have developed with substantially lower consumption each August followed by increased consumption in the 2 succeeding reporting periods (April and December - Figure 46). Between 2016 and 2020, regional use of methylamphetamine tended to be higher than in the capital cities. However, since mid-2020, average consumption in capital cities and regional areas has been very similar.

MDMA consumption has decreased since a peak in December 2019 (Figure 46). Consumption of the drug in the current reporting period has increased, as it has since April 2022, although the change has to be seen in the context of short-term variability since late 2020. MDMA was consumed at a higher rate in regional areas prior to the end of 2020, but the pattern has largely reversed since then.

Cocaine consumption increased until December 2020. Cocaine consumption then decreased until record low capital city and regional consumption was recorded in August 2022. Consumption has increased during the current reporting period, both in regional areas and capital cities (Figure 47). Long-term trends relating to cocaine clearly show much higher consumption in capital cities compared to regional areas.

MDA excretion has shown sporadic spikes, particularly in regional parts of the country (Figure 47). The initial pattern for MDA tended to show a preference for the drug in regional areas, although this trend has disappeared since late 2020. Excretion of the drug has remained relatively low since late 2020, with the lowest MDA excretion levels in both capital city and regional areas recorded by the Program in April 2022.

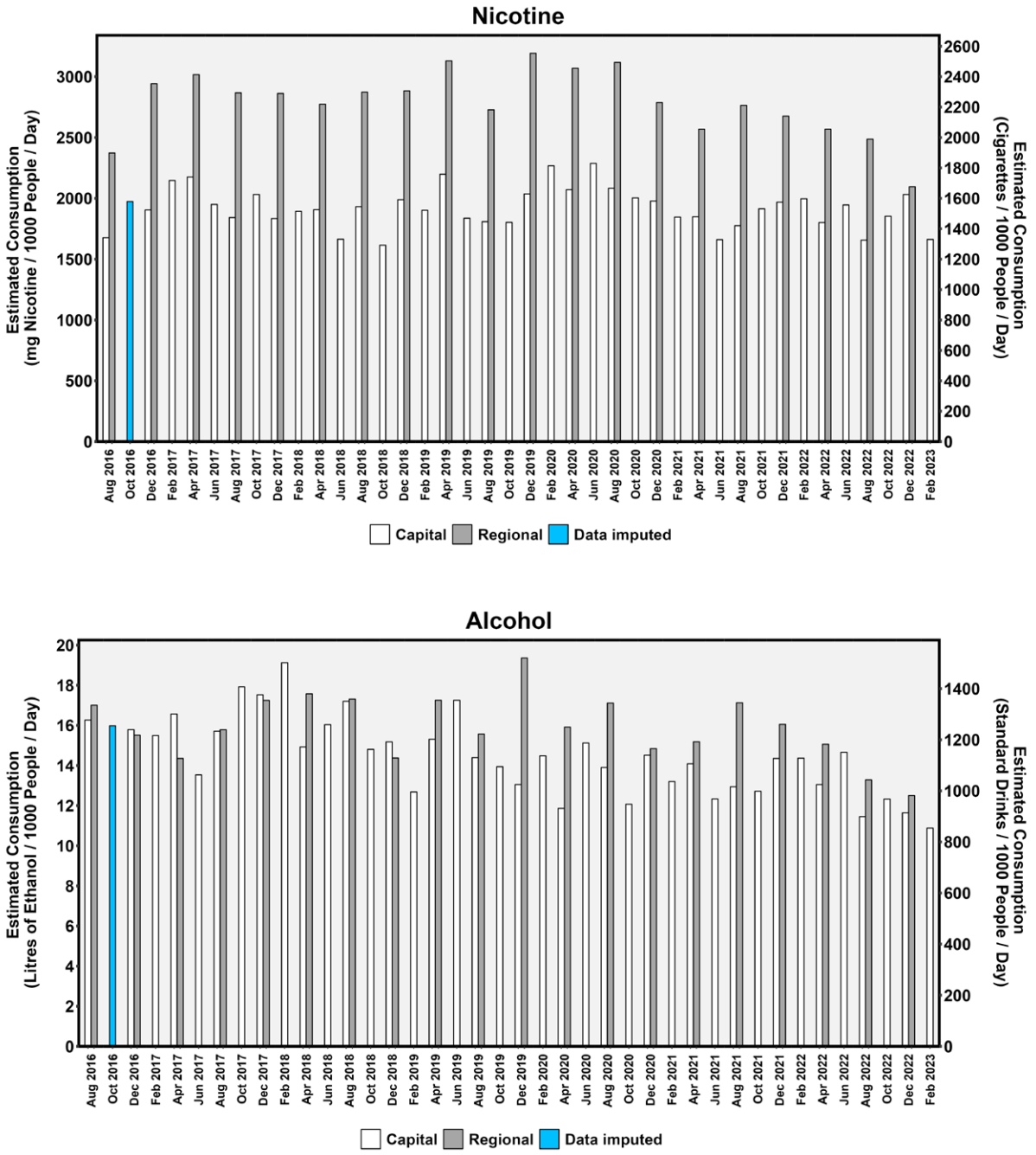
The pharmaceutical opioids oxycodone and fentanyl both show very large differences between capital cities and regional Australia, although the difference has narrowed for fentanyl (Figure 48). Capital city populations consumed both drugs at lower levels than regional areas. Oxycodone consumption increased steadily after early 2017 to a peak in December 2018, followed by an ongoing decline to record low regional consumption in December 2022 and record low capital city consumption in February 2023. Fentanyl consumption largely followed a similar trend until April 2022, since when both capital city and regional consumption has increased.

The remaining substances, heroin, ketamine and cannabis had mixed patterns in a national context (Figure 49 and Figure 50, respectively). Heroin consumption has decreased tangibly in the current reporting period. Short-term changes have been evident since the drug was first included in the Program, albeit within a relatively narrow range. Overall, capital city heroin consumption continues to exceed regional consumption.

Analysis of ketamine commenced in December 2020. Excretion of the pharmaceutical compound has been consistently lower in regional Australia compared to the capital cities. The changes in ketamine excretion to date have occurred within a narrow band, considering the small daily excreted loads measured in wastewater. That said, excretion has increased in capital city and regional sites since April 2022.

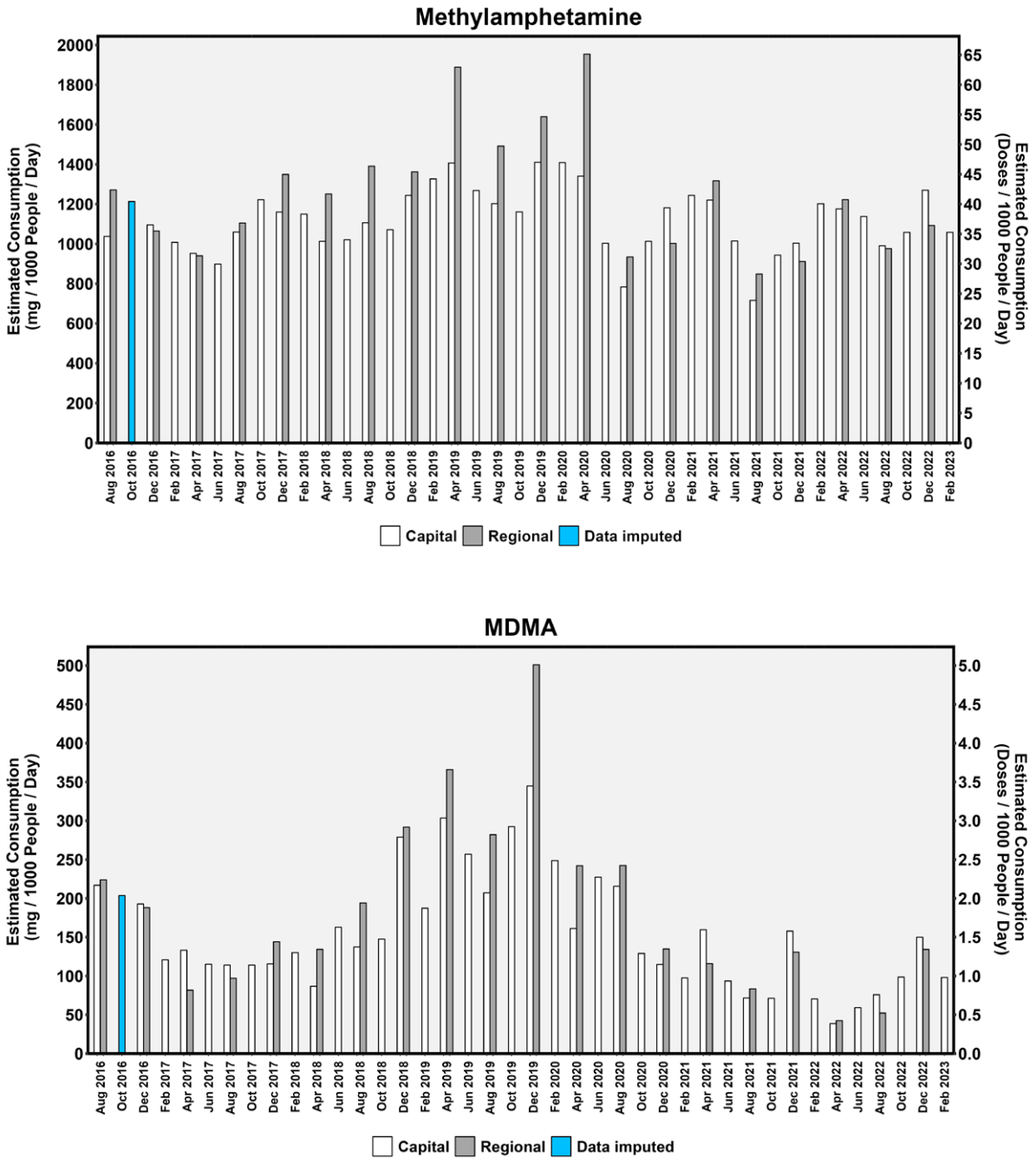
Cannabis consumption has been much lower in capital cities compared to regional areas (Figure 50). Current consumption of the drug in regional Australia is at relatively high levels, with a gradual overall increase evident since the start of cannabis monitoring in 2018. Capital city use of the drug has fluctuated and presently falls within a consistent range spanning the last 3 years. An apparent trend has emerged in regional cannabis consumption over the best part of the past 3 years whereby consumption in August tangibly exceeds subsequent recorded consumption in December and April.

Figure 45: The population-weighted average of all sites for nicotine and alcohol.



