REPORT 20

NATIONAL WASTEWATER DRUG MONITORING PROGRAM

AUSTRALIAN CRIMINAL INTELLIGENCE COMMISSION

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

University of South Australia

CONTENTS

CEO FOREWORD

I am pleased to present Report 20 of the National Wastewater Drug Monitoring Program. Wastewater analysis is one of the most cost-effective, least intrusive methods of measuring drug use at a population level. The Australian Criminal Intelligence Commission (ACIC)'s wastewater program is world leading.

This report is based on data collected in April and June 2023. In April 2023, the program covered 55% of the Australian population. The findings are critical to the 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 and the level of community harm increases in line with consumption.

Serious and organised crime groups engaged in illicit drug trafficking and production have no regard for our laws or the harms their trade causes. Groups engaged in illicit drug trafficking and production are highly capable, well-resourced, resilient and increasingly transnational. Australians are relatively high per capita users of illicit stimulants in particular and are willing to pay premium prices for illicit drugs.

Report 20 underlines the pervasive and ongoing threat posed by serious and organised crime groups through their exploitation of Australians to derive large illicit profits. Since Report 19 there have been increases in the average consumption of alcohol, methylamphetamine, oxycodone, 3,4-methylenedioxyamphetamine (MDA) and ketamine in capital city and regional sites. Average consumption of heroin, 3,4-methylenedioxymethylamphetamine (MDMA) and fentanyl has decreased. Methylamphetamine and cocaine consumption increased to the highest levels recorded since 2020. Methylamphetamine remains the highest risk illicit drug.

Wastewater insights allow the ACIC to identify and forecast emerging issues in Australia's illicit drug markets. In December 2020, the program included the monitoring of ketamine in response to concerns around the drug's increasing illicit use in Australia. Sufficient longitudinal data has been collected to draw initial conclusions. In April 2023, the data showed record high consumption of ketamine in both capital city and regional sites, with higher consumption in the capital cities than in regional areas. Noting that the program cannot distinguish between legitimate and illicit use of ketamine, differences in consumption of the drug across Australia are greater than would be expected if consumption was confined to legitimate medical and veterinary purposes. Independent reporting available to the ACIC highlights large scale manufacture and consumption of ketamine in Asia and increasing consumption in Europe. ACIC will continue to monitor this market through wastewater and other means, as we are with the fentanyl market, which is posing a significant threat in North America.

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 intelligence and law enforcement partners to identify and disrupt 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 by the ACIC so that the effectiveness of responses and the reaction of organised crime groups and drug consumers can be monitored. The geographic spread of this work is increasing.

Australia is a global leader in wastewater analysis and its use to inform policy and operational decision making. A number of countries in Europe and Asia are reaching out to the ACIC for advice on their own wastewater programs and are being guided by the ACIC's model. This contributes to enhanced global understanding of the threat posed by illicit drug markets and related threats to community health.

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 April 2023 collection covers around **55 per cent** of Australia's population – about **14 million Australians**

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

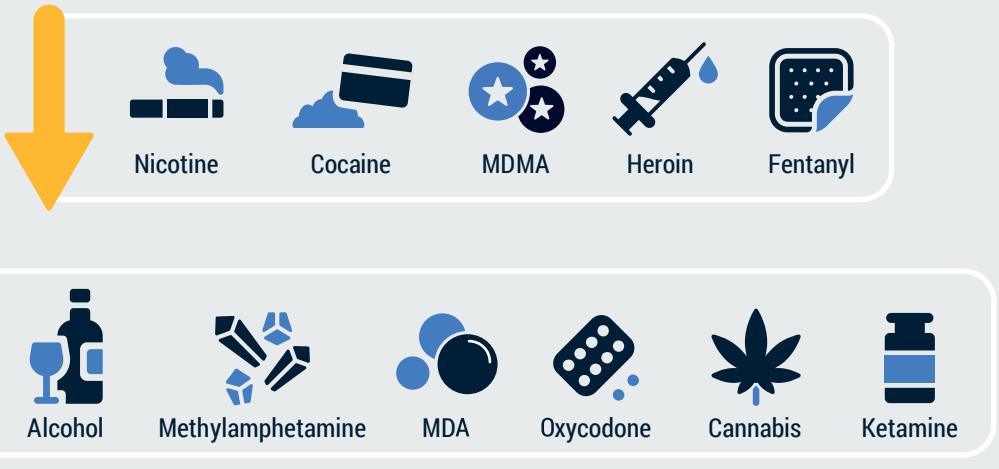
Regional **alcohol, nicotine, MDA, oxycodone, fentanyl** and **cannabis** average consumption exceeded capital city consumption.

APRIL 2023 HIGHLIGHTS

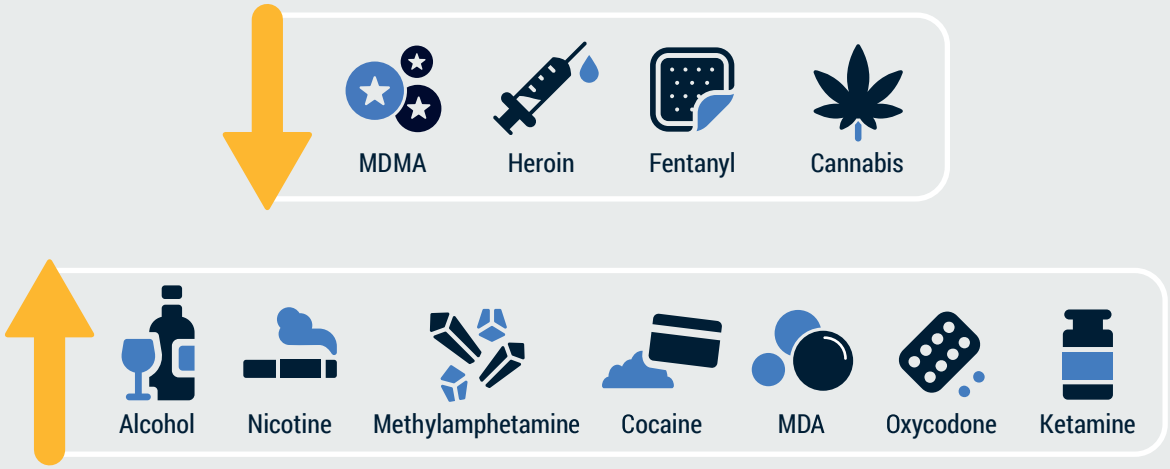
RECORD HIGH

KETAMINE
regional and capital city (April)

Between December 2022 and April 2023, the population-weighted average capital city consumption of:



Between December 2022 and April 2023, the population-weighted average regional consumption of:



INTRODUCTION

This is the 20th report of the National Wastewater Drug Monitoring Program (the Program) to be publicly released by the Australian Criminal Intelligence Commission (ACIC). Report 20 presents data on Australia's drug consumption for 12 substances and includes data for April (capital city and regional sites) and June 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:

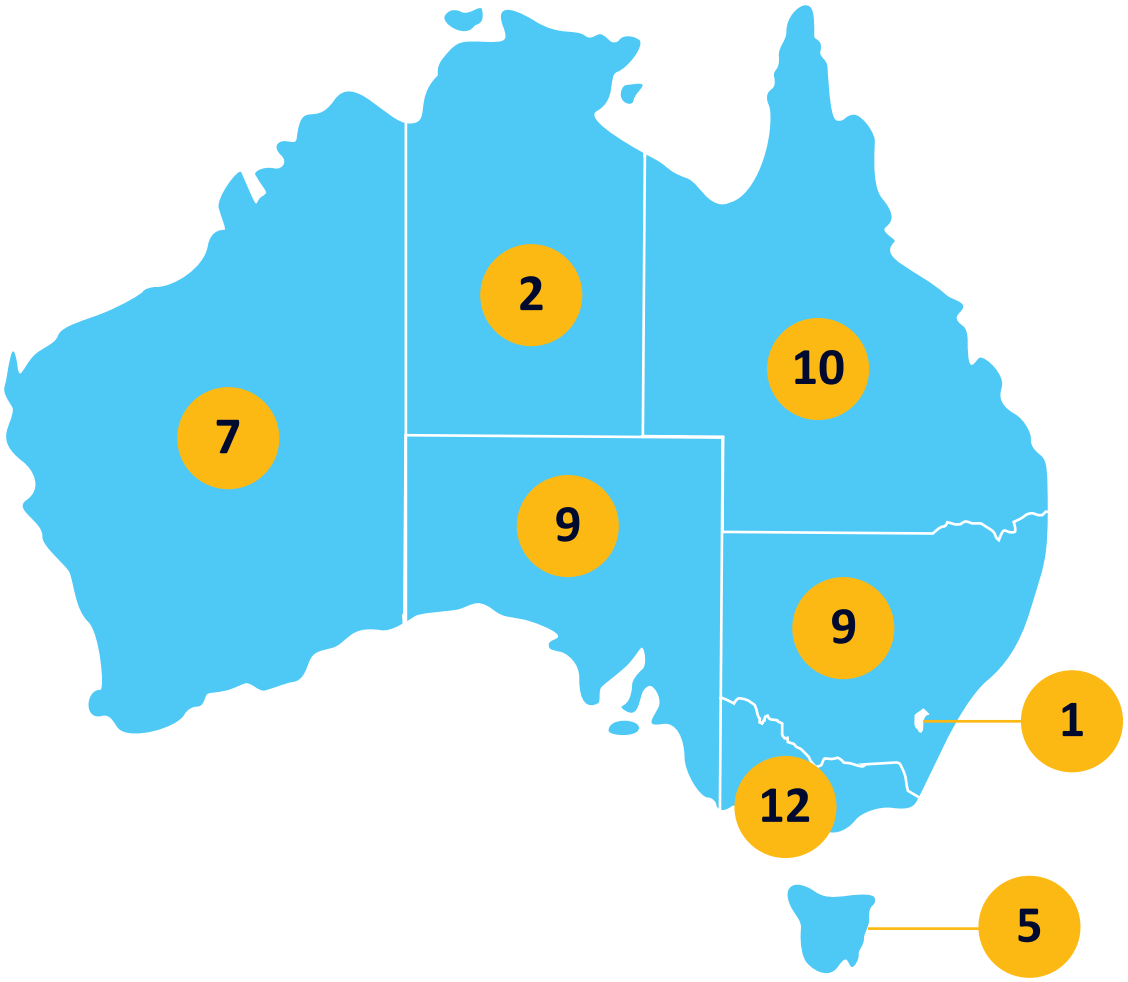
- methylamphetamine
- amphetamine
- cocaine
- 3,4-methylenedioxymethylamphetamine (MDMA)
- 3,4-methylenedioxyamphetamine (MDA)
- heroin
- cannabis
- oxycodone
- fentanyl
- nicotine
- alcohol
- ketamine.

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 April 2023, 55 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: Breakdown of sites by jurisdiction for April 2023.



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 June 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 20 measures the drug use of approximately 55% of the Australian population.

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.

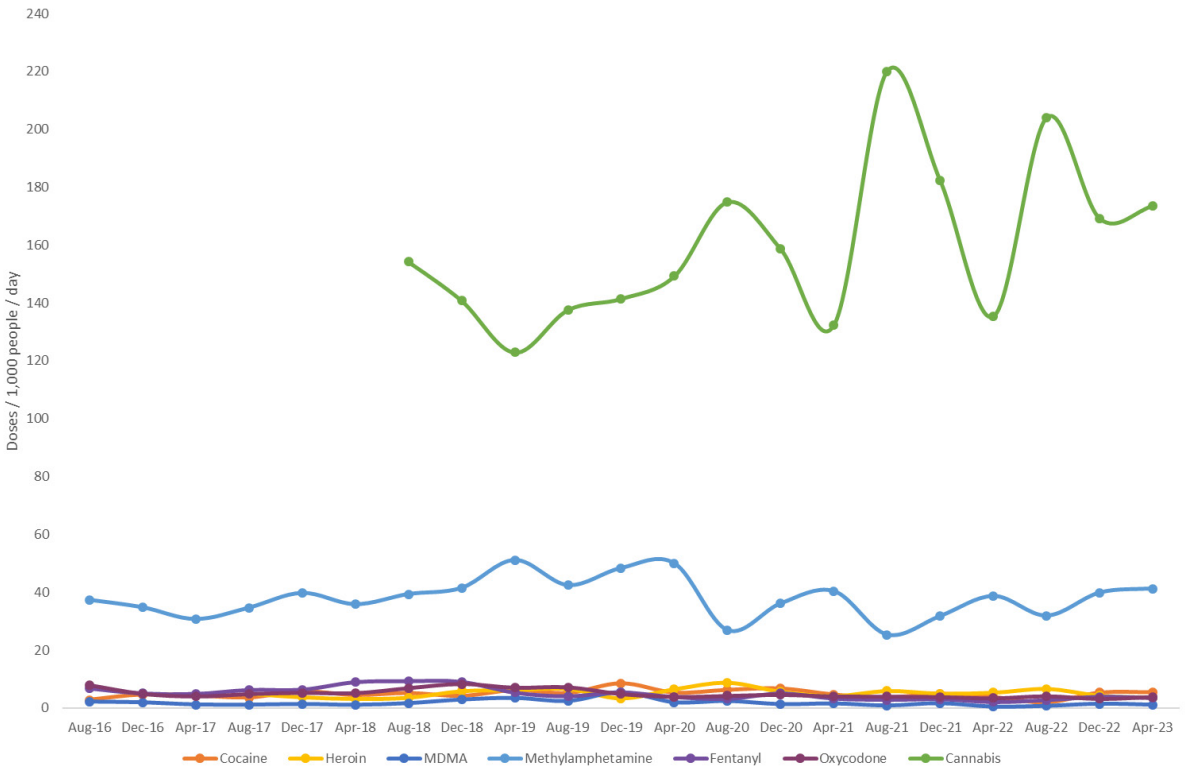
The ACIC engages with academic institutions, industry and public sector agencies to identify further data applications. Identified opportunities included informing responses in high risk areas; measuring drug use in specific local areas; estimating the size of discrete illicit markets; and exploring 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

Average consumption of alcohol increased in the capital cities and regional areas, while for nicotine, average consumption decreased in capital cities but increased in regional areas.

Nicotine and alcohol aside, cannabis is the most consumed drug by a large margin, despite substantial fluctuations (Figure 2). Cannabis consumption increased in capital cities but decreased in regional areas. Cannabis consumption has shown considerable variability since August 2020. This is surprising for a drug that is almost exclusively domestically cultivated and is consumed regularly by users. The reasons for this are being explored.

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



Methylamphetamine consumption increased in both capital city and regional areas to the highest level recorded since April 2020 (Figure 3).