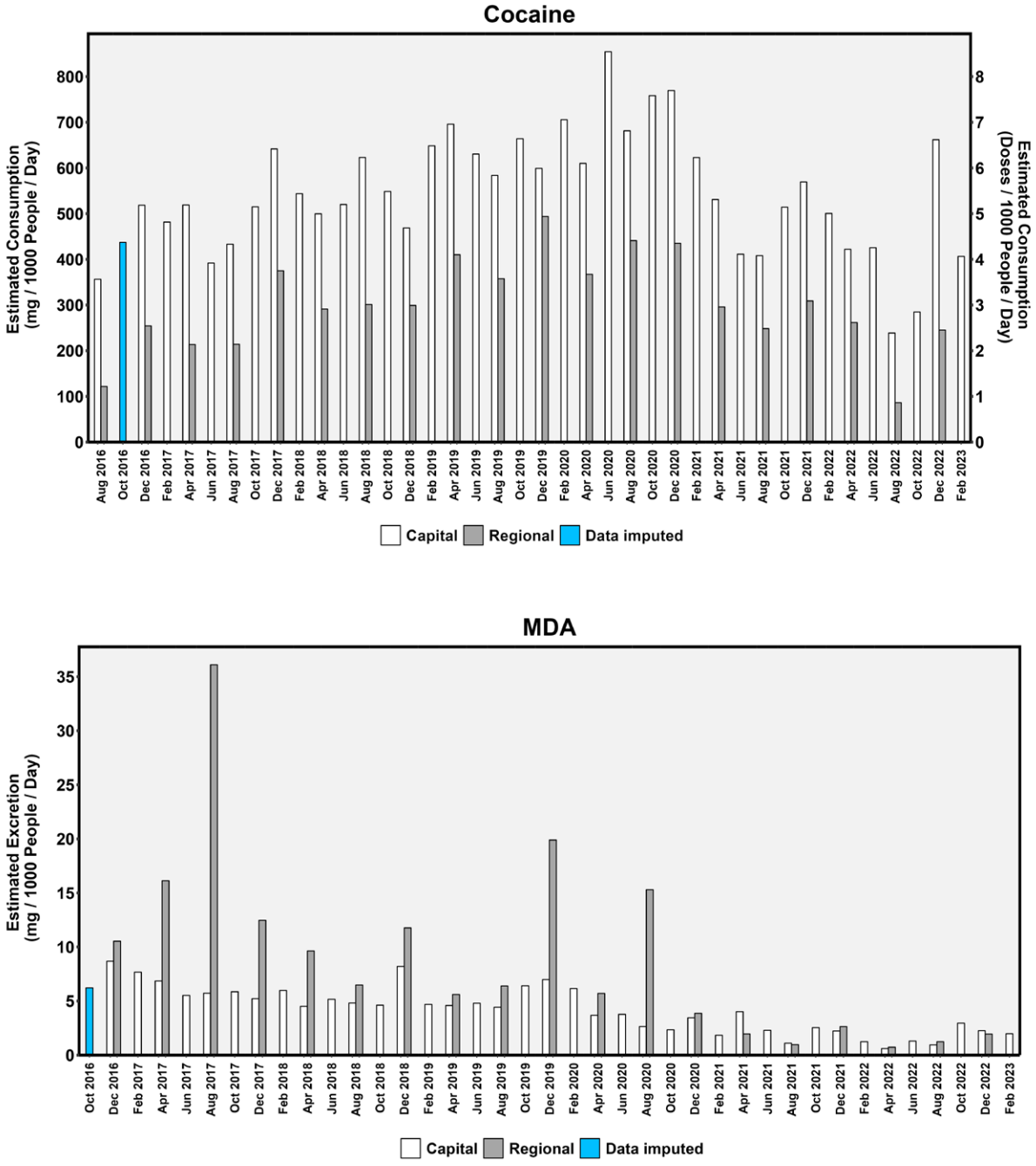
As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

Figure 46: The population-weighted average of all sites for methylamphetamine and MDMA.



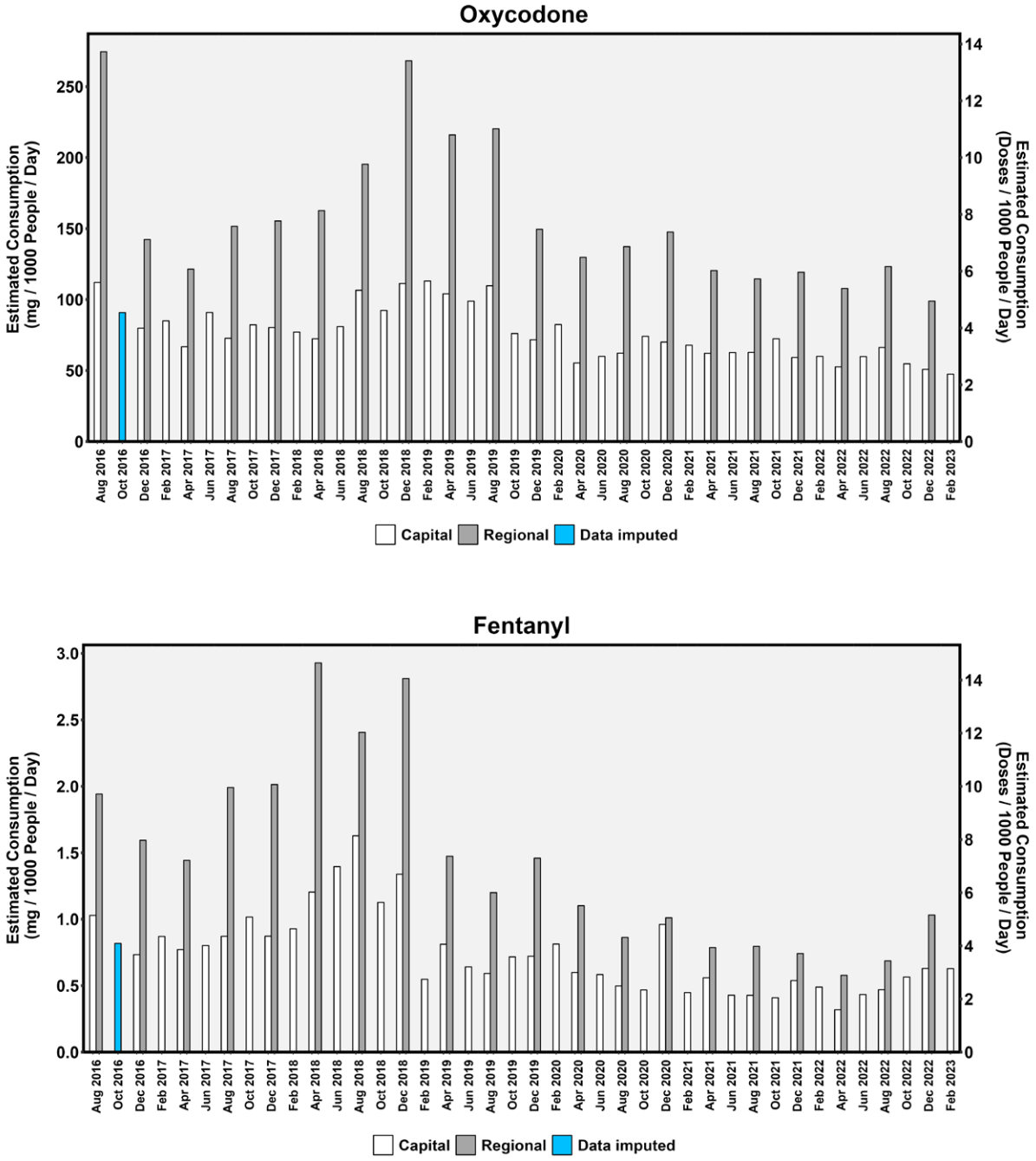
As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

Figure 47: The population-weighted average of all sites for cocaine and MDA.



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 48: The population-weighted average of all sites for oxycodone and fentanyl.



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 49: The population-weighted average of all sites for heroin and ketamine.

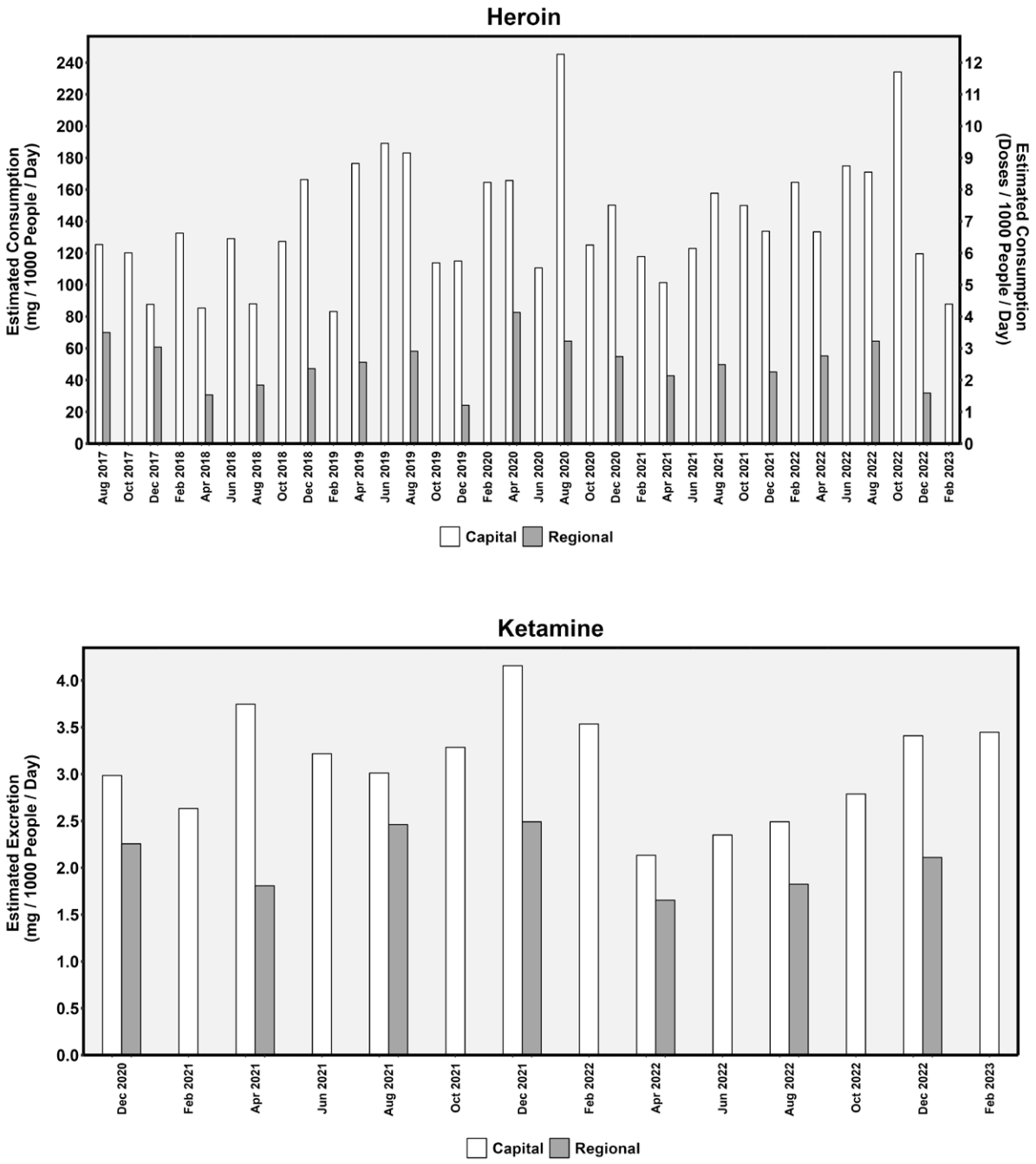
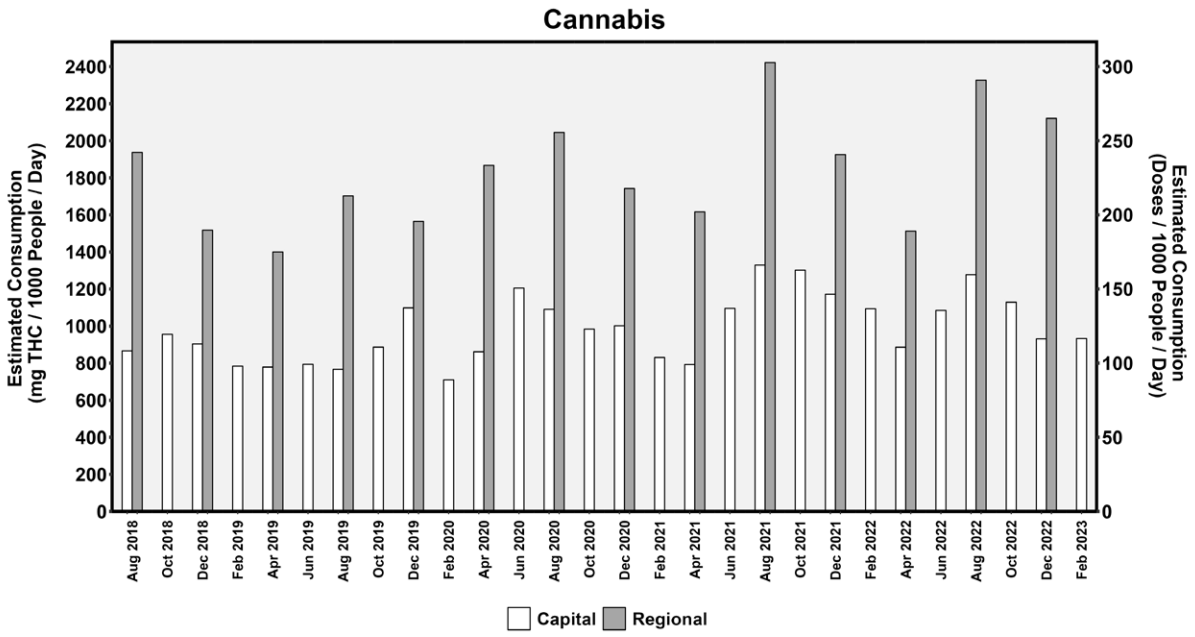


Figure 50: The population-weighted average of all sites for cannabis.



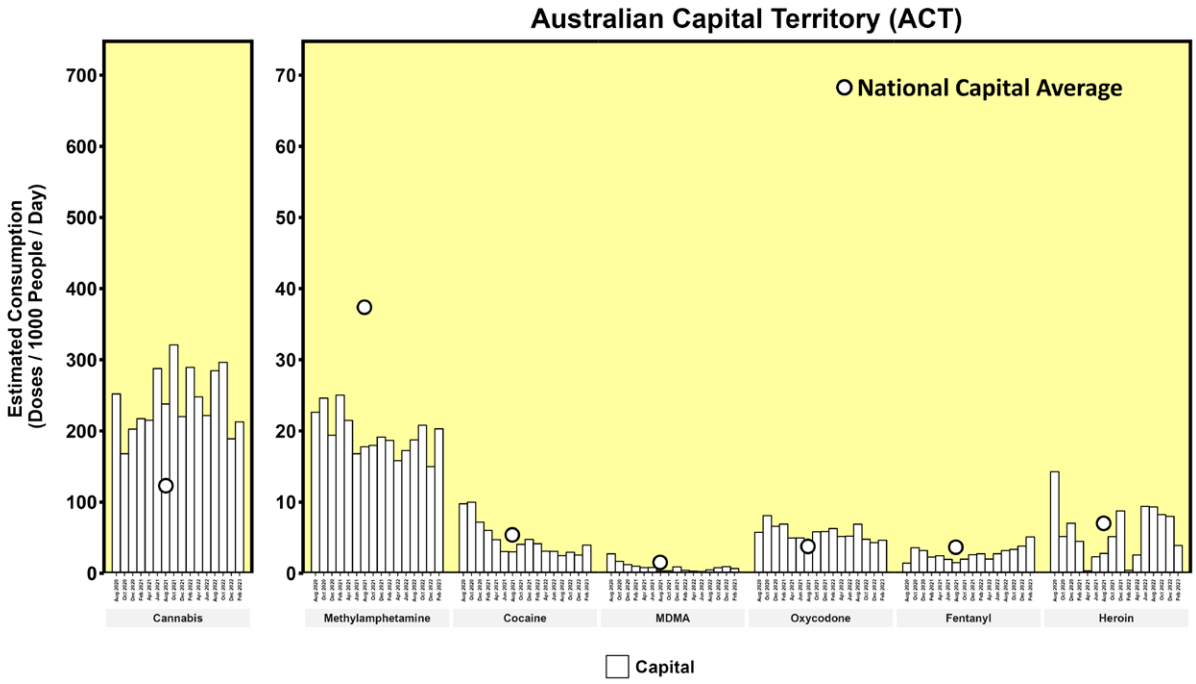
4.4 DRUG PROFILE FOR EACH STATE AND TERRITORY

To compare 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 and plotted on the same figure. Cannabis has been included for the first time in this section as dose amounts have now been defined, as well as a revised excretion rate. In the absence of clear pharmacokinetic excretion data for MDA and ketamine, these compounds were excluded from the section.

When the amount of drug measured in wastewater was normalised for population size and average dose consumed (excretion factors listed in Appendix 1), alcohol and nicotine remained consistently the highest consumed drugs in all states and territories.

Of the remaining drugs, in terms of the substances with available dose information, cannabis ranked the highest, with methylamphetamine next (Figure 51 to Figure 54). The difference between cannabis and the other drugs is sufficiently large that the graphs have been split into 2 parts for some of the less consumed drugs to remain visible. This was the case across all jurisdictions, with the scale of cannabis consumption consistently higher for both capital cities and regional areas. Methylamphetamine was the most consumed drug after cannabis across all jurisdictions. The next highest consumed drug after cannabis and methylamphetamine depends on the state, territory and time period.

Figure 51: Profile of average drug consumption by state or territory, August 2020 to February 2023 for capital city sites and to December 2022 for regional sites. 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.



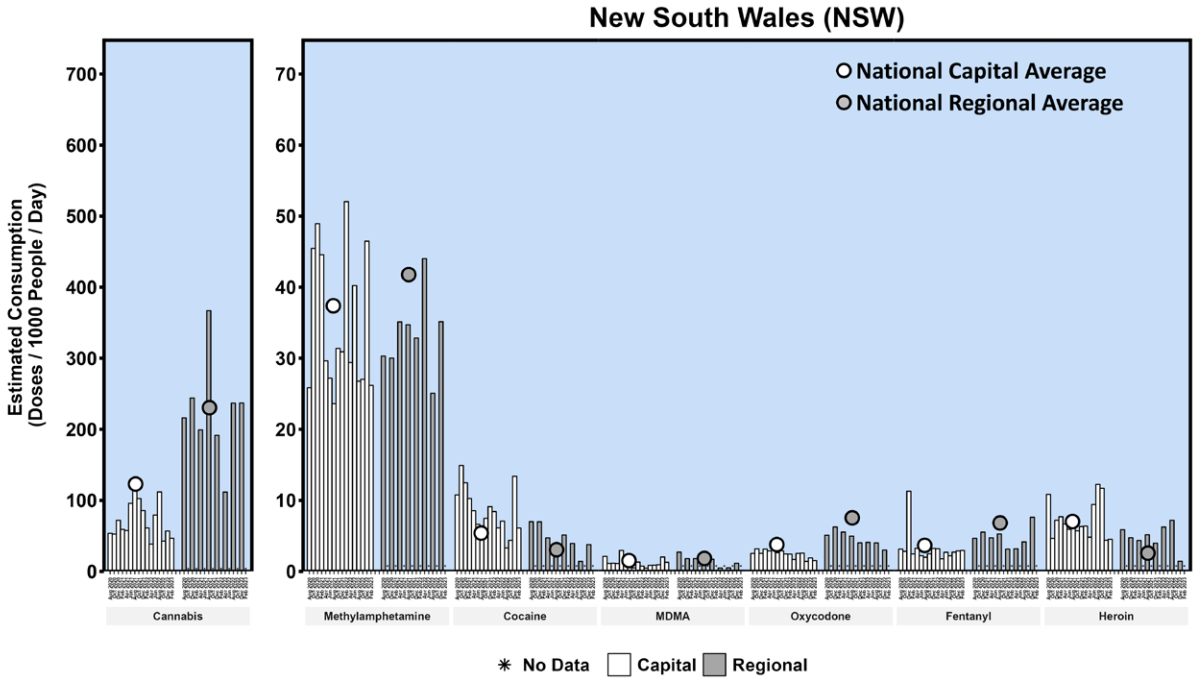
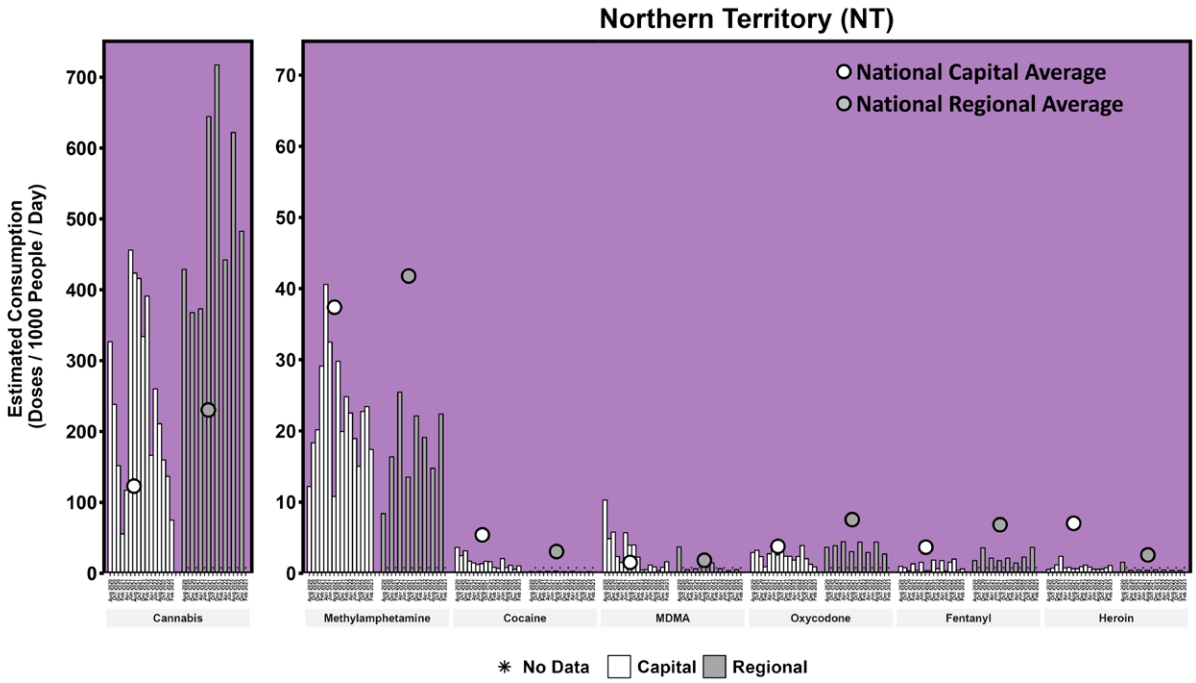