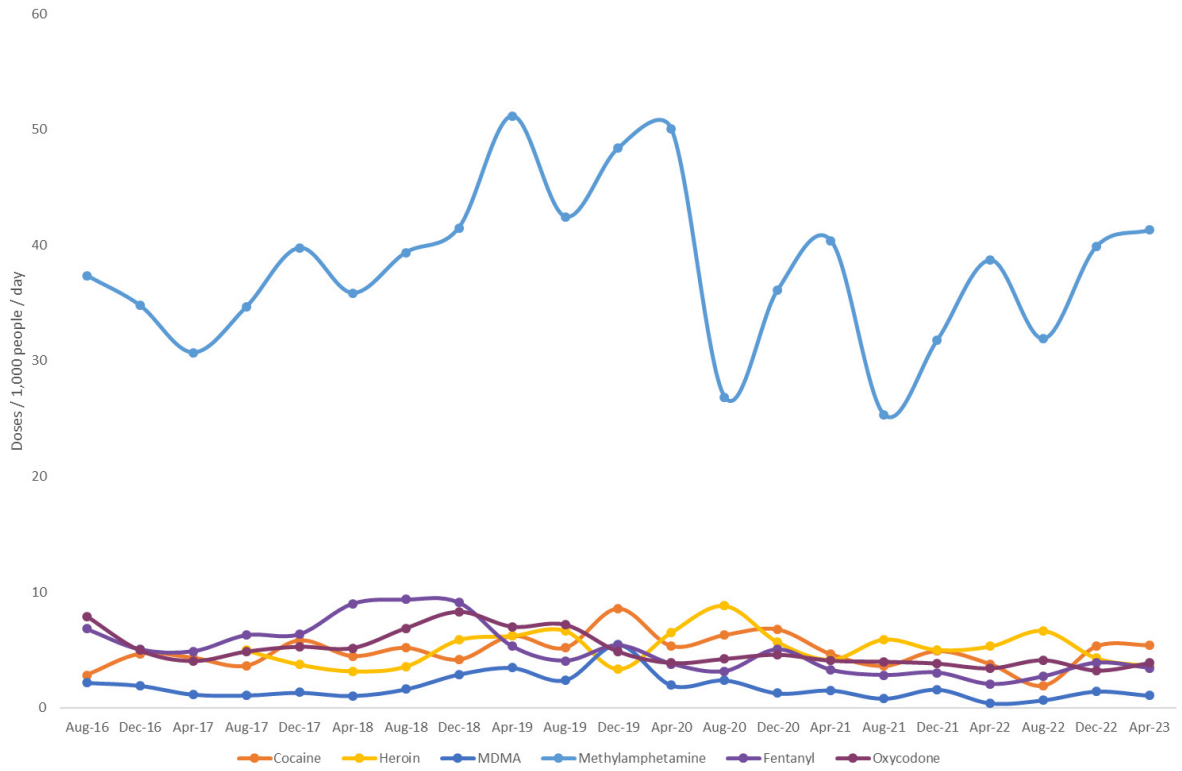
Cocaine consumption decreased in the capital cities, but increased in regional areas, resulting in a slight increase in consumption nationally to a level that is the highest since December 2020 and approximates what appears to be the long-term average consumption level since August 2016.

MDMA consumption returned this reporting period to what has generally been a long-term decline in consumption since December 2019.

Heroin consumption decreased in both capital city and regional areas to a combined consumption level that is the fourth lowest since the Program started monitoring heroin in 2017.

Of the pharmaceutical opioids, oxycodone consumption increased in both capital city and regional areas, while fentanyl consumption decreased in both.

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



BENEFITS 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. This report builds on national drug consumption data contained in the 19 preceding reports to identify trends over more than 6 years in drug use across states, territories and the nation.

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 and to more remote areas of the country. 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

Prepared by The University of Queensland (B Tscharke, J O'Brien, R Bade, P Prasad, D Barry, G Elisei, T Reeks, K Thomas, J Mueller) and University of South Australia (E Jaunay, M Ghetia, S Paxton, K Paxton, B Simpson, J White, C Gerber)

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) has reported 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 drugs. 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 20, wastewater samples were collected for up to 7 consecutive days during weeks in April and June 2023. The April 2023 collection involved regional and capital city sites, while June 2023 included capital city sites only. A total of 55 sites participated in April 2023, consisting of 20 capital city WWTPs and a further 35 regional WWTPs, covering a population of 14 million Australians. Data from this report equates to coverage of approximately 55 per cent of Australia's population for April 2023 and 48 per cent for June 2023 (capital city sites only).

A total of 511 new samples have been added to the 9,600 already reported previously, bringing the total number since the beginning of the Program to 10,111. 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 April 2023 was compared with historical data included in previous reports. The April 2023 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 June 2023.

In April 2023, alcohol and nicotine consistently ranked the highest consumed drugs in all states and territories when drugs were expressed in average dose amounts. However, cannabis was the most consumed illicit drug across the country, followed by methylamphetamine. Other 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 higher in regional areas in April 2023 compared to capital cities. Nicotine use varied substantially between sites. Sites with above average consumption of nicotine were distributed across most states and territories. Tasmania capital city nicotine use was prominent compared to the other capital cities. The Northern Territory and Tasmania have generally been the jurisdictions with highest overall nicotine consumption over the life of the Program.

Alcohol consumption in regional areas was slightly higher than in the capital cities in April 2023. Several sites in most states and territories had relatively high alcohol consumption. Nevertheless, national alcohol consumption remained at the lower end of levels recorded since the Program commenced in 2016.

Population weighted average methylamphetamine consumption was marginally higher in the capital cities than in regional Australia. Some sites in capital city New South Wales and South Australia had relatively high use in April 2023, with regional sites in South Australia and Victoria also using the drug at well-above average levels. On a jurisdictional level, the findings show that methylamphetamine consumption was highest in New South Wales, South Australia and Western Australia.

Cocaine consumption in Australia in April 2023 was much higher in the capital cities compared to regional parts of the country. The drug was most consumed in the capital city of New South Wales and single sites in Tasmania, Queensland and Victoria. Overall, the recent results showed a decrease in capital city use nationally from the previous collection period and an increase in regional use nationally.

MDMA use in the current reporting period was tangibly lower than in the previous reporting period and well below levels earlier in the Program. Use of the drug in capital cities was marginally higher than in regional Australia in April 2023. Sites in several states had relatively high consumption on some of the collection days. However, the changes reflect very small actual amounts of drug, considering the low level of use 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 MDA excretion was highest in regional areas, with capital city and regional sites in several states and territories, including several Victorian sites, recording use well above the respective national averages.

Oxycodone and fentanyl are prescription pharmaceutical opioids with abuse potential. The average consumption of both drugs was considerably higher in regional areas of the country in April 2023 compared to city sites. In the case of oxycodone, the difference was double. Use of oxycodone increased in many parts of the country, causing an overall increase in the reporting period compared to the previous reporting period. Fentanyl consumption varied in the current collection period and decreased slightly from the previous period.

Population weighted heroin consumption in the capital cities was more than triple that in regional Australia in April 2023. Consumption of the drug was highest in capital city Victoria and a regional site in the same state, with very high levels recorded on some of the collection days. In contrast, heroin use in many other regional parts of Australia was too low to measure using current methods.

Cannabis consumption was much higher in regional Australia than in the capital cities in April 2023. Use of the drug in some regional areas of New South Wales, South Australia and the Northern Territory was the highest in the nation, although sites in several other states had well above average consumption of the drug. National average consumption decreased tangibly in regional areas but increased slightly in the capital cities.

In addition to its use in pain management, ketamine is a compound of emerging concern over its abuse potential. On average, capital city excretion levels were higher than the regional averages in April 2023. Some sites across several states recorded relatively high levels and large consumption differences across the collection week. Nevertheless, excreted amounts were relatively low compared to other drugs included in the Program. Increased use of ketamine was mainly confined to the capital city of the Northern Territory and the state of Victoria.

2: INTRODUCTION

2.1 PREAMBLE

Wastewater analysis is a technique for monitoring the population-scale consumption of substances. The University of Queensland and the University of South Australia have been commissioned to provide drug consumption data to the ACIC since 2016, including a total of 21 public reports. 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 April 2023 and capital cities in June 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, the 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.

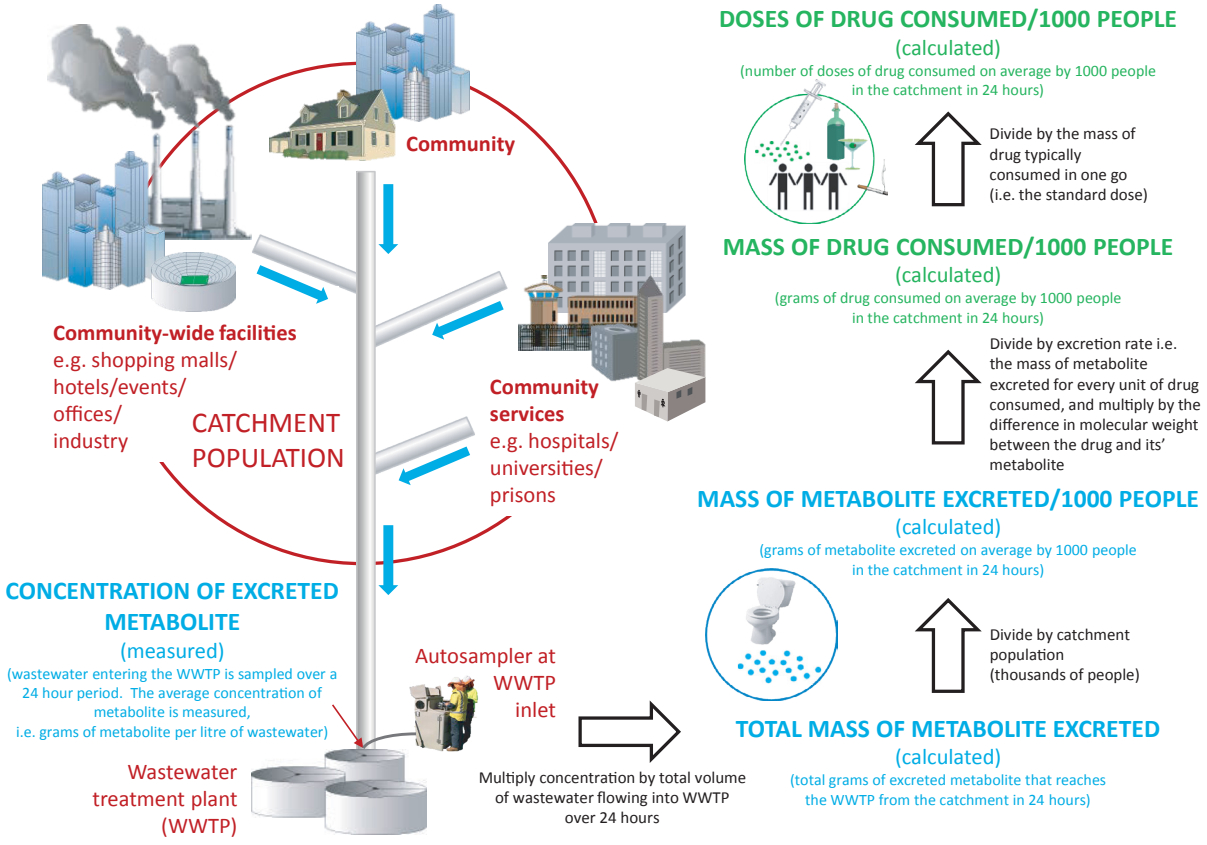
Cannabis results in earlier reports were expressed as the amount consumed per day per 1,000 people. From Report 19, a revised excretion factor and dose have been applied in the back-calculation to estimate consumption so that the scale of cannabis use can be compared to other drugs. More information 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 that is consumed (irrespective of whether it is swallowed, inhaled/smoked or injected) will subsequently be excreted. This may be either in the chemical form it was consumed and/or in a chemically modified form that is referred to as a metabolite. 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.[3] Collectively, waste products in the sewer system arrive at a WWTP where wastewater samples are collected over a defined sampling period. Measuring the amount of a target compound in the wastewater stream allows for a back-calculation factor to be applied to determine the amount of drug that was used over the collection period (Figure 4). The method is non-invasive and is done on a population-scale level, so individuals are not targeted, and privacy is respected.

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.



3 Information in relation to heroin appears in Report 3.

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 the THC-COOH dose can be found in Appendix 1 of this report. 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-five WWTPs across Australia participated in the NWDMP for the April 2023 collection period (Figure 5). Of these, 20 sites were located in capital cities and a further 35 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 April 2023 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.

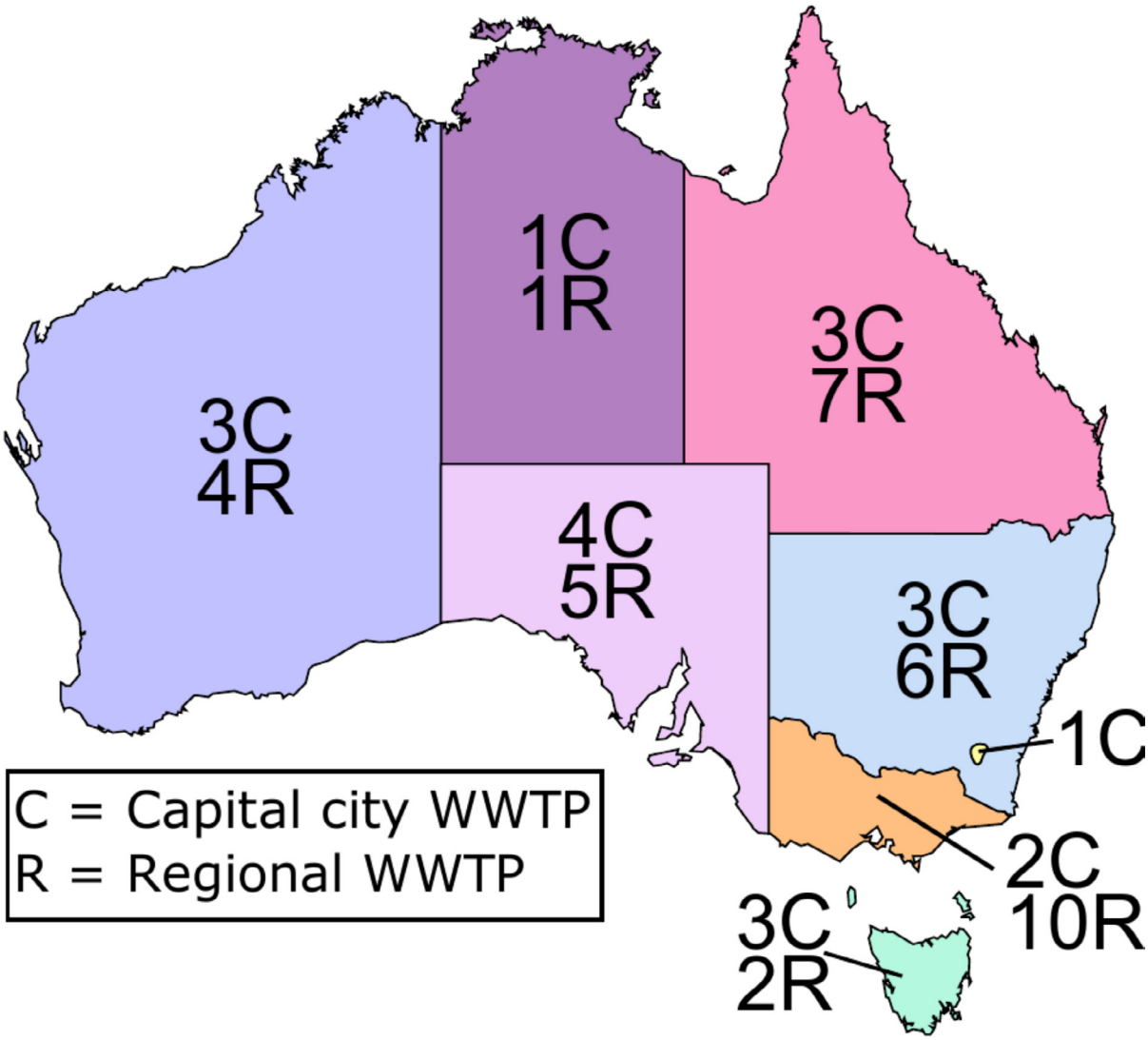


Table 1: Number of participating WWTPs for the periods covered in this report. One collection period aims to collect data from both capital city (C) and regional (R) sites, while the other collection period aims to collect data from capital city sites only.

State or territory	Apr 2023 Capital	Apr 2023 Regional	Jun 2023 Capital
ACT	1	0	1
NSW	3	6	3
NT	1	1	1
Qld	3	7	3
SA	4	5	4
Tas	3	2	3
Vic	2	10	2
WA	3	4	3
Sites	**20**	**35**	**20**
Population (millions) C & R	**12.1**	**2.0**	**12.1**
% of Australian population	**47.6**	**7.8**	**47.6**
Total population (millions)	**14.1**		**12.1**
% of Australian population	**55.4**		**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 number, all data were then summed and divided by the total population across all capital city sites. Reported average values are therefore not skewed towards usage data from small, non-representative populations.

Per capita consumption: The per capita consumption estimates presented in this report are calculated using the total estimated catchment population (which includes children). For example, per capita alcohol consumption has previously been reported by the Australian Bureau of Statistics (ABS) based on population numbers for people aged 15 and over. The consumption values presented in the current report will be under-estimated compared to those determined for an adult-only population. For consistency, data from other studies included in this report were recalculated where necessary using 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 also similar for ketamine. From Report 19, cannabis results are being 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)[4] is a concentration (higher than the LOD), above which we have high confidence that the concentration measured on the analytical instrument is accurate. Above the LOD but below the LOQ there may be some uncertainty as to the actual concentration. To be conservative (a drug may be present but there is uncertainty as to its concentration) and in line with current practice, for back calculations to estimate per capita consumption, a concentration below the LOD was included as a value of LOD/√2. A concentration above the LOD but below LOQ, is included at the midpoint between the LOD and LOQ (i.e. (LOD + LOQ)/2). The frequency of detection of each analyte of interest is included in Appendix 3.

4 Information in relation to heroin appears in Report 3.

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).

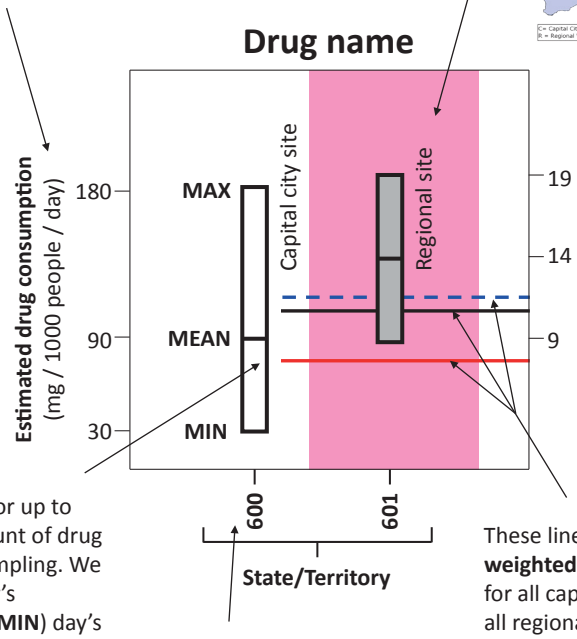
Figure 6: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

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.

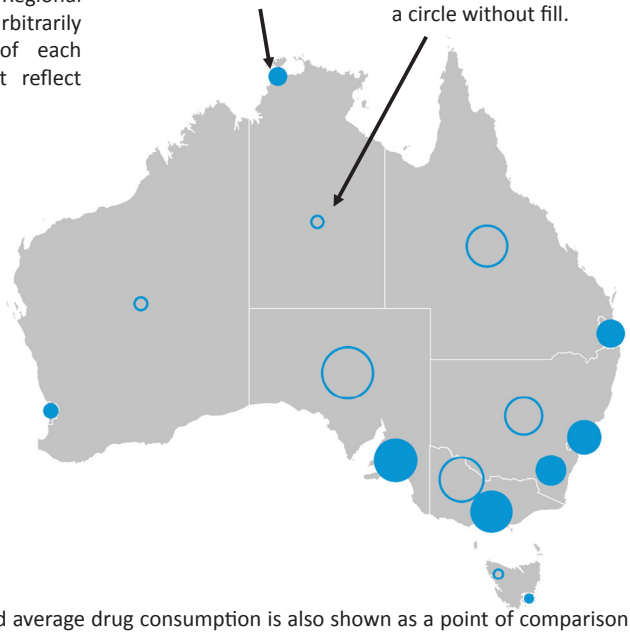
Figure 7: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

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.

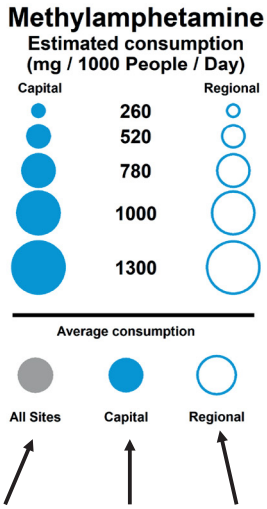
This type of plot gives a rough overview of drug consumption per jurisdiction. The other temporal and spatial comparison graphs give greater resolution to compare between locations and over time, and should be used for analysis.

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). April 2023 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 APRIL 2023

4.1.1 NICOTINE AND ALCOHOL

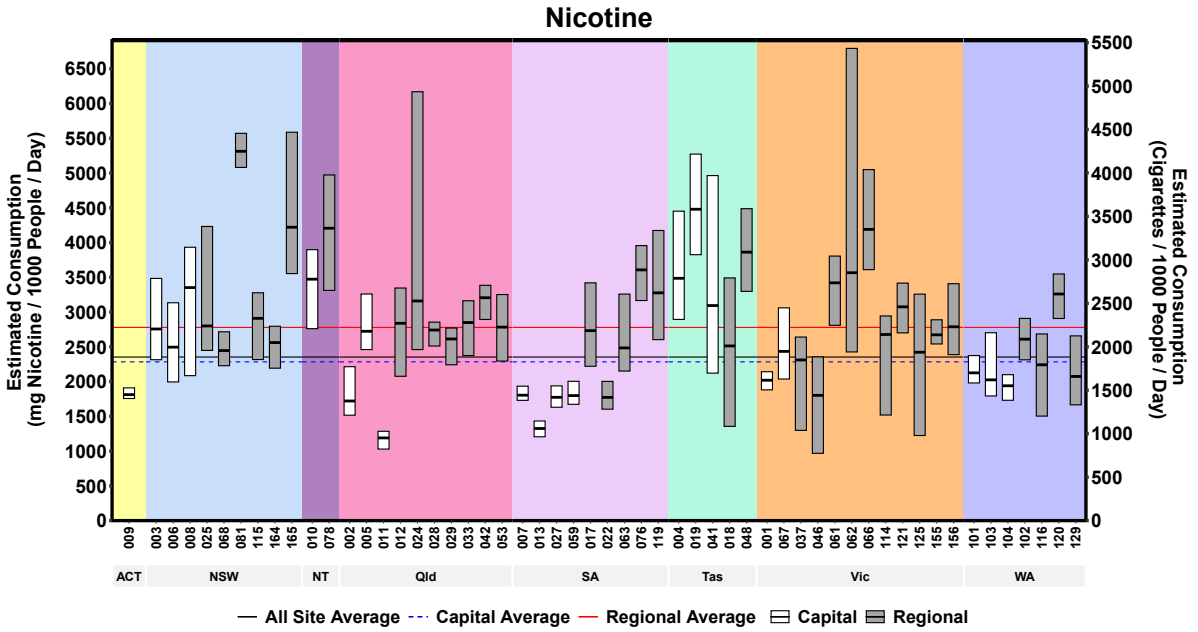
Nicotine is the main psychoactive substance present in tobacco leaves, some vaping products and treatments aimed at discouraging smoking behaviour. Two nicotine metabolites, cotinine and hydroxycotinine, were used to estimate the consumption of nicotine. The estimate is expressed as nicotine in this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

Nicotine consumption during the April 2023 collection week shows a high degree of variability across the country (Figure 8). The regional average was higher than in the capital cities on a national level (red horizontal and dotted blue lines, respectively). Tasmania had the highest consumption of nicotine of the capital cities. Specific sites in several states consumed nicotine at levels well above the respective national 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 April 2023 averages show that alcohol consumption was higher in regional areas than in capital cities (Figure 9). In general, large differences were evident between days of the week in many parts of the country, reflected by the length of the bars in the graph. In most cases this was 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.

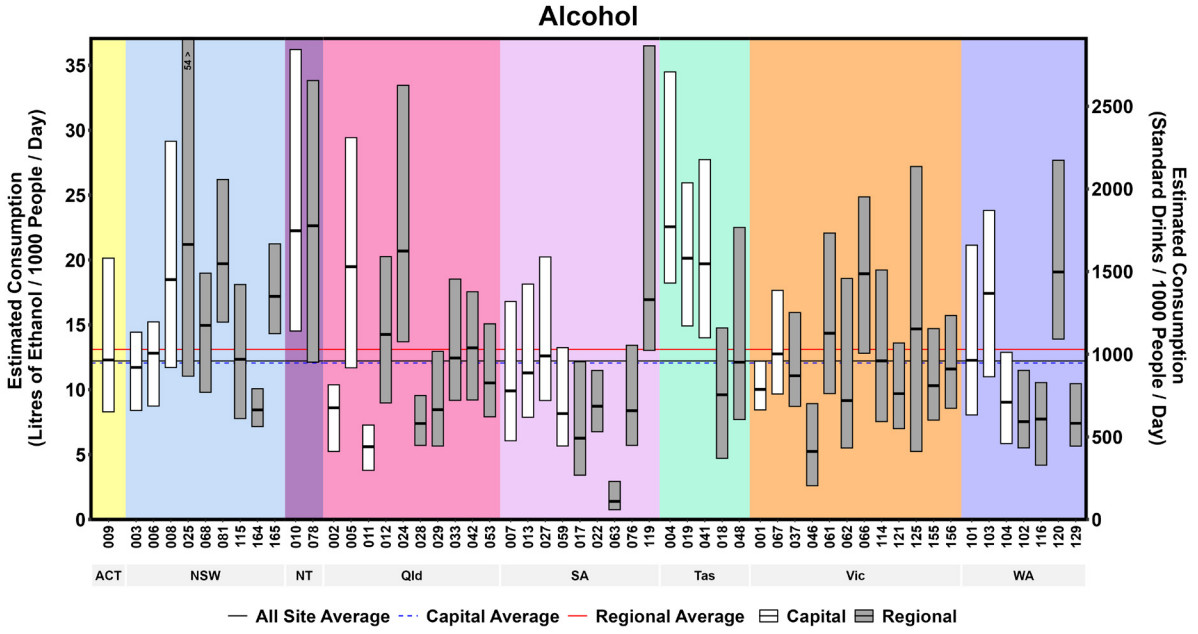
Relative consumption levels can be represented by showing the scale of consumption of nicotine (Figure 10) and alcohol (Figure 11) as capital city or regional ‘bubbles’ for each state and territory. The largest nicotine bubbles represent the Northern Territory and the capital city of Tasmania. A similar pattern emerged for alcohol consumption across Australia, with levels being highest in the same jurisdictions as nicotine.

Figure 8: Estimated nicotine consumption for April 2023 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 April 2023 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. Text describing the extreme values shown above the graph are based on the left y axis.



- Regional average higher
- Wide weekly spread a common feature

Figure 10: Estimated average nicotine consumption per jurisdiction for April 2023 in number of cigarettes per day per thousand people. The number of collection days varied from 5 to 7.

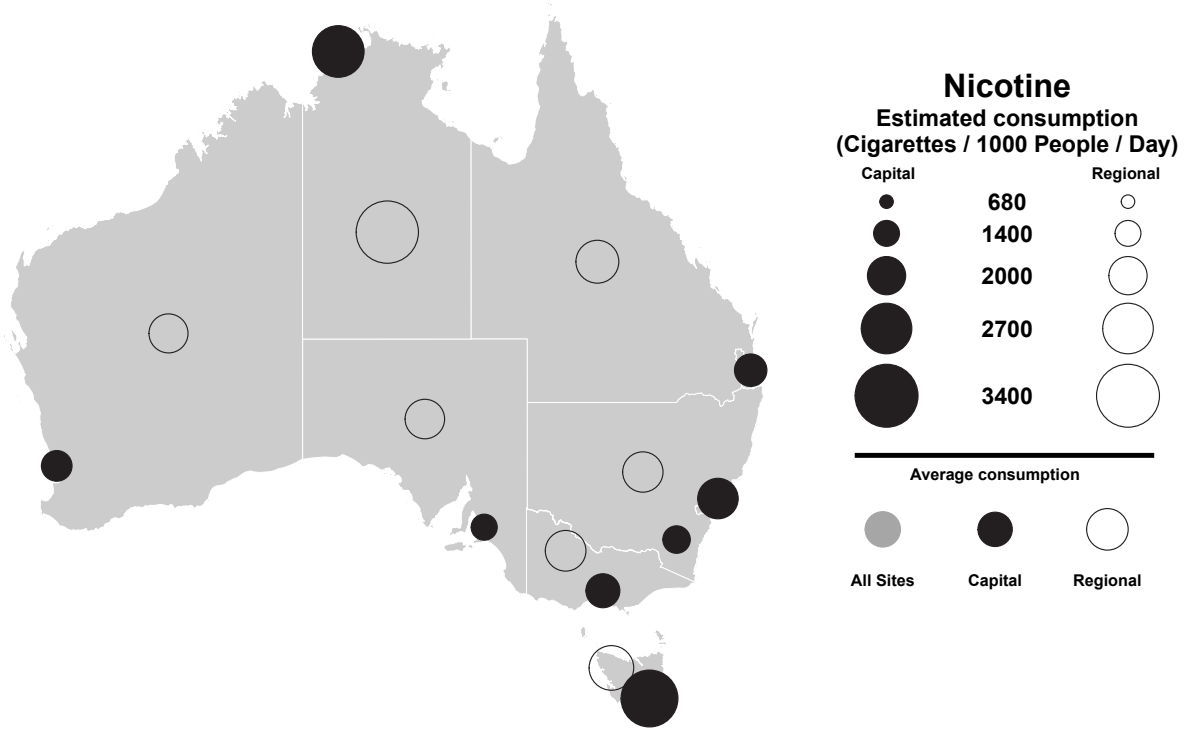
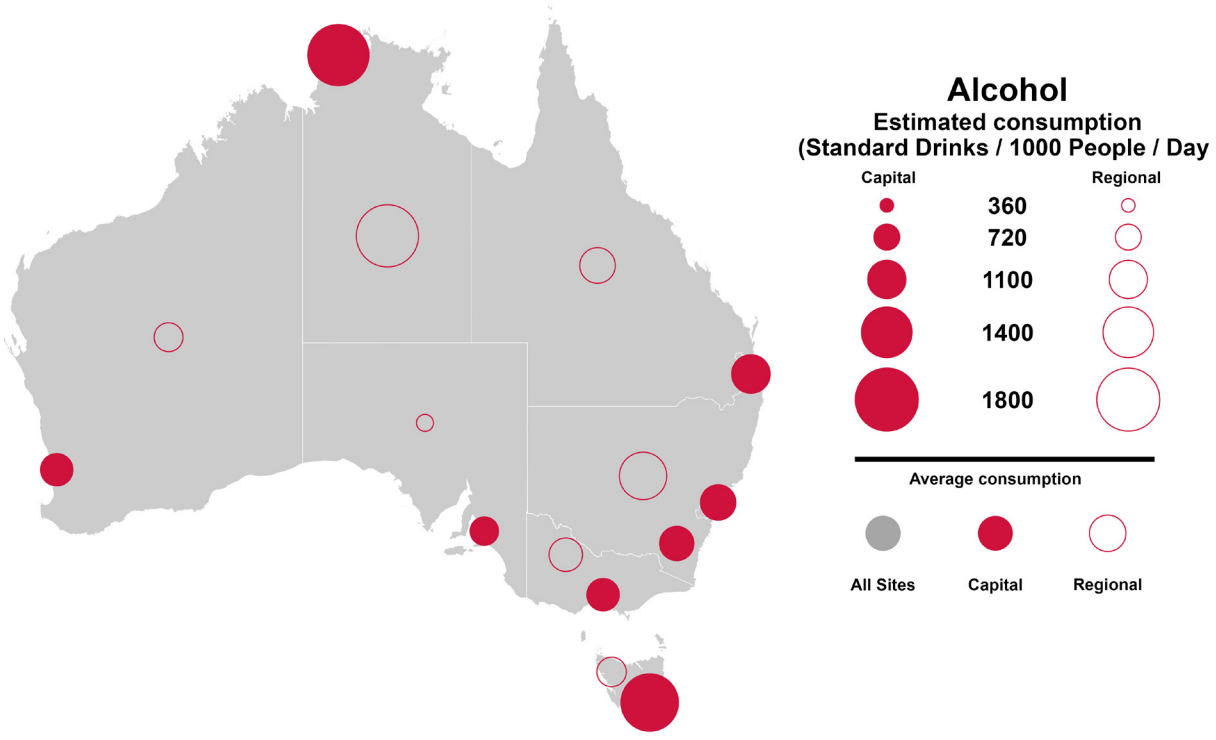


Figure 11: Estimated average alcohol consumption per jurisdiction for April 2023 in number of standard drinks per day per thousand people. The number of collection days varied from 5 to 7.