Figure 52: Profile of average drug consumption by state or territory, August 2020 to February 2023 for capital city sites and to December 2022 for regional sites.



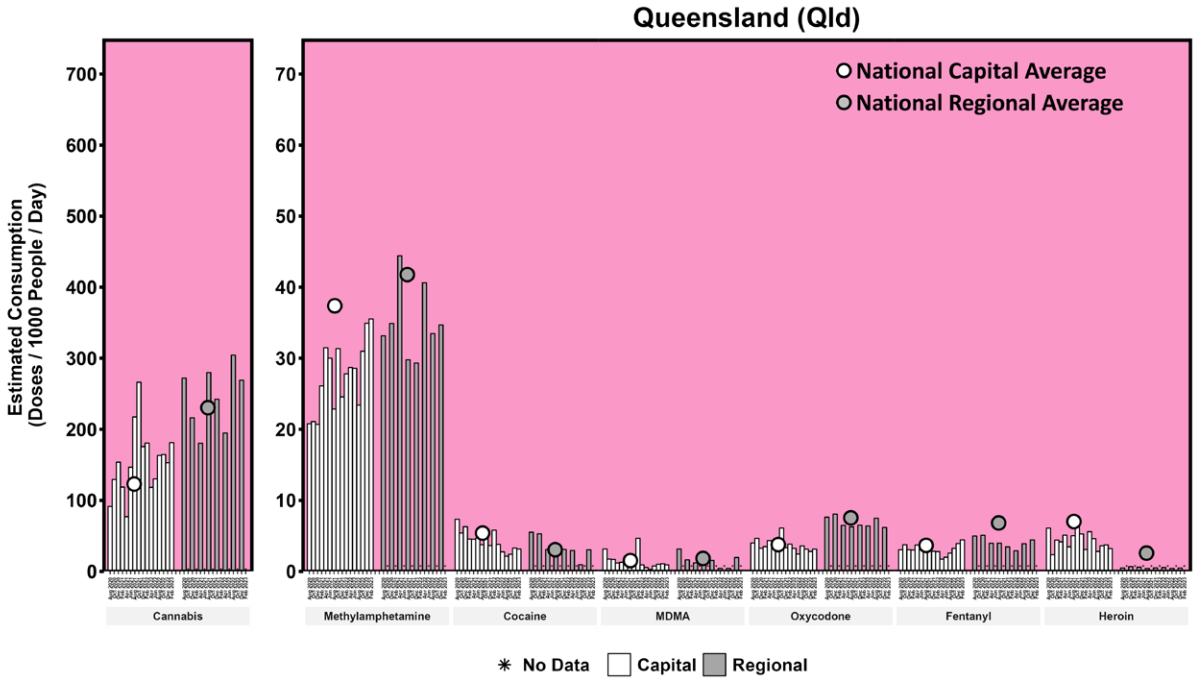


Figure 53: Profile of average drug consumption by state or territory, August 2020 to February 2023 for capital city sites and to December 2022 for regional sites.

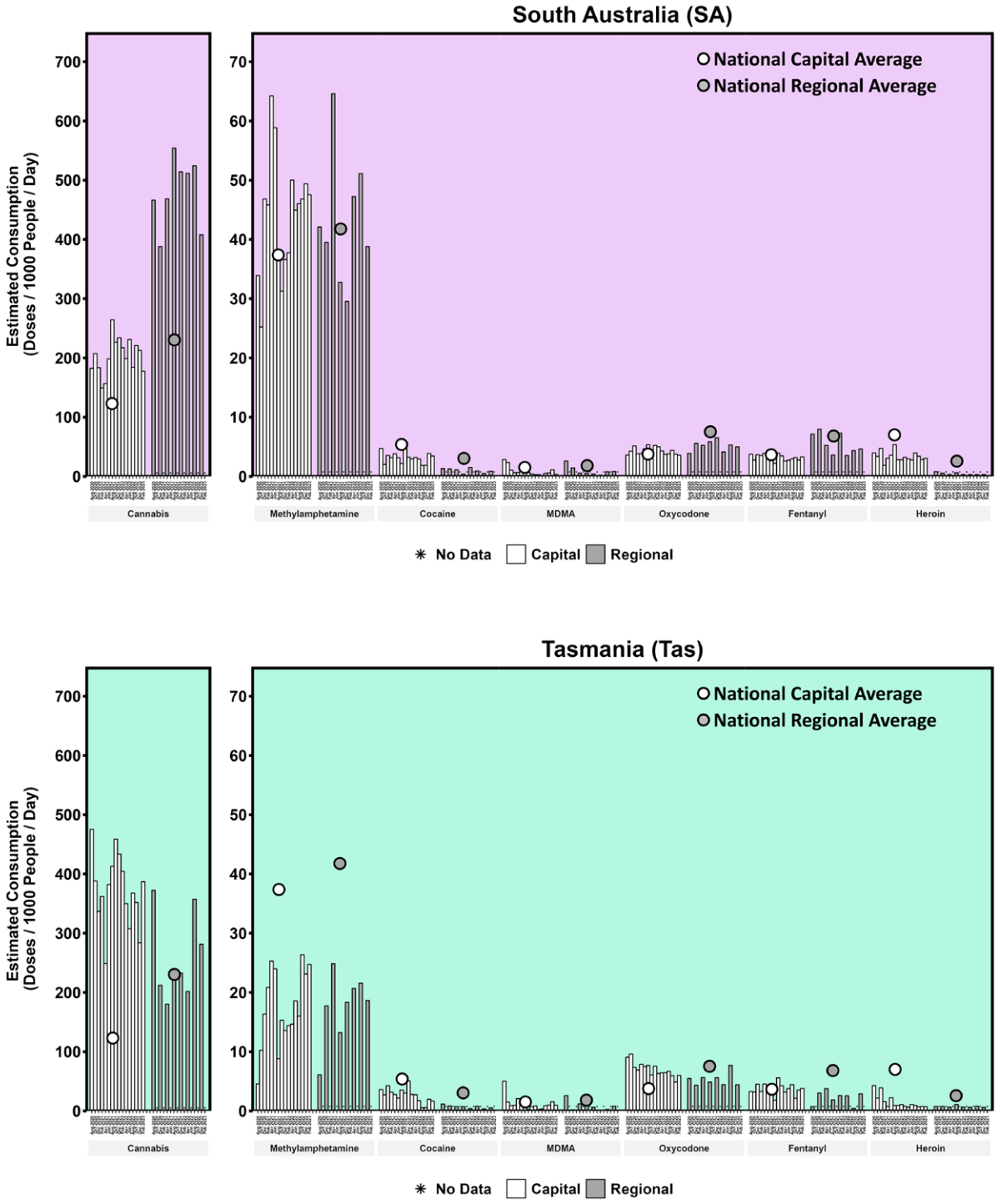
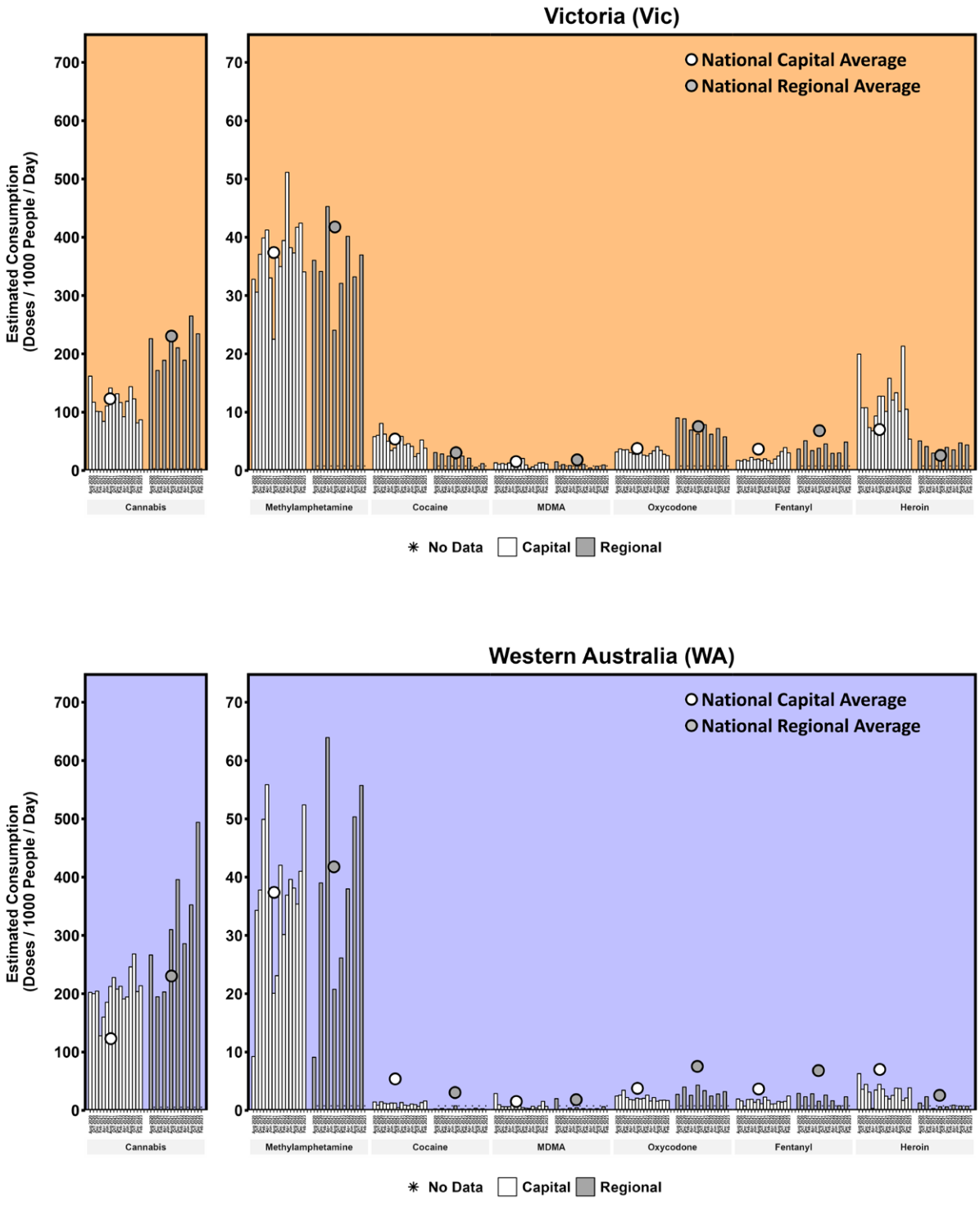


Figure 54: Profile of average drug consumption by state or territory, August 2020 to February 2023 for capital city sites and to December 2022 for regional sites.



5: COMPARISONS WITH INTERNATIONAL DATA

5.1: BACKGROUND

Wastewater-based epidemiology has been standardised by a European network of laboratories focused on quality sampling and analysis, called the Sewage Core Group Europe (SCORE). The SCORE network facilitates an annual inter-laboratory testing program among participating laboratories that research and measure illicit drugs in wastewater across the globe. SCORE is partially funded by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). As part of this routine laboratory benchmarking, participating laboratories which pass analytical criteria are invited to submit 7 days of wastewater data for their region in roughly the same time period, thus ensuring the quality of the analysis for reported data. The research teams at The University of Queensland and University of South Australia have participated in and passed this testing regime for more than 5 years. As the methods are standardised and tested internationally, this allows for the comparison of data between countries.

European data from this inter-laboratory testing regime were obtained from the SCORE network, as reported on the EMCDDA website. The most recent available data were from March and May 2022 from participating laboratories, specifically from 104 cities in 24 countries across Europe, 4 cities in New Zealand, 1 city in South Korea and 1 city in the United States of America (USA). SCORE reports their results as the amount of drug excreted in mg per day per 1,000 people, whereas the NWDMP converts these measures to consumption (either as mg consumed/day/1,000 people or doses consumed/day/1,000 people). To compare the SCORE data with Australian data, the former were converted to the NWDMP consumption estimates by applying the same excretion factors and doses as are used in the NWDMP. The data for each site was aggregated by population-weighting each site to formulate the country average, using the same methodology as the NWDMP.

A comparison between the per-capita consumption of stimulants was made between data from Australia (from the NWDMP) and data from the recent SCORE study. These comparisons can help to evaluate the relative scale of use across several countries. However, it should be noted such comparisons need to be understood in the context of preferences and availability of drugs which may be very different between countries. For example, throughout many parts of Europe, amphetamine is more commonly consumed than methylamphetamine, which is the opposite in Australia. It may also be the case that the availability, price, trafficking networks or preferences may be different between Australia and elsewhere, which may drive differences observed in the ratio of cocaine, amphetamine, MDMA and methylamphetamine use. Additionally, the latest SCORE data may only relate to only a single site or city per country, so the data from one site might not necessarily be representative of drug use across the entire country.

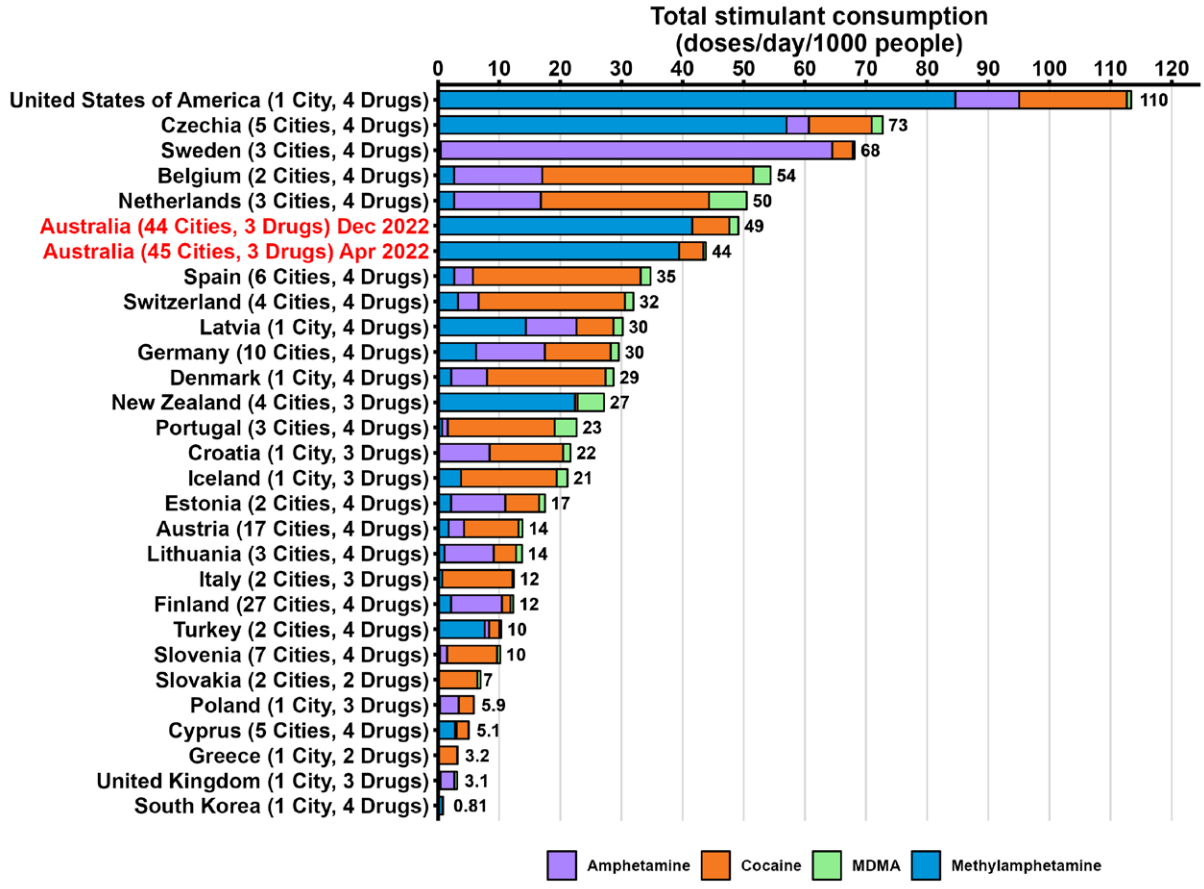
5.2: RESULTS

Due to the large difference in consumption between stimulant drugs, it may be useful to compare the total stimulant use between locations to account for these preferences. In Figure 55, cocaine, MDMA, methylamphetamine and amphetamine were summed as the number of doses/day/1,000 people to evaluate the total use of these 4 common stimulants. In the case of amphetamine, all data were adjusted for the expected percentage of the drug which is derived from methylamphetamine metabolism. For the Australian data we did not include amphetamine, as generally the majority of amphetamine in the wastewater is suspected to be due to methylamphetamine metabolism.

In some countries, including Australia, amphetamine (dexamfetamine, dextroamphetamine or lisdexamfetamine) can also be prescribed for the treatment of ADHD, which cannot be separated using the methodology which has been used to acquire these drug concentrations. It should also be noted not all sites measured for or detected all drugs, which may also limit the comparisons between some locations.

Australian data submitted to SCORE was collected in April and December 2022. Comparisons of Australian data with SCORE data are based on the data obtained in April 2022 as it represented roughly the same sampling period as the other participating countries. Australia ranked sixth highest in terms of combined stimulant use when compared to the SCORE dataset at 44 doses per day per 1,000 people (Figure 55). The Australian data were driven chiefly by methylamphetamine and were lower than the USA (110), Czechia (73), Sweden (68), Belgium (54) and the Netherlands (50). The Australia, USA and Czechia rankings are a consequence of a high proportion of methylamphetamine use, whereas Sweden, Belgium and the Netherlands were proportionally higher in cocaine or amphetamine use.

Figure 55: The total amount of stimulants consumed (as the population-weighted average doses per 1,000 people per day) for each country in the SCORE dataset. Note the data labels are rounded to 2 significant figures.