4.1.2 STIMULANTS

4.1.2.1 METHYLAMPHETAMINE

Methylamphetamine consumption varied widely across Australia in April 2023 (Figure 12). The overall regional average was marginally lower than that of the capital cities. Capital city New South Wales, as well as parts of regional South Australia and a site in Victoria had very high levels of methylamphetamine use on some days of the sampling week. Of the capital cities, the 2 territories and some Queensland and Tasmanian sites had well-below average consumption of methylamphetamine. No clear pattern was evident for regional catchments across the country.

4.1.2.2 AMPHETAMINE

The measured concentration of amphetamine in the April 2023 samples mostly fell within a range which is consistent with the reported excretion rates following methylamphetamine consumption (Gracia-Lor et al. 2016). The results broadly matched our previous findings (see Appendix 4 of Report 1). The levels of amphetamine in wastewater samples can be mostly 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. The high levels of methylamphetamine in most parts of the country means a firm conclusion is not possible.

4.1.2.3 COCAINE

Benzoylecgonine, the specific metabolite of cocaine, was used to estimate consumption of the stimulant (Figure 13). On average, capital city cocaine consumption was well above consumption in regional areas. Cocaine use was very low in some regional catchments and dropped to below quantification limits on some days. In contrast, capital city sites in New South Wales and Tasmania had very high use levels on some days.

4.1.2.4 MDMA (3,4-METHYLENEDIOXYMETHYLAMPHETAMINE)

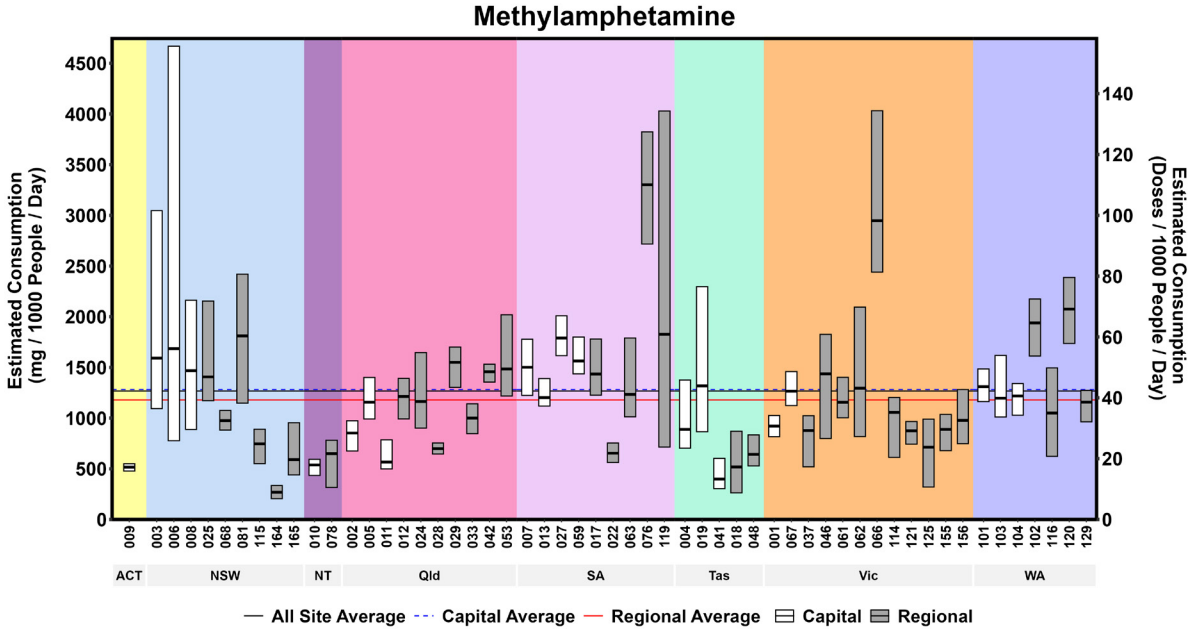
The average consumption of MDMA in Australia was much lower than methylamphetamine and cocaine (Figure 14). A few sites in different states had relatively high consumption of MDMA. However, this is best understood in the context of the low overall use of MDMA in the April 2023 collection week across the country. The regional average consumption of MDMA was below that of the capital city average in April 2023.

4.1.2.5 MDA (3,4-METHYLENEDIOXYAMPHETAMINE)

The excreted amounts of MDA were spread relatively evenly across Australia, with no clear pattern being evident (Figure 15). Sites in several states and territories had well-above-average consumption levels. Some of the sites coincided with those where MDMA use was also high. In contrast to MDMA, average national regional MDA use exceeded the national capital city average.

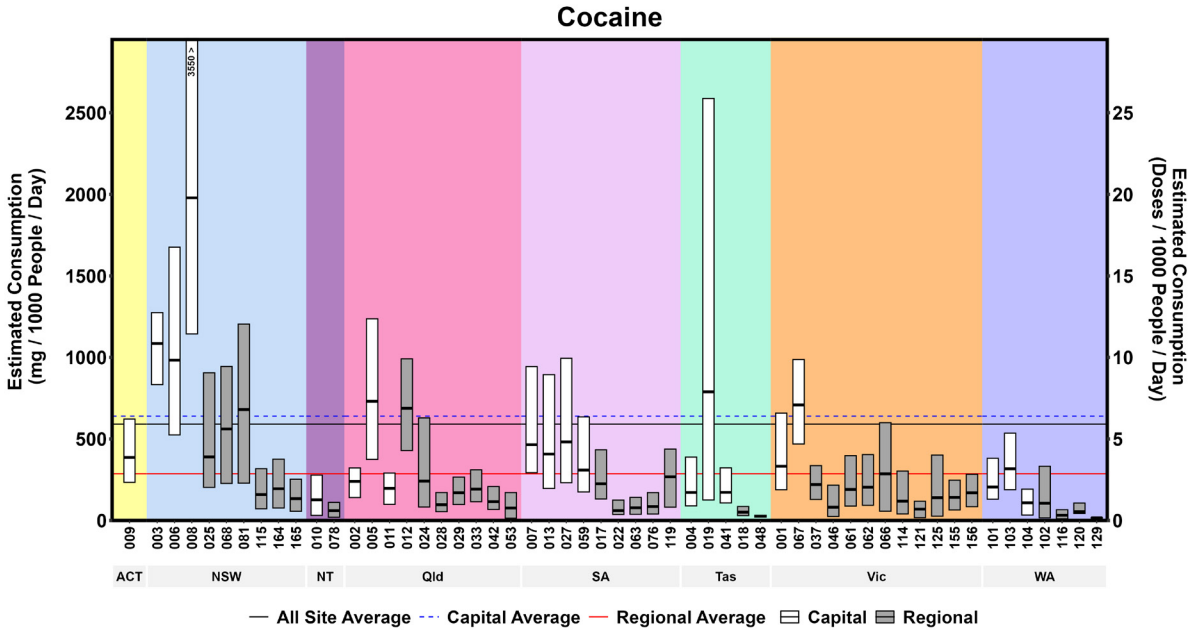
The scale of consumption is expressed as a bubble graph to compare regional and capital city consumption of methylamphetamine (Figure 16), cocaine (Figure 17), MDMA (Figure 18) and MDA (Figure 19) across the country. Higher consumption of methylamphetamine was evident in capital city New South Wales and regional Western Australia and South Australia. Cocaine use was very prominent in capital city New South Wales as well, while MDMA featured more in Victoria, Tasmania and regional Northern Territory. MDA use was centred more in the Northern Territory, although the result is more prominent due to only a single capital city site being included in the Program for the territory.

Figure 12: Estimated methylamphetamine consumption for April 2023 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.



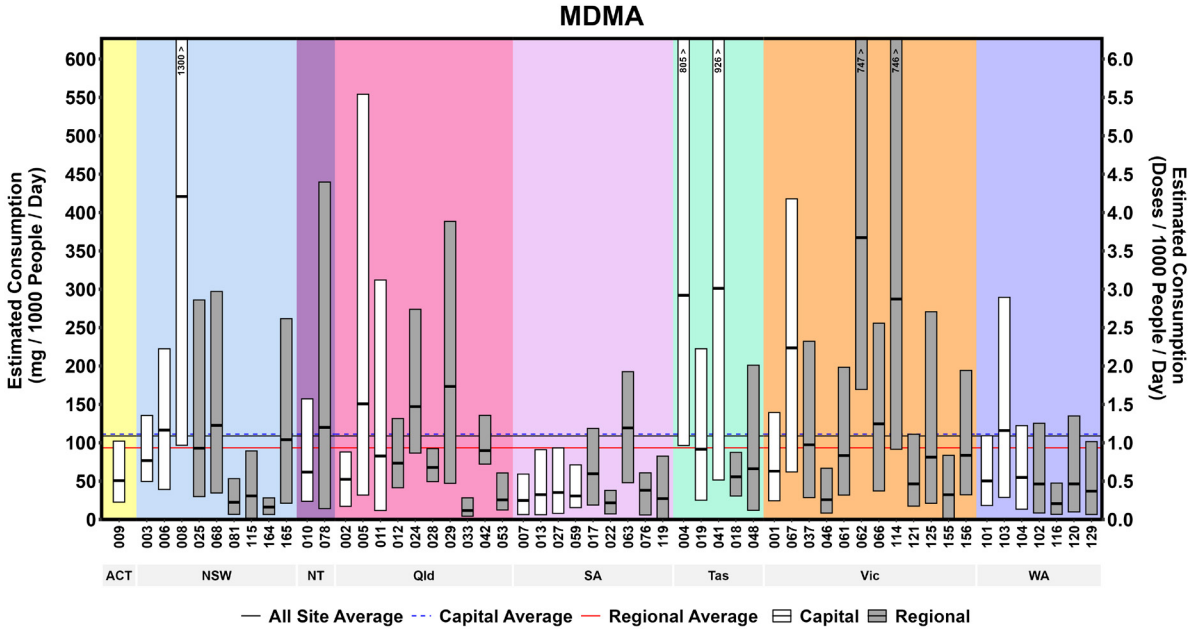
- Relatively high levels in several sites
- Lower regional average

Figure 13: Estimated cocaine consumption for April 2023 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. Text describing the extreme values shown above the graph are based on the left y axis.



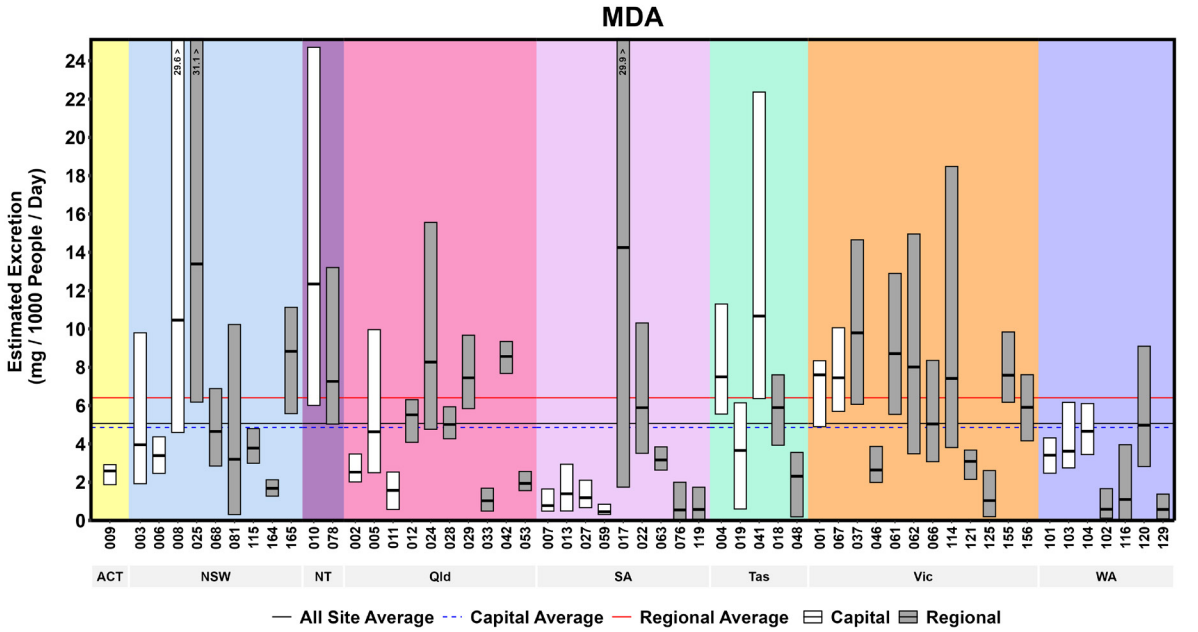
- Higher capital city consumption
- High use in New South Wales

Figure 14: Estimated MDMA consumption for April 2023 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. Text describing the extreme values shown above the graph are based on the left y axis.



- Relatively low consumption
- Localised spikes in consumption

Figure 15: Estimated MDA excretion for April 2023 in mass excreted per day per thousand people. The number of collection days varied from 5 to 7. Text describing the extreme values shown above the graph are based on the left y axis.