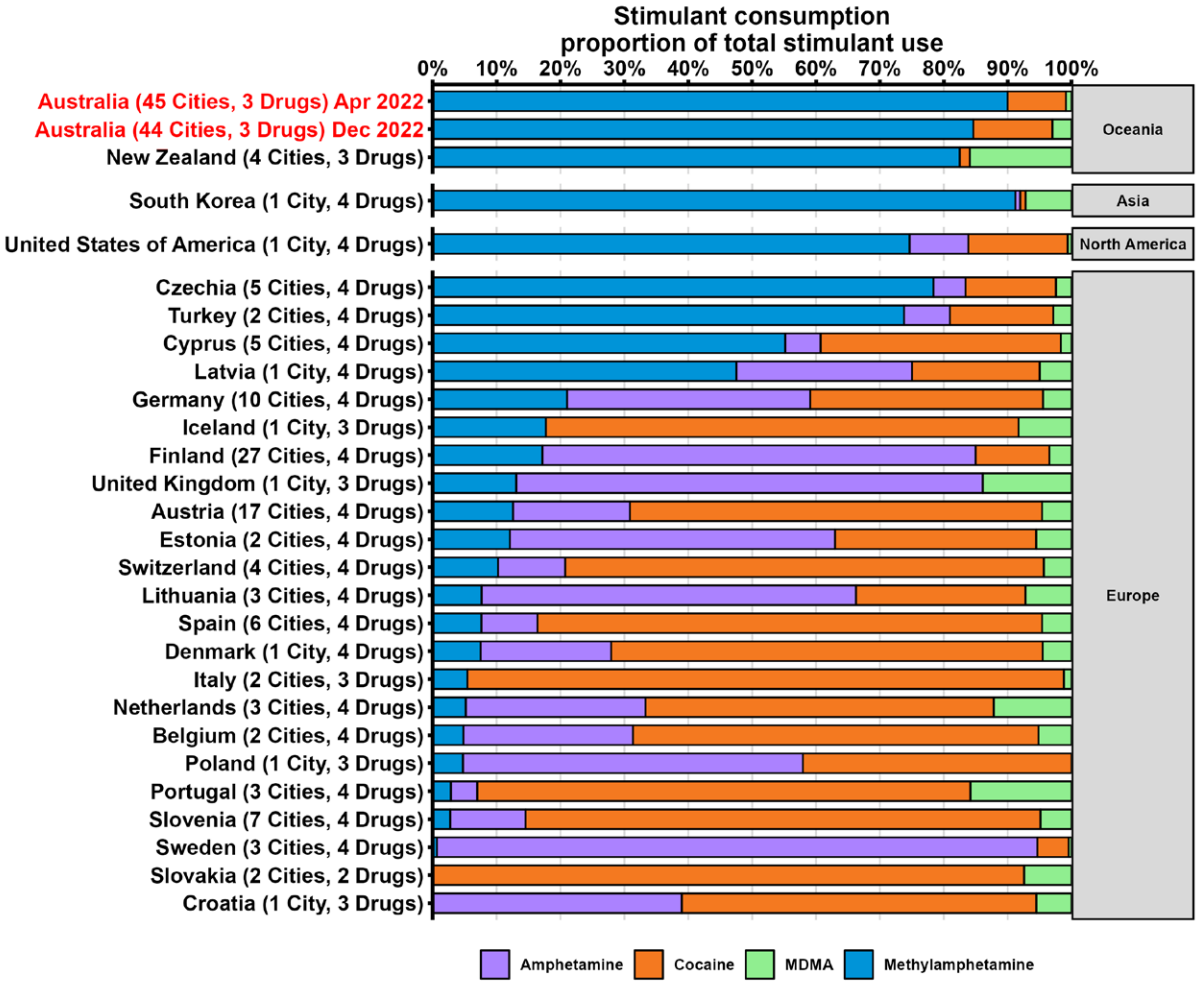


Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE European data were from March - May 2022. Australian data is from April and December 2022.

The proportion that each of the 4 stimulants contributes to the total number of doses can be visualised a different way to reveal which of the drugs contribute most to the stimulant use within each country. Figure 56 shows the same data as Figure 55, but with each drug scaled as a percentage of the total consumed within each country. This representation of the data (scaled to the same value of 100%) reveals the contribution of each drug to the total use, or drug profile, which can be compared between locations.

The profile of stimulant use in Australia is heavily influenced by methylamphetamine, which comprises 80% (in December 2022) and 90% (in April 2022) of the 3 main illicit stimulants consumed. This is similar to some countries such as Czechia at around 80%, New Zealand (>80%), the USA (>70%), and South Korea (>90%). Of the European cities, sites in Czechia, Latvia, Cyprus and Turkey were also methylamphetamine dominant, while Finland, Sweden, Poland, the United Kingdom (UK) and Lithuania were amphetamine dominant. The remaining locations predominantly favoured cocaine.

Figure 56: National population weighted average consumption for cities reported in the SCORE European study for methylamphetamine, MDMA, cocaine and amphetamine, represented as the proportion of the total stimulant consumption in each country. Note that some countries did not analyse for or detect all substances.



The high methylamphetamine consumption estimates in Australia were evident when compared with sites in the SCORE study (Figure 57). Methylamphetamine levels in Australia (39 doses/day/1,000 people) were the third highest compared to other countries participating in the study, behind the site in the USA (85 doses/day/1,000 people) and Czechia (57 doses/day/1,000 people). It is important to note that some countries with relatively high methylamphetamine use according to police actions or research papers, such as in Asia and other parts of the Americas, are not represented here. Amphetamine data is shown for the other countries in Figure 58.

Figure 57: National population weighted average consumption of methylamphetamine in SCORE data and Australia.

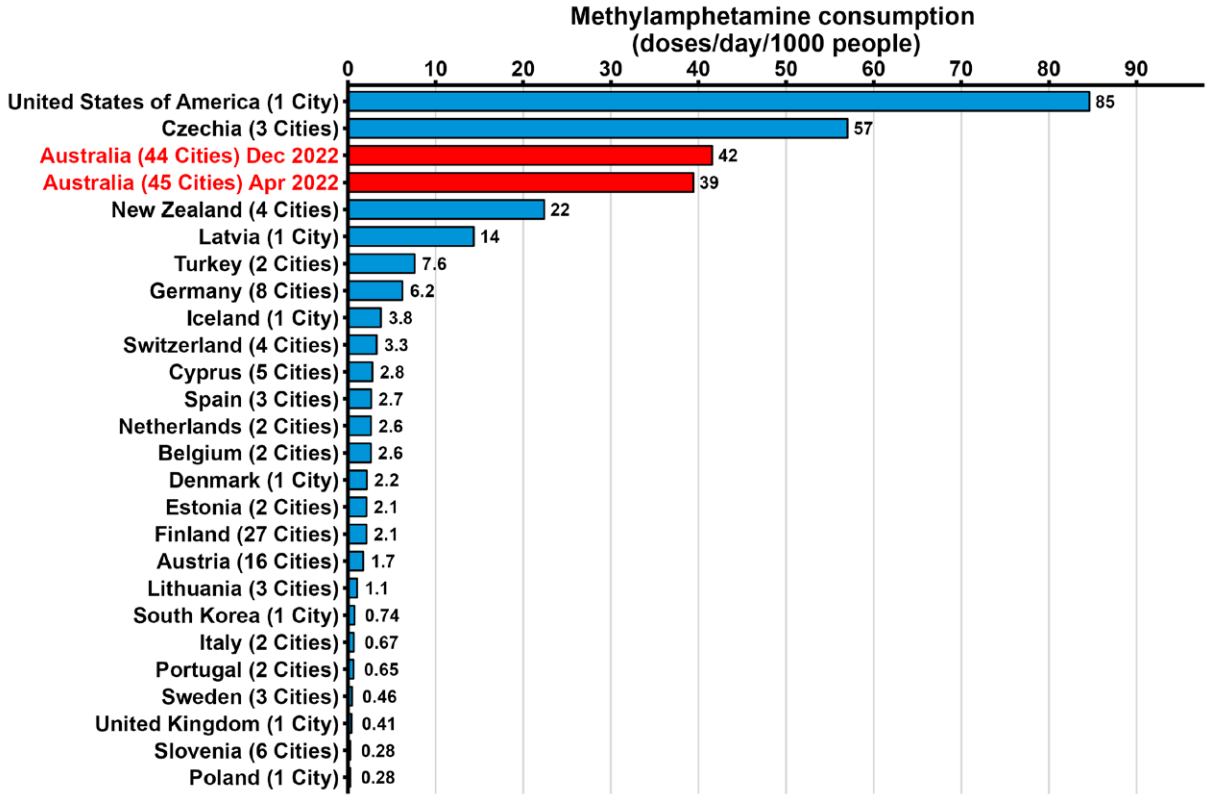
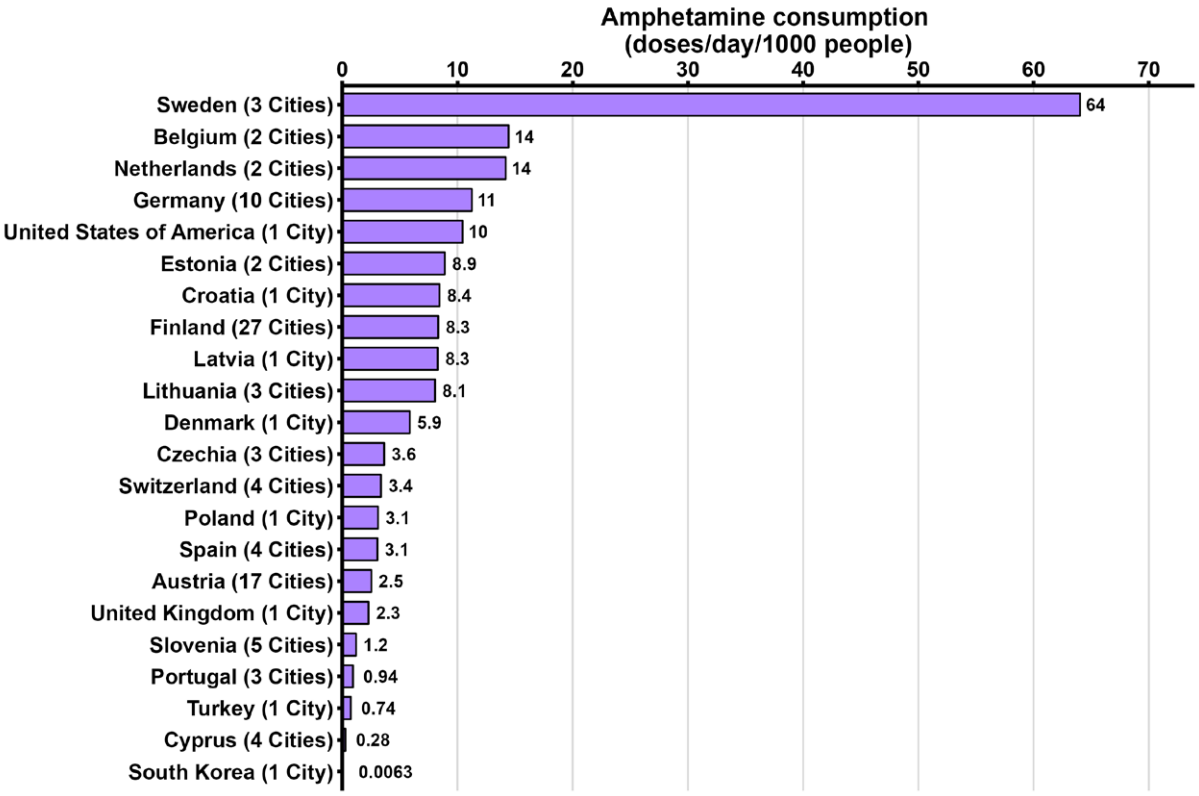


Figure 58: National population weighted average consumption of amphetamine in SCORE data.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE data were from March - May 2022. Australian data is from April and December 2022.

Compared to the SCORE dataset, Australian cocaine consumption ranked towards the lower end (4 doses/day/1,000 people, Figure 59), and well below the highest consumption observed in Belgium, the Netherlands and Spain (27-35 doses/day/1,000 people).