- Higher regional average
- Some sites well above average

Figure 16: Estimated average methylamphetamine consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

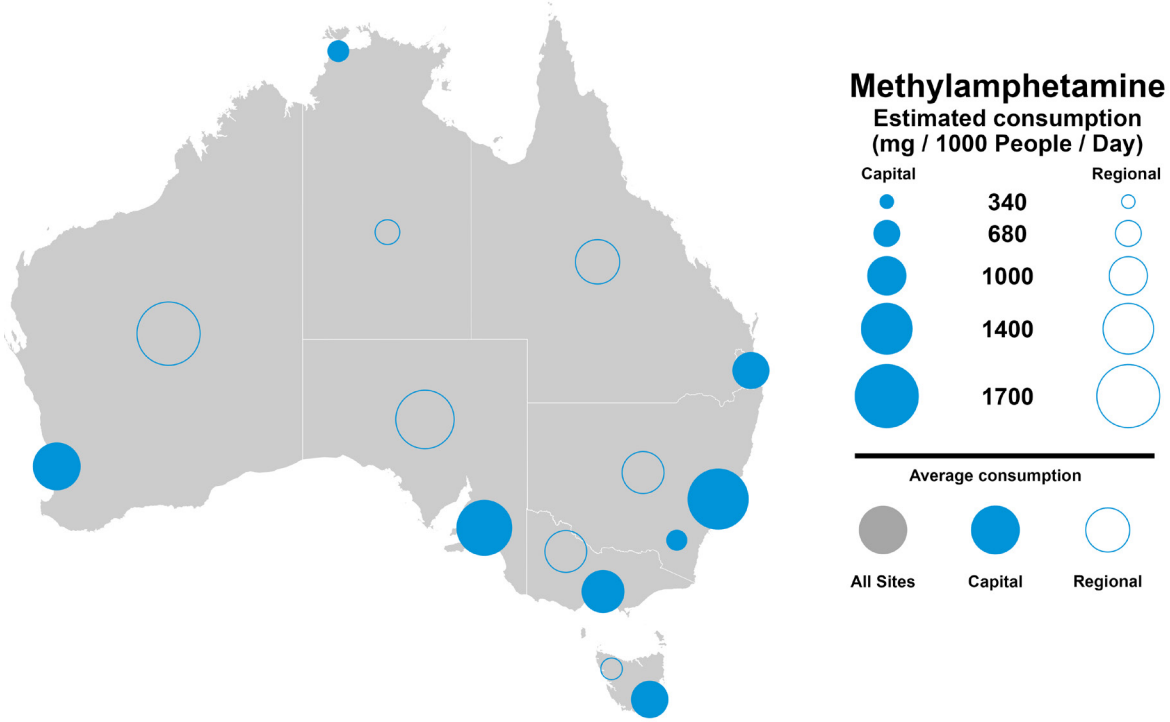


Figure 17: Estimated average cocaine consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

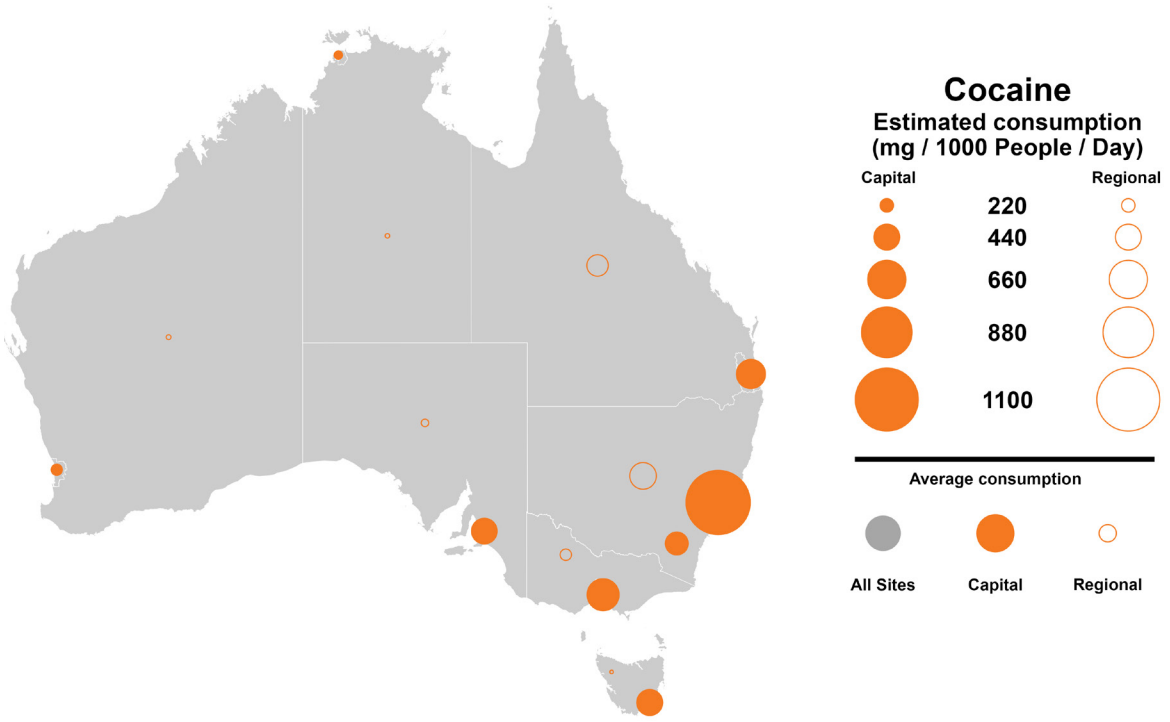


Figure 18: Estimated average MDMA consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

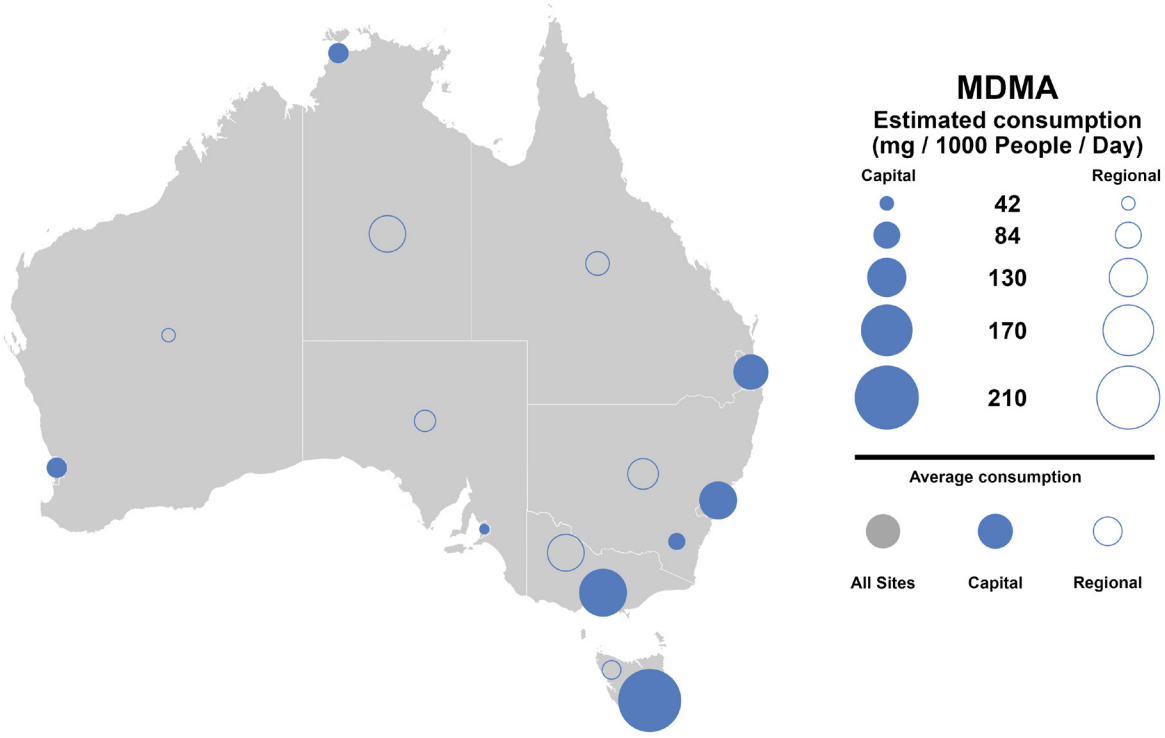
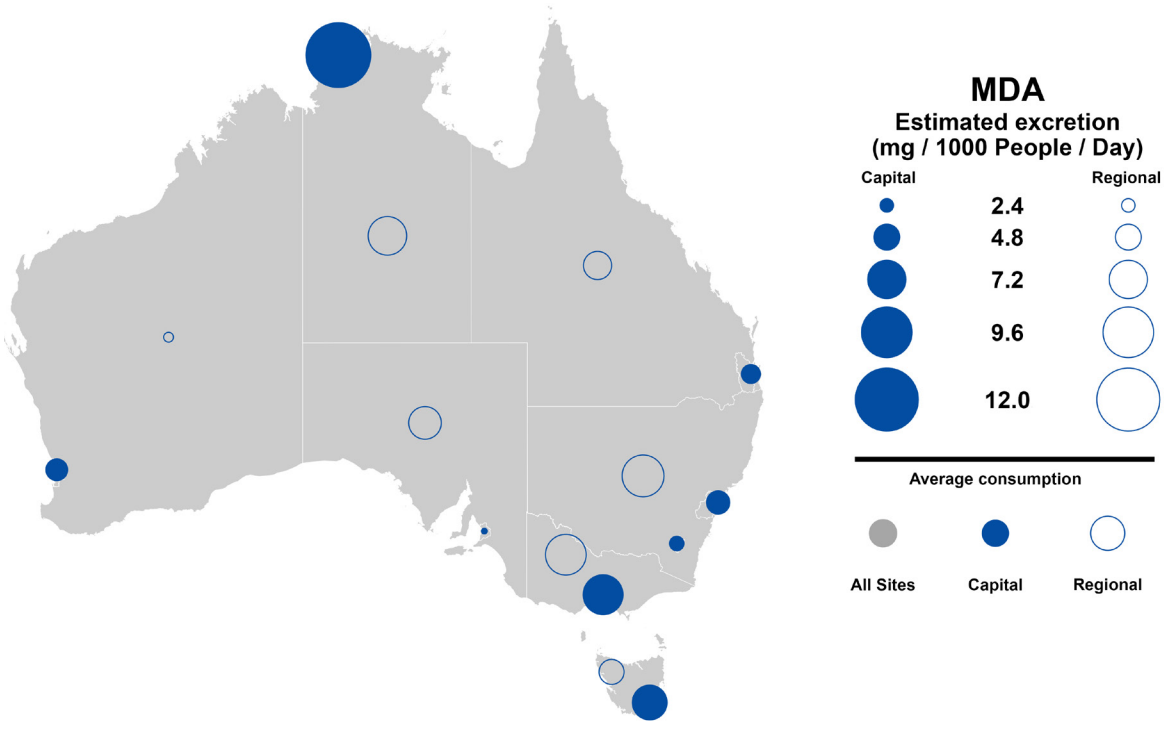


Figure 19: Estimated average MDA excretion per jurisdiction for April 2023 in mg excreted per day per thousand people. The number of collection days varied from 5 to 7.



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.

Considering its predominantly pharmaceutical use, consumption of oxycodone in the April 2023 collection week was remarkably variable (Figure 20). There was less of a difference between the capital cities, apart from sites in Tasmania. In some instances, large variations in use were observed over the collection week, particularly in regional areas. Oxycodone consumption on average is much higher in regional areas compared with the capital cities.

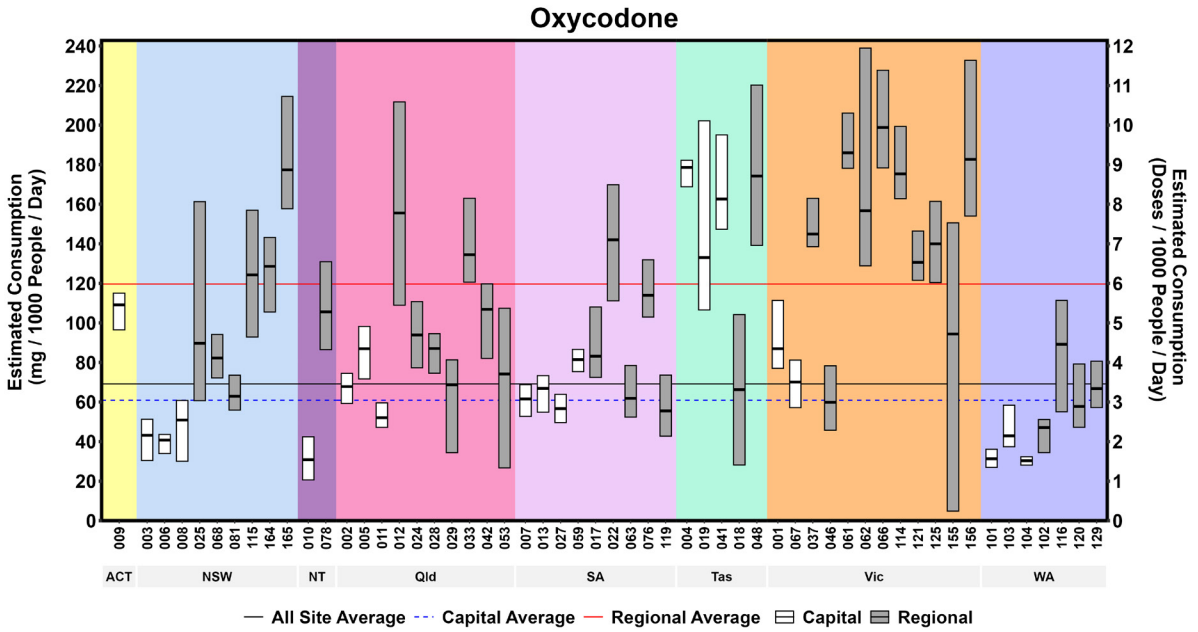
Fentanyl consumption was similarly higher on average in regional Australia and, particularly in New South Wales, quite variable (Figure 21). Some regional sites had a large variation over the course of the sampling week. Fentanyl fell below the method quantification limits in a number of cases, mostly in regional catchments, but also in the capital city of the Northern Territory. The highest regional consumption of fentanyl was spread across states, while sites 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 areas and presented in bubble graph form. Higher pharmaceutical opioid consumption was particularly evident in regional parts of the mainland and capital city Tasmania in the case of oxycodone (Figure 22). Fentanyl use was prominent in the regional south-east and capital city Tasmania (Figure 23).

4.1.3.2 HEROIN

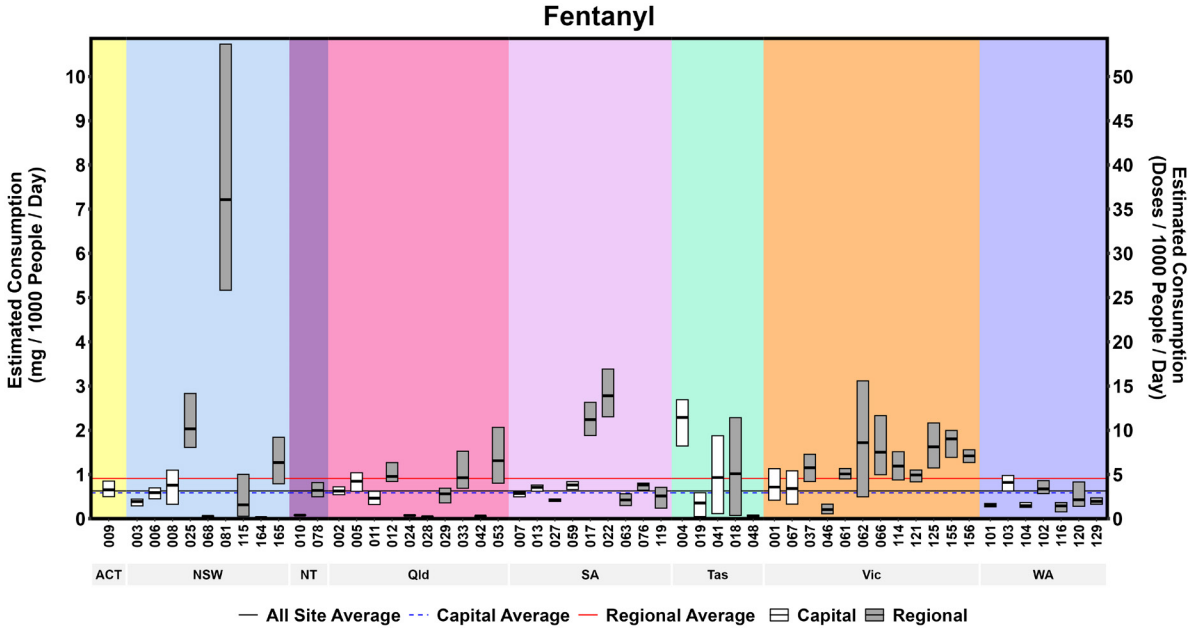
The heroin marker, 6-monoacetylmorphine (6-MAM), was used to determine consumption of the drug. Since the compound is characteristic of heroin metabolism, it can be used to distinguish heroin from other opioids such as morphine and codeine. Heroin consumption was mostly low across the country in the April 2023 collection week and fell below the method quantification limits at many sites (Figure 24). In contrast, heroin use in sites 46 and 67 in Victoria was very high. The high number of non-reportable values for heroin in regional Australia contributed to the low national regional average compared to the capital cities. The elevated heroin consumption in Victoria is clearly evident from the bubble graph (Figure 25).

Figure 20: Estimated oxycodone consumption for April 2023 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 capital city use

Figure 21: Estimated fentanyl consumption for April 2023 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 at some sites

Figure 22: Estimated average oxycodone consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

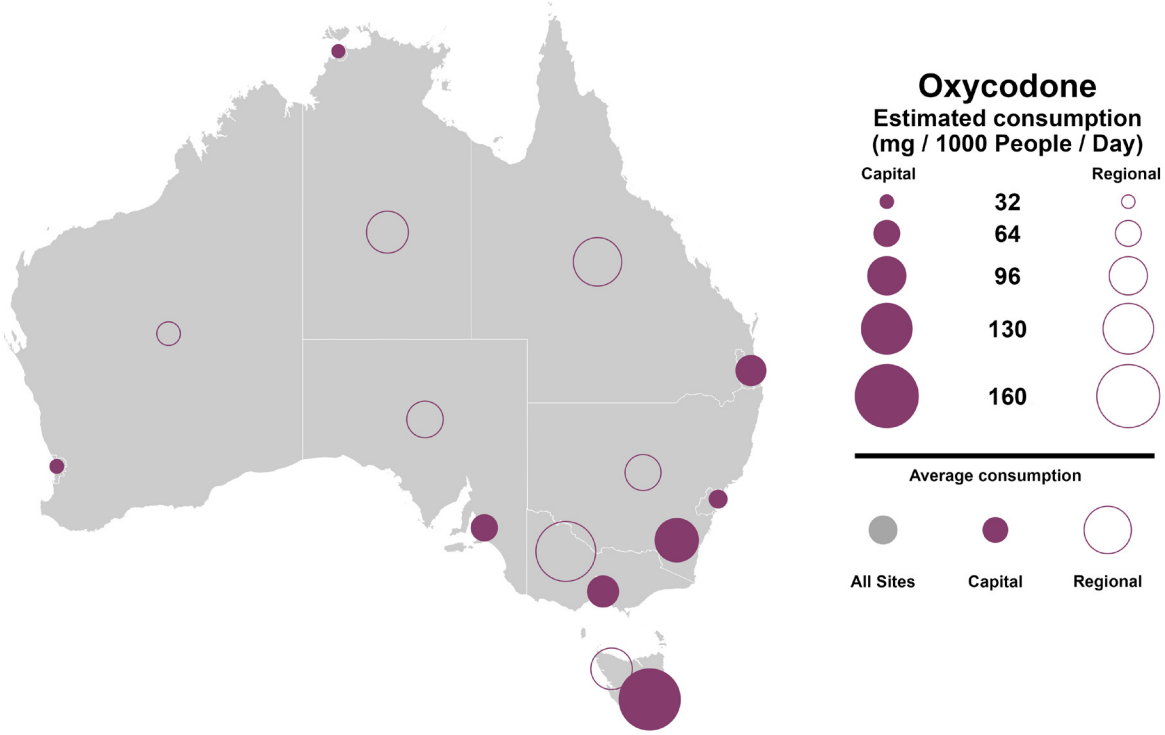


Figure 23: Estimated average fentanyl consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.

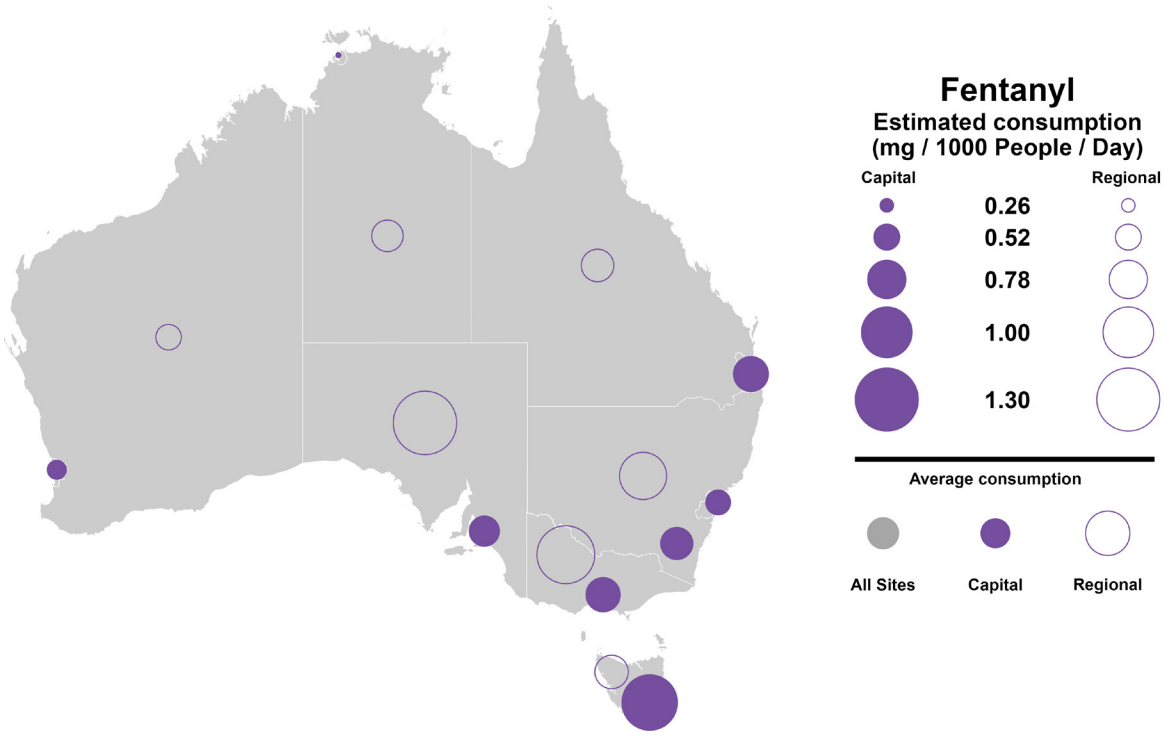
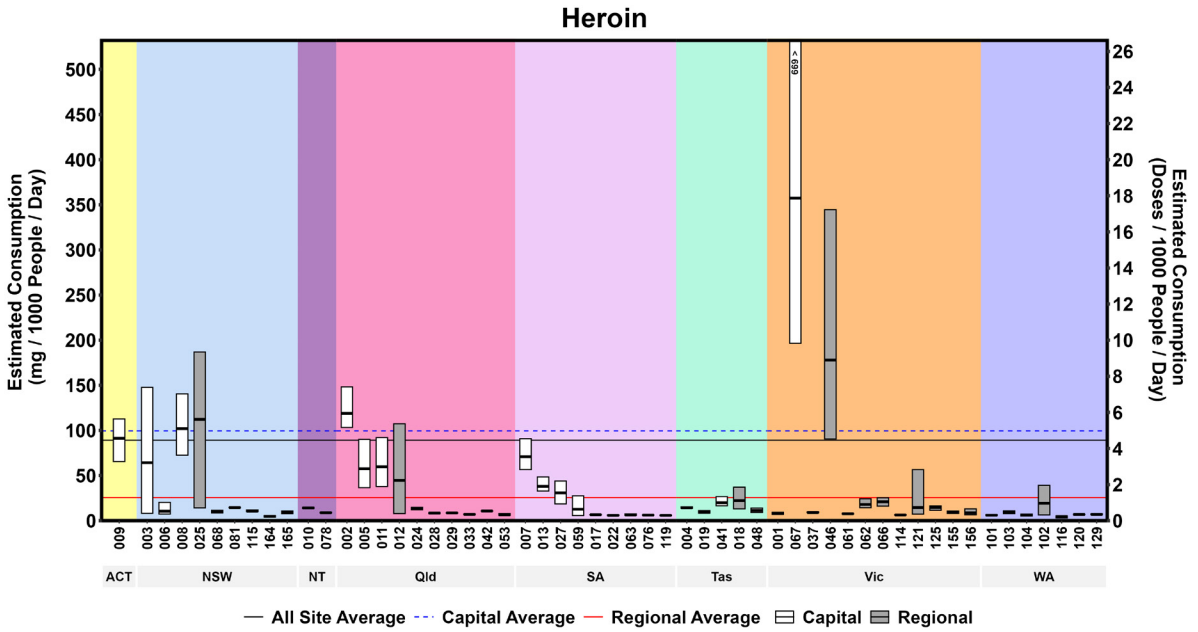
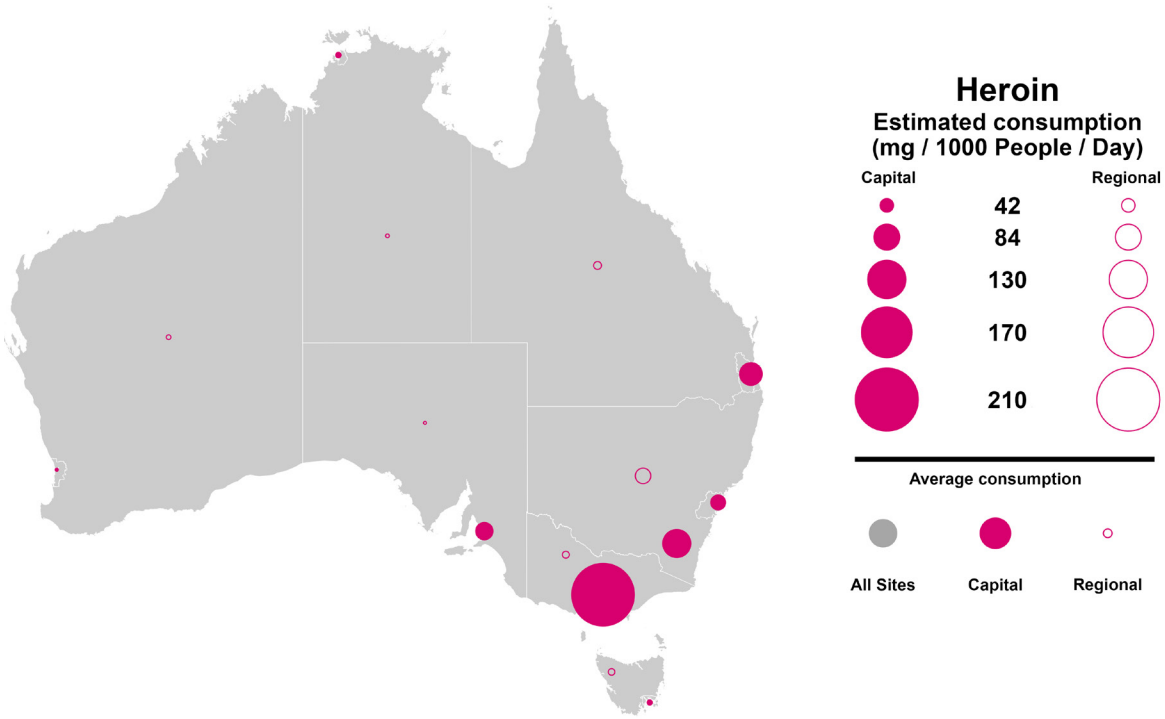


Figure 24: Estimated heroin consumption for April 2023 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5 to 7. Text describing the extreme values shown above the graph are based on the left y axis.



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

Figure 25: Estimated average heroin consumption per jurisdiction for April 2023 in mg consumed per day per thousand people. The number of collection days varied from 5 to 7.



4.1.4 CANNABIS

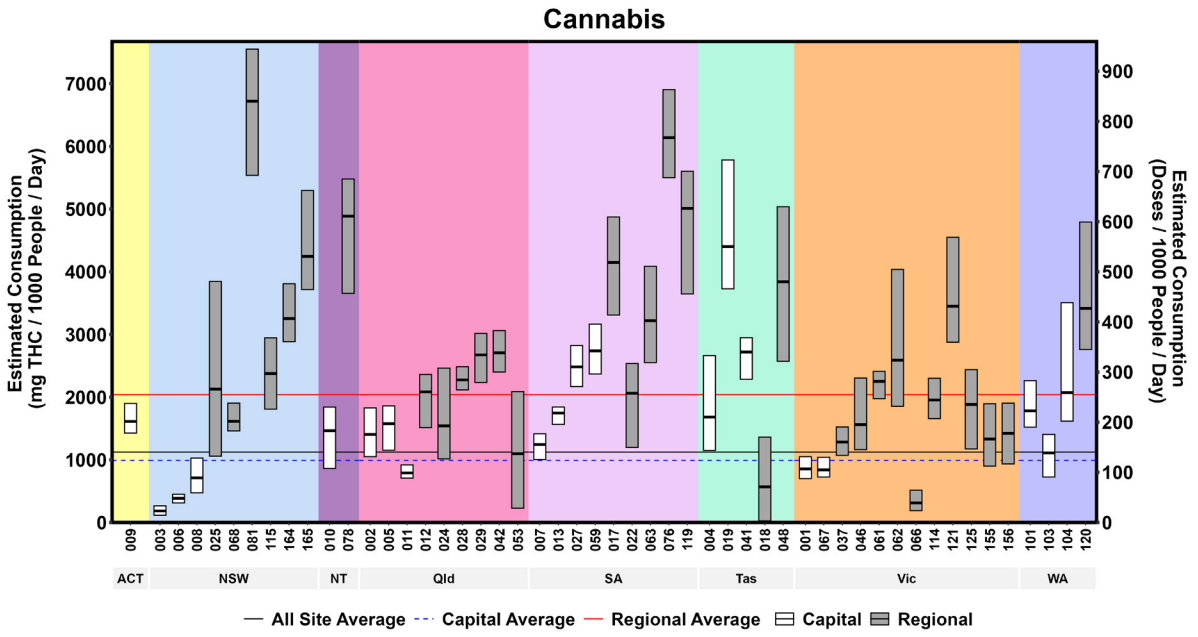
Tetrahydrocannabinol (THC) is the main psychoactive compound found in cannabis. The compound is metabolised and largely cleared through the gastrointestinal tract. A small proportion is excreted through the kidneys as 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH). The latter is known to adsorb to 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. The dose amount (8mg) used in the Report is 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). An 8 mg amount would represent between 210-450 mg of dried cannabis containing 15% THC, depending on occasional or regular users consuming the product (Sharma et al 2012).

Large spatial differences were evident across Australia in April 2023 (Figure 26). Regional cannabis consumption was substantially higher than in the capital cities. Tasmania, South Australia, the Australian Capital Territory and Western Australia had the highest cannabis use in capital cities. 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. Only one site in regional Western Australia was able to provide daily samples for cannabis reporting.