Australian MDMA consumption ranked towards the lower end of the SCORE sites (0.39 doses/day/1,000 people, Figure 60) and well below consumption levels observed in the Netherlands (6.1 doses/day/1,000 people).

Figure 59: National population weighted average consumption of cocaine in SCORE data and Australia.

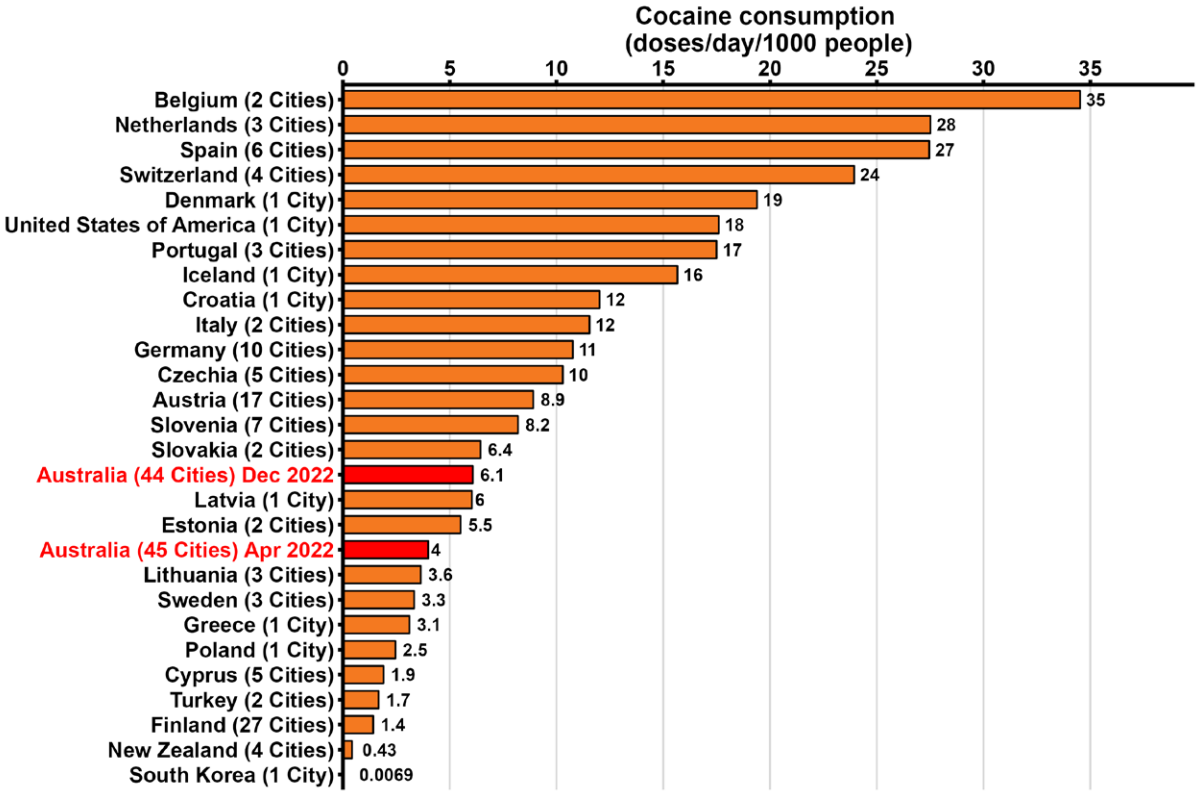
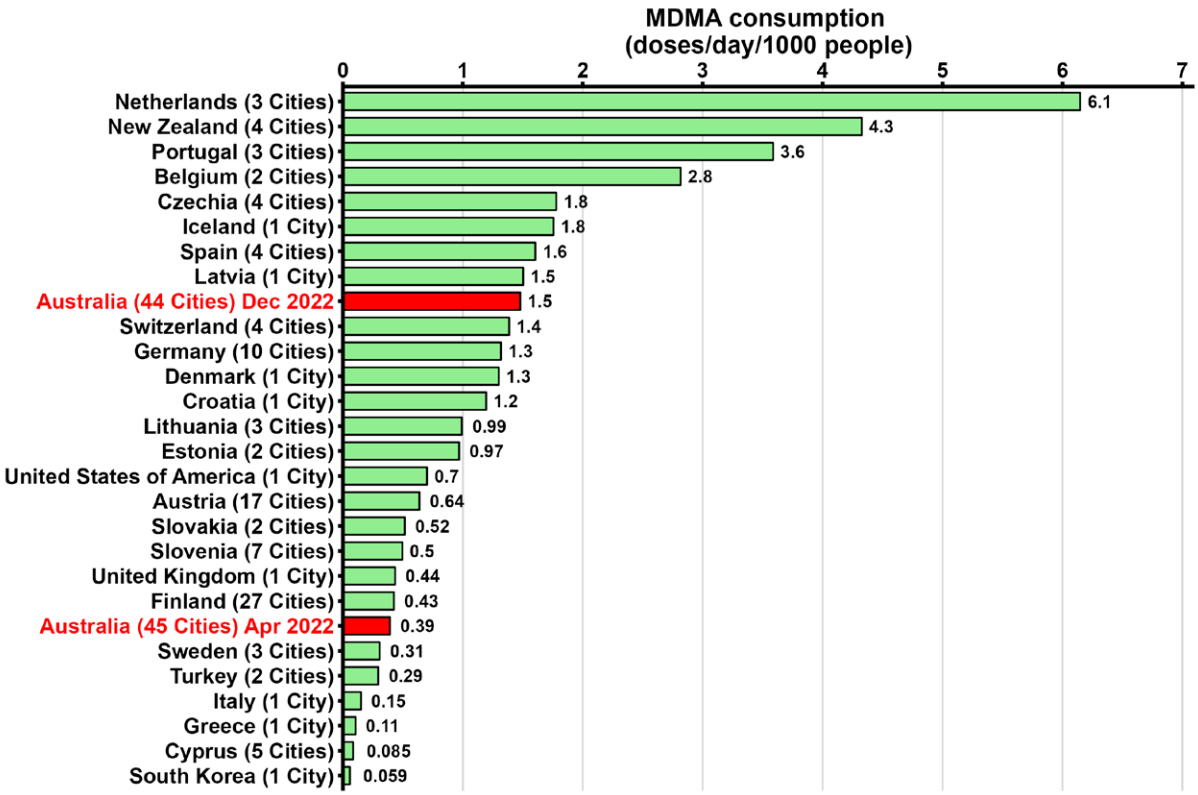


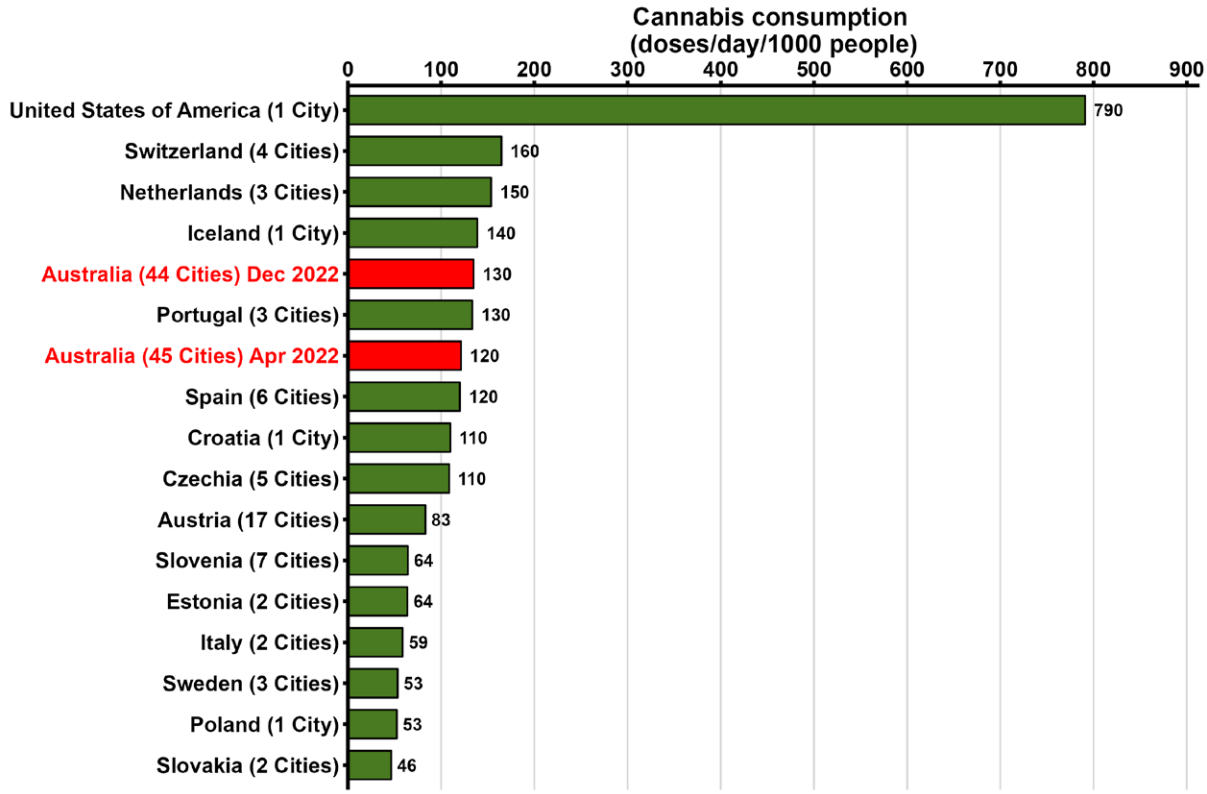
Figure 60: National population weighted average consumption of MDMA in SCORE data and Australia.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE data were from March - May 2022. Australian data are from April and December 2022.

Australian data was compared with cannabis consumed in 15 other countries (Figure 61). The site tested in the USA recorded the highest use at around 790 doses/day/1,000 people, which could be related to the legal status of cannabis in many states of the USA. Caution should be applied when comparing with the USA data as the legal status of cannabis varies between states and the participating city may not be representative of the country as a whole. Australia ranked sixth of the 16 countries, (120 doses/day/1,000 people).

Figure 61: National population weighted average consumption of cannabis in SCORE and Australian datasets.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE data were from March - May 2022. Australian data is from April and December 2022.

6: ACKNOWLEDGEMENTS

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.

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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.

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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]
Methylamphetamine	Methylamphetamine	33	100	0.39[g]	30[b]
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	0.1[##]	8**
Norketamine	Ketamine	1	2	n.a.^	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.