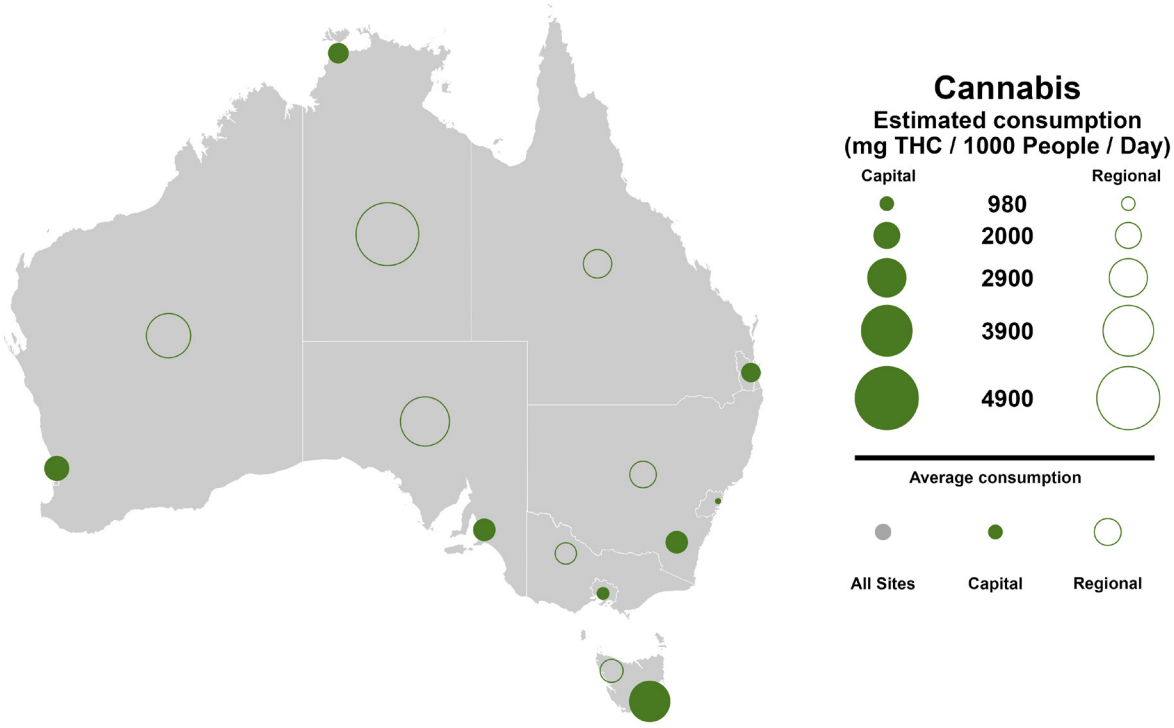
The bubble plot and jurisdictional differences for cannabis consumption across Australia show the generally higher consumption in regional areas, apart from in Tasmania (Figure 27).

Figure 26: Estimated cannabis consumption for April 2023 in mass consumed per day (left axis) and doses per day (right axis). The number of collection days varied from 5 to 7.



- Higher regional consumption
- Variable consumption across the country

Figure 27: Estimated average cannabis consumption per jurisdiction for April 2023 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, measured levels are being shown here as excreted daily mass loads, similar to the case of the stimulant, MDA.

Ketamine use tended to be low across the country in terms of excreted amounts (Figure 28). Relatively high levels were recorded at some sites, with a large variation in use across the sampling week being evident at some sites. The state of Victoria was unusual, having multiple sites with ketamine use above the national averages. The regional average excretion of ketamine was lower than the capital cities. The bubble plot shows the relative scale of ketamine excretion across Australia, with the elevated use in Victoria being the most prominent feature (Figure 29).

Figure 28: Estimated ketamine excretion for April 2023 in mass excreted per day (left axis) per thousand people. The number of collection days varied from 5 to 7. Text describing the extreme values shown above the graph are based on the left y axis.

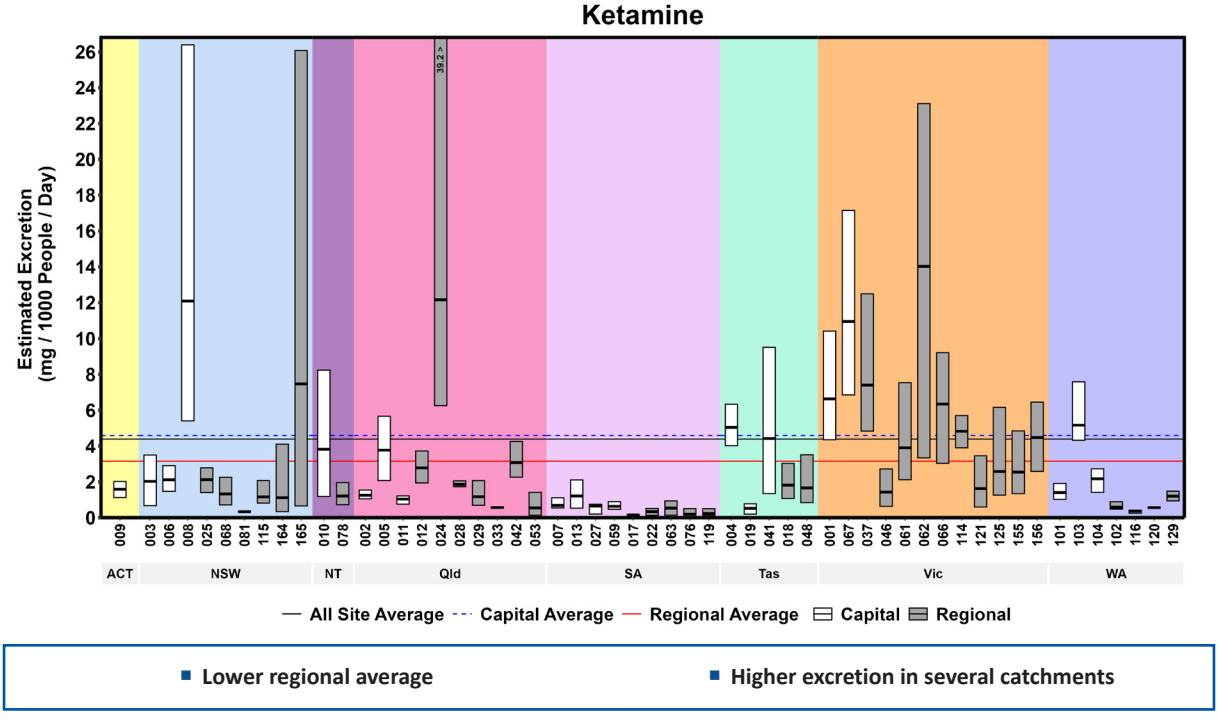
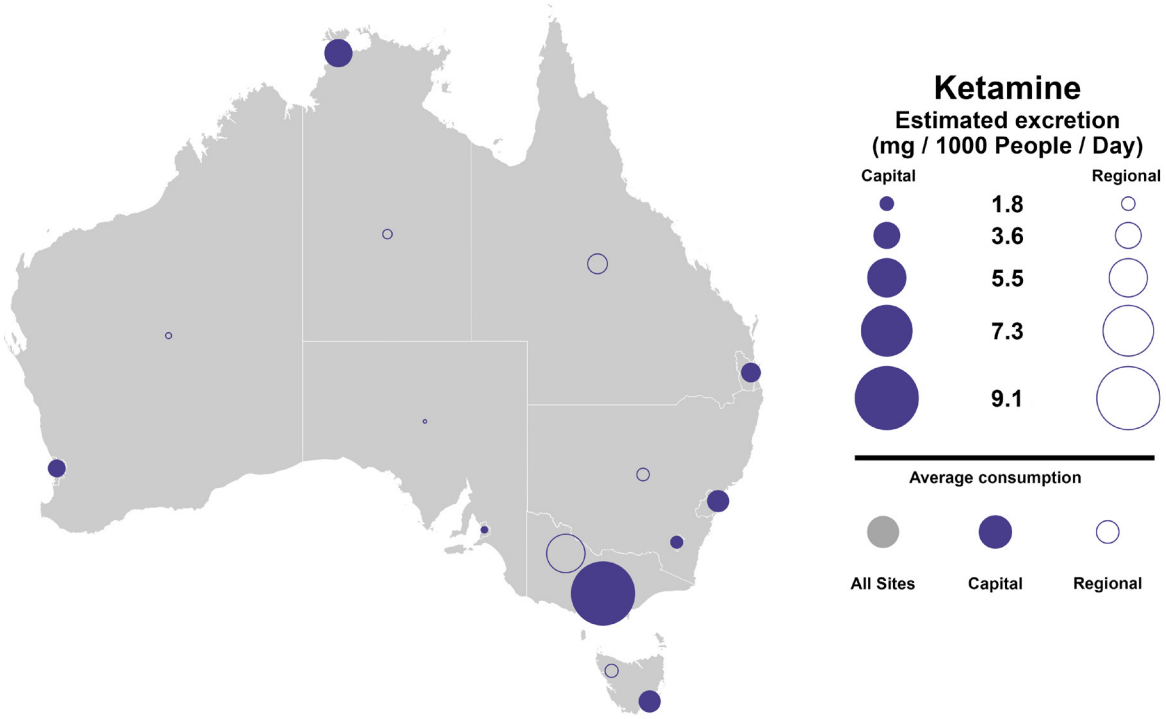


Figure 29: Estimated average ketamine excretion per jurisdiction for April 2023 in mg excreted per day per thousand people. The number of collection days varied from 5 to 7.



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 in this sampling period 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 April and June 2023 collections, while regional areas were updated for April 2023. 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 and 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 2 most recent bars consisting of capital cities (April and June 2023) and the single most recent bar for regional areas (April 2023). Some temporal changes reflected in these bars may be a consequence of updated populations used in the calculations, see Appendix 5 of Report 17 for the difference in populations for the 2016 and 2021 Census for each catchment.

4.2.1 NICOTINE AND ALCOHOL

The long-term 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). There is no consistent national trend in nicotine consumption in capital cities or regional areas and a surprising level of difference between consumption in a number of jurisdictions.

Overall alcohol consumption in the current collection period is mostly consistent with the previous reporting period (Figure 31). Some localised changes include regional New South Wales where alcohol consumption rose, while a decrease was evident in regional parts of the Northern Territory and Tasmania. The difference in alcohol consumption in regional areas compared to the cities has been less pronounced than for nicotine, but is similarly higher in regional areas since the start of the Program. This difference at the national level is not reflected in all jurisdictions, for example South Australia, where regional use of alcohol is consistently below that in the capital city. In the case of Tasmania, the lack of sampling on a weekend in regional areas may account for the lower reported levels in that jurisdiction.

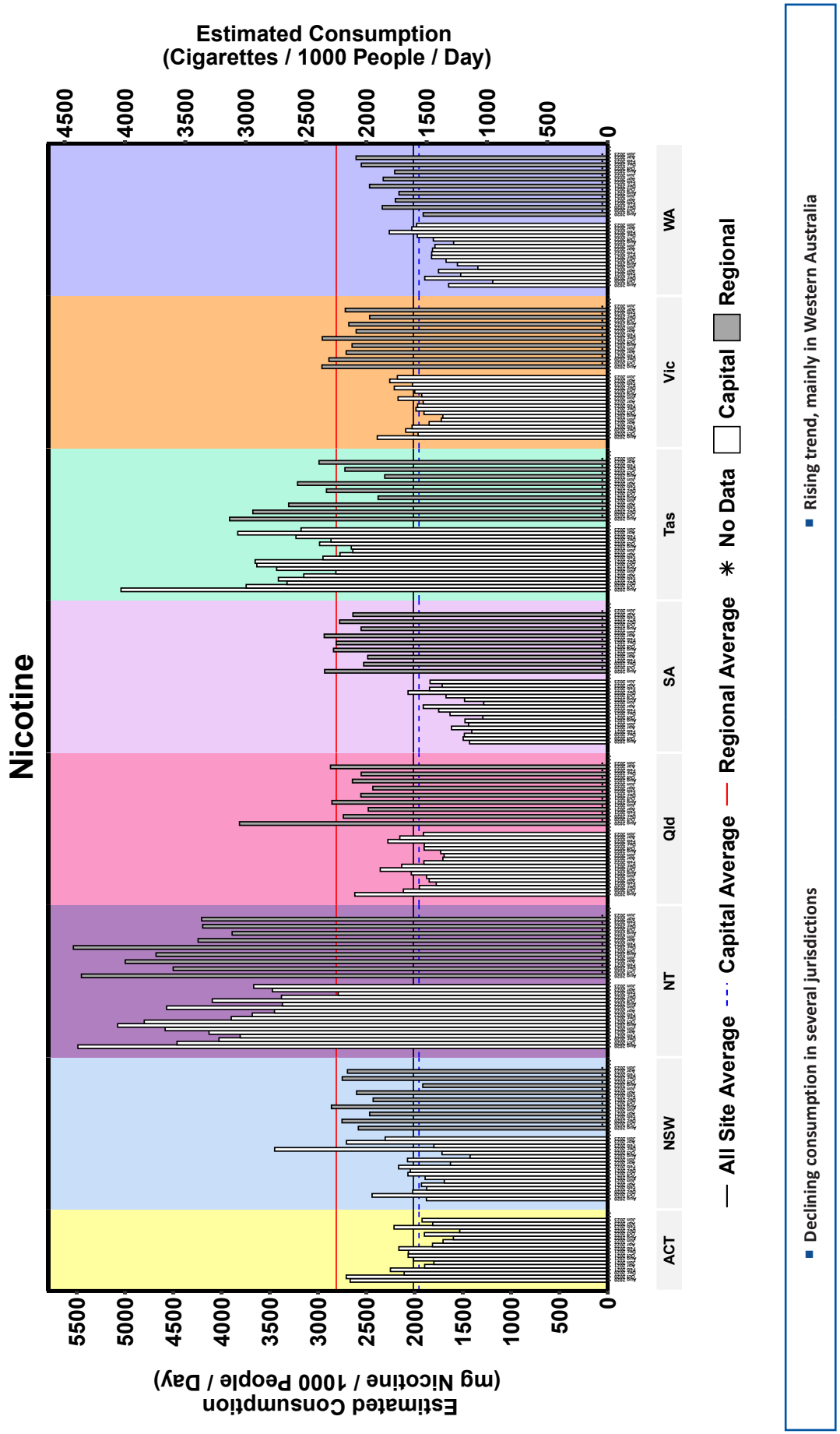


Figure 30: Estimated average consumption of nicotine by state/territory, August 2020 to June 2023, where 1 cigarette provides 1.25 mg of nicotine.