^Ketamine is excreted as norketamine and several conjugated metabolites. As the level of conjugation is not well known and conjugated metabolites (e.g., glucuronides) are likely to deconjugate in the sewer, a ketamine excretion rate has not been assigned at this time. Once the impact of in-sewer deconjugation is known, this will be revised.

**A dose of 8 mg THC has been suggested to provide the desirable effect for the average user, regardless of the route of administration (Freeman and Lorenzetti, 2020). This takes into consideration that not all the available THC in a joint or edibles is inhaled or absorbed by the lung or the intestine and enters the blood stream.

##Between 23% (edibles) and 31% (smoked) of an ingested dose of cannabis is excreted in faeces as the metabolite, THC-COOH, and another 3% in urine in free or conjugated form (Wall and Perez-Reyes, 1981). Recent research shows that the particulate fraction of wastewater can contain upwards of 40% of the total excreted THC-COOH load (Campos-Manas et al, 2022). Experiments by the authors of this report on wastewater from around Australia show that the water-soluble fraction of THC-COOH on average is about 33% of the total load, inclusive of the bound glucuronide which deconjugates in the sewer. Therefore, a correction factor of 10% has been applied in this report to convert the measured excreted load to consumed amounts. This number was derived as follows:

Of THC consumed, 30% enters the sewer as THC-COOH (Wall and Perez-Reyes, 1981). This load partitions with approximately 67% adsorbed to particulates and 33% dissolved in the water fraction on average (unpublished data). Therefore, the measured amount in water represents 10% of the original amount of THC consumed. This approach represents a reasonable average based on local data and may need to be refined further as more research comes to light. It should not be considered a universal correction factor for cannabis due to the differences between wastewater and infrastructure in other countries.

APPENDIX 2: SAMPLING DETAILS FOR THIS REPORT

Sites	Capital or regional	Dec 2022	Feb 2023	Population
ACT: 009	Capital	7	7	> 150,000
NSW: 003	Capital	7	7	> 150,000
NSW: 006	Capital	7	7	> 150,000
NSW: 008	Capital	7	7	> 150,000
NSW: 016	Regional	7	–	30,000 to 150,000
NSW: 025	Regional	7	–	30,000 to 150,000
NSW: 068	Regional	7	–	> 150,000
NSW: 115	Regional	7	–	30,000 to 150,000
NSW: 163	Regional	7	–	< 30,000
NSW: 164	Regional	7	–	< 30,000
NSW: 165	Regional	7	–	< 30,000
NT: 010	Capital	7	7	30,000 to 150,000
NT: 078	Regional	7	–	< 30,000
Qld: 002	Capital	7	7	> 150,000
Qld: 005	Capital	7	7	> 150,000
Qld: 011	Capital	7	7	> 150,000
Qld: 012	Regional	7	–	> 150,000
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: 042	Regional	7	–	30,000 to 150,000
Qld: 053	Regional	7	–	< 30,000
Qld: 077	Regional	7	–	< 30,000
SA: 007	Capital	7	7	> 150,000
SA: 013	Capital	7	7	> 150,000
SA: 027	Capital	7	7	30,000 to 150,000
SA: 059	Capital	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	7	–	< 30,000
SA: 119	Regional	7	–	< 30,000
Tas: 004	Capital	5	5	< 30,000
Tas: 019	Capital	5	5	< 30,000
Tas: 041	Capital	5	7	< 30,000
Tas: 018	Regional	5	–	< 30,000
Tas: 048	Regional	5	–	< 30,000

APPENDIX 2 (CONTINUED)

Sites	Capital or regional	Dec 2022	Feb 2023	Population
Vic: 001	Capital	7	7	> 150,000
Vic: 067	Capital	7	7	> 150,000
Vic: 046	Regional	7	–	30,000 to 150,000
Vic: 061	Regional	7	–	30,000 to 150,000
Vic: 062	Regional	7	–	< 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: 125	Regional	7	–	30,000 to 150,000
Vic: 155	Regional	7	–	30,000 to 150,000
Vic: 156	Regional	7	–	< 30,000
WA: 101	Capital	7	7	> 150,000
WA: 103	Capital	7	7	> 150,000
WA: 104	Capital	7	7	> 150,000
WA: 102	Regional	7	–	30,000 to 150,000
WA: 116	Regional	7	–	< 30,000
WA: 120	Regional	7	–	30,000 to 150,000
WA: 129	Regional	7	–	< 30,000
Regional Sites		37	–	
Capital Sites		20	20	
Total Sites		**57**	**20**	
Regional Samples		255	–	
Capital Samples		134	136	
Total Samples		389	136	
Cumulative Samples		**9,464**	**9,600**	

APPENDIX 3: PROPORTION OF SAMPLES ABOVE LOD (%) FOR EACH DRUG AND PERIOD ASSESSED[6]

Drug	Capital or regional	Dec 2022	Feb 2023
Alcohol	Capital	100	100
Alcohol	Regional	100	–
Cannabis	Capital	100	100
Cannabis	Regional	100	–
Cocaine	Capital	96	98
Cocaine	Regional	75	–
Fentanyl	Capital	90	88
Fentanyl	Regional	90	–
Heroin	Capital	73	79
Heroin	Regional	21	–
Ketamine	Capital	96	96
Ketamine	Regional	78	–
MDA	Capital	75	74
MDA	Regional	55	–
MDMA	Capital	100	99
MDMA	Regional	98	–
Methylamphetamine	Capital	100	100
Methylamphetamine	Regional	100	–
Nicotine	Capital	100	100
Nicotine	Regional	100	–
Oxycodone	Capital	100	100
Oxycodone	Regional	100	–

6 Percentage detections for previous collection periods are available in Appendix 4 of Report 6 and Appendix 3 of Reports 7 to 18.

CONCLUSIONS

CONCLUSIONS

For the 19th report of the National Wastewater Drug Monitoring Program, wastewater analysis was conducted in December 2022 (capital city and regional sites) and February 2023 (capital city sites only). The Program identified variations in patterns of drug consumption 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. Cannabis consumption has been expressed as doses for the first time in Report 19 and was the most consumed illicit drug in Australia by some margin, followed by methylamphetamine.[7]

METHYLAMPHETAMINE

When comparing data for August and December 2022, the population-weighted average consumption of methylamphetamine increased in both capital city and regional sites. Average capital city methylamphetamine consumption then decreased from December 2022 to February 2023. In December 2022, capital city methylamphetamine consumption exceeded regional consumption. In December 2022, South Australia had the highest estimated average capital city consumption of methylamphetamine, while Western Australia had the highest average regional consumption.

COCAINE

When comparing data for August and December 2022, the population-weighted average consumption of cocaine increased in both capital city and regional sites. Average capital city cocaine consumption then decreased from December 2022 to February 2023. Average capital city cocaine consumption continued to exceed average regional consumption. In December 2022, New South Wales had the highest estimated average capital city and regional consumption of cocaine.

3,4-METHYLENEDIOXYMETHYLAMPHETAMINE (MDMA)

When comparing data for August and December 2022, the population-weighted average consumption of MDMA increased in both capital city and regional sites. Average capital city MDMA consumption then decreased from December 2022 to February 2023. In December 2022, average capital city MDMA consumption exceeded regional consumption. In December 2022, New South Wales had the highest estimated average capital city MDMA consumption, while Queensland had the highest average regional consumption.

3,4-METHYLENEDIOXYAMPHETAMINE (MDA)

MDA is a metabolite of MDMA, but also an illicit drug in its own right. When comparing data for August and December 2022, MDA excretion increased in both capital city and regional sites. Average capital city MDA excretion then decreased from December 2022 to February 2023. In December 2022, average capital city MDA excretion exceeded average regional excretion for the first time since August 2021. In December 2022, Western Australia had the highest estimated average capital city excretion of MDA, while the South Australia had the highest average regional excretion.

7 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 and December 2022, the population-weighted average consumption of heroin decreased in both capital city and regional sites. Average capital city heroin consumption then decreased further from December 2022 to February 2023. Average capital city heroin consumption continued to exceed average regional consumption. In December 2022, Victoria had the highest estimated average capital city and regional consumption of heroin.

CANNABIS

When comparing data for August and December 2022, the population-weighted average consumption of cannabis decreased in both capital city and regional sites. Average capital city cannabis consumption then increased from December 2022 to February 2023. Average regional cannabis consumption continued to exceed average capital city consumption. In December 2022, Tasmania had the highest estimated average capital city consumption of cannabis, while Western Australia had the highest average regional consumption.

KETAMINE

When comparing data for August and December 2022, the population-weighted average excretion of ketamine increased in both capital city and regional sites. Average ketamine excretion then increased further from December 2022 to February 2023. Average capital city ketamine excretion continued to exceed regional ketamine excretion. In December 2022, Victoria had the highest estimated average capital city consumption of ketamine excretion, while Northern Territory[8] had the highest average regional ketamine excretion.

OXYCODONE

When comparing data for August and December 2022, average consumption of oxycodone decreased in both capital city and regional sites, to record low levels. Average capital city oxycodone consumption then decreased further from December 2022 to February 2023. Average regional oxycodone consumption exceeded average capital city consumption. In December 2022, Tasmania had the highest estimated average capital city consumption of oxycodone, while Queensland had the highest average regional consumption.

FENTANYL

When comparing data for August and December 2022, average consumption of fentanyl increased in both capital city and regional sites. Average capital city fentanyl consumption then remained relatively stable from December 2022 to February 2023. Average regional fentanyl consumption continued to exceed average capital city consumption. In December 2022, Victoria had the highest estimated average capital city consumption of fentanyl, while New South Wales had the highest average regional consumption.

8 As the Northern Territory only had 2 participating sites, results may not be representative of the Territory as a whole, however the 2 sites cover approximately 25% of the population of the Northern Territory.

NICOTINE

When comparing data for August and December 2022, the population-weighted average consumption of nicotine increased in capital city sites and decreased in regional sites to a record low level. Average capital city nicotine consumption then decreased from December 2022 to February 2023. Average regional nicotine consumption continued to exceed average capital city consumption. In December 2022, New South Wales had the highest estimated average capital city consumption of nicotine, while the Northern Territory[9] had the highest average regional consumption of nicotine.

ALCOHOL

When comparing data for August and December 2022, the population-weighted average consumption of alcohol increased in capital city sites and decreased in regional sites to a record low level. Average capital city alcohol consumption then decreased from December 2022 to February 2023 to a record low level. Average regional alcohol consumption exceeded average capital city consumption. In December 2022, the Northern Territory[10] had the highest estimated average capital city and regional consumption of alcohol.

NEXT REPORT

The 20th report of the National Wastewater Drug Monitoring Program is scheduled for public release in October 2023.

9 Ibid.
10 Ibid.