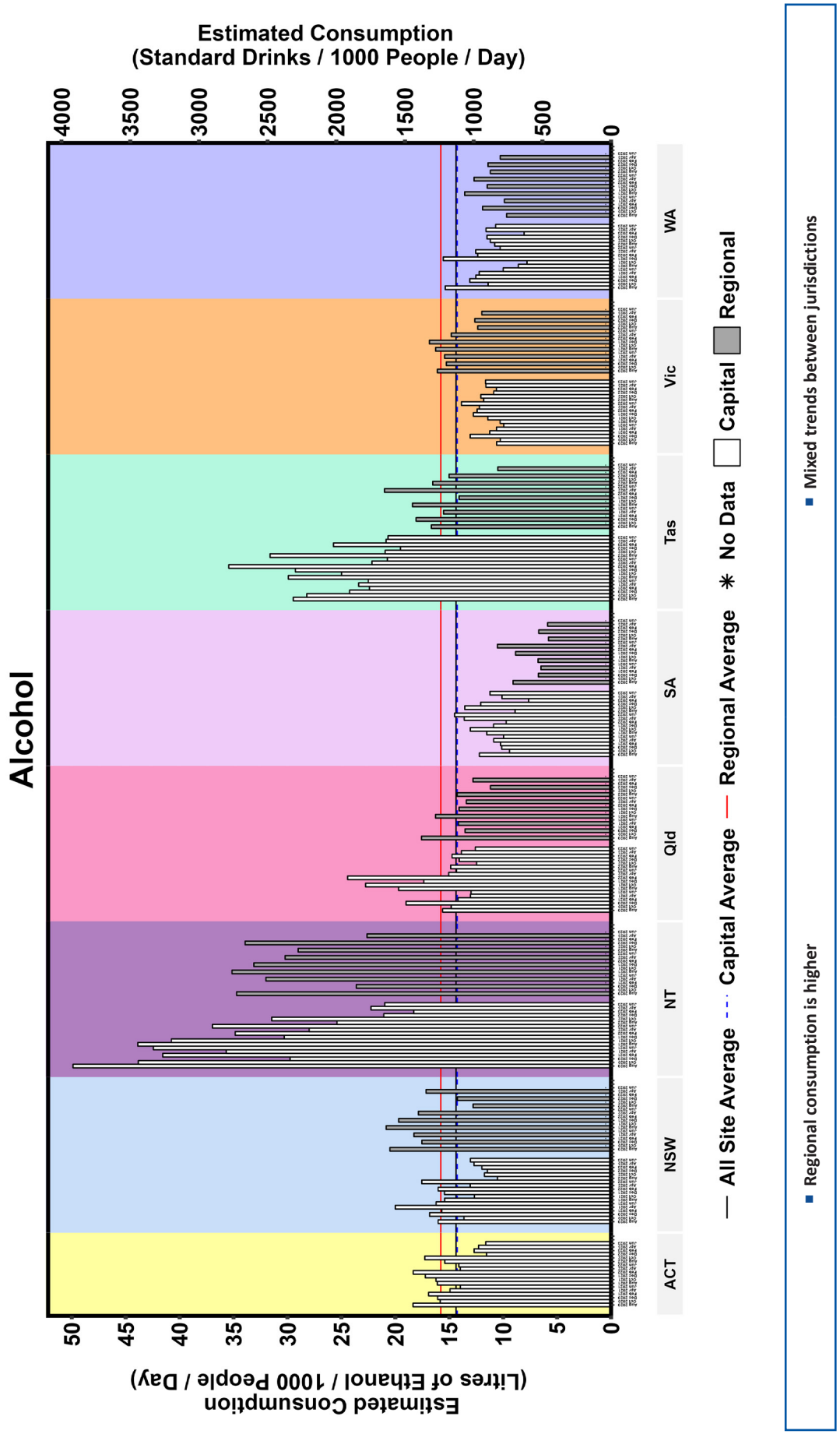


Figure 31: Estimated average consumption of alcohol by state/territory, August 2020 to June 2023. A standard drink is 10.0 g, or 12.6 mL.

4.2.2 STIMULANTS

Temporal changes in the consumption of methylamphetamine have been variable, with short term fluctuations a prominent feature (Figure 32). Consumption in New South Wales rose substantially compared to the previous reporting period (December 2022 and February 2023). In other parts of the country, no consistent patterns were observed, with current capital city and regional levels changing in opposite directions within the same state or remaining steady. 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. New South Wales had the highest capital city consumption of methylamphetamine in June 2023, while Western Australia had the highest regional consumption in April 2023, followed by South Australia. 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 (Figures 33 and 34).

Cocaine consumption has been showing large fluctuations over the past 2 years (Figure 35). Compared to the previous reporting period, results are currently higher in every capital city of the country except New South Wales. Even in that jurisdiction, cocaine use is at a high level. Consumption in regional areas has also increased in the current period, Tasmania being the only exception. The long-term averages show that regional use of cocaine is well below consumption in the capital cities.

MDMA consumption across Australia has declined, with current levels fluctuating within a narrow range (Figure 36). A few jurisdictions have shown small recent increases, although when considered in dose amounts, the changes are relatively minor. Current levels of MDMA consumption have mostly been below the long-term averages, with the exception of the capital cities of Tasmania, the Northern Territory and Victoria. Regional use exceeds that of the capital cities.

MDA use has been variable over the last 2 years, with sporadic, localised spikes being a feature (Figure 37). There have been increases in several jurisdictions in the current reporting period. Considering the variability in MDA use over the past 2 years, no emerging patterns can be identified. Long-term average regional excretion has been higher than in the capital cities.

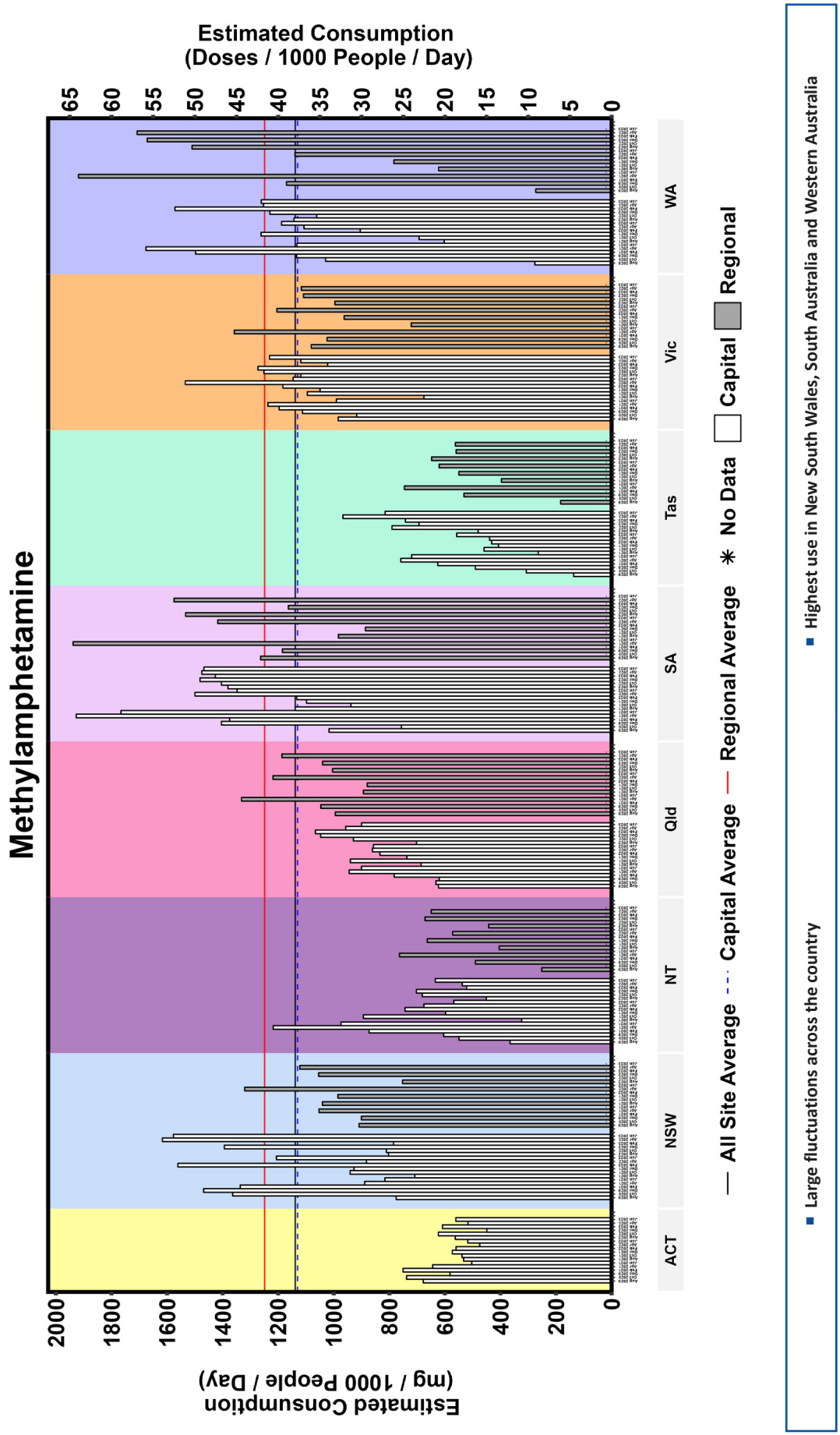


Figure 32: Estimated average consumption of methylamphetamine by state/territory, August 2020 to June 2023.

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

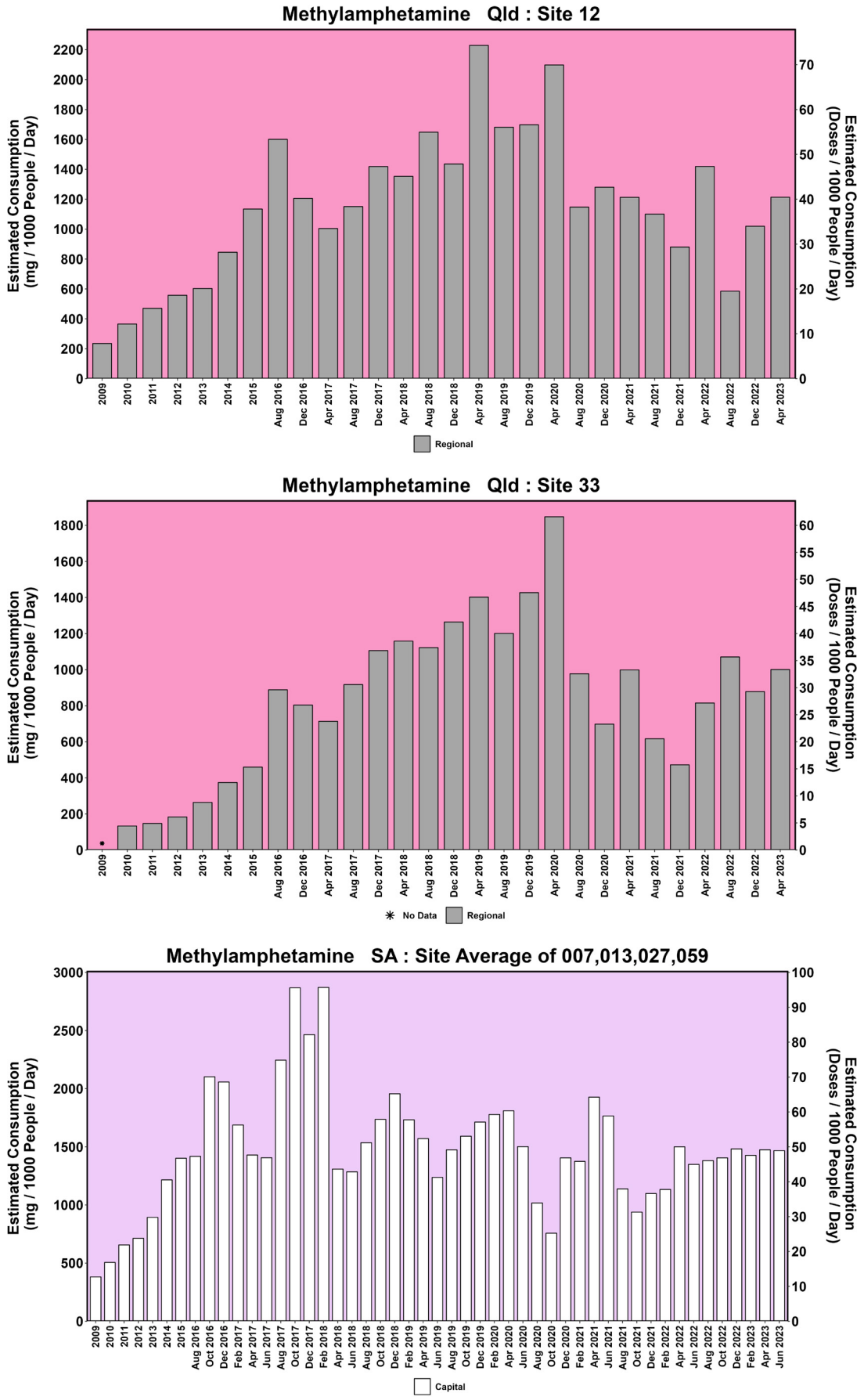
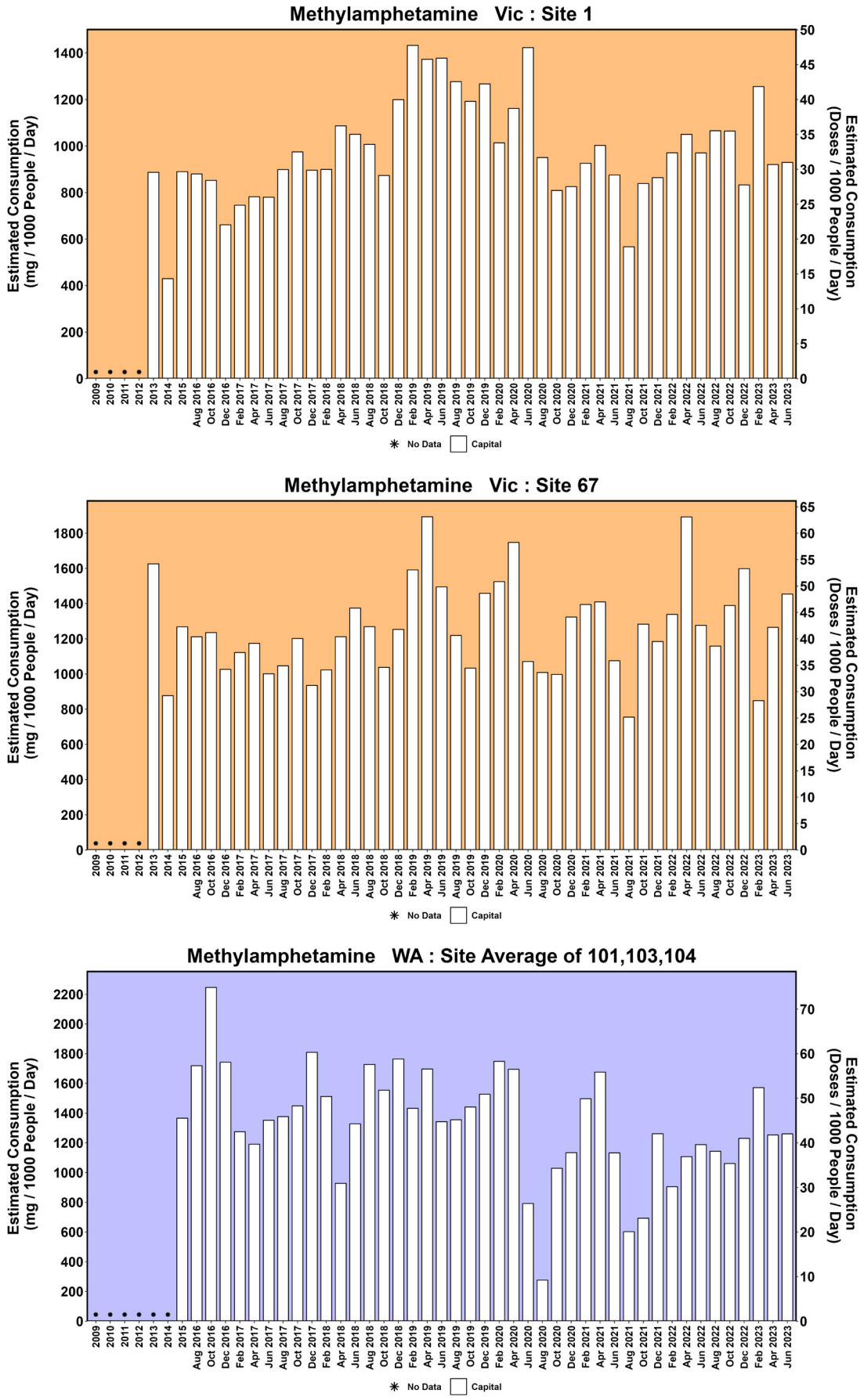


Figure 34: Change in methylamphetamine consumption for sites in Victoria and Western Australia with historical data. Both Victorian sites were the average of one week per year in 2013, 2014 and 2015.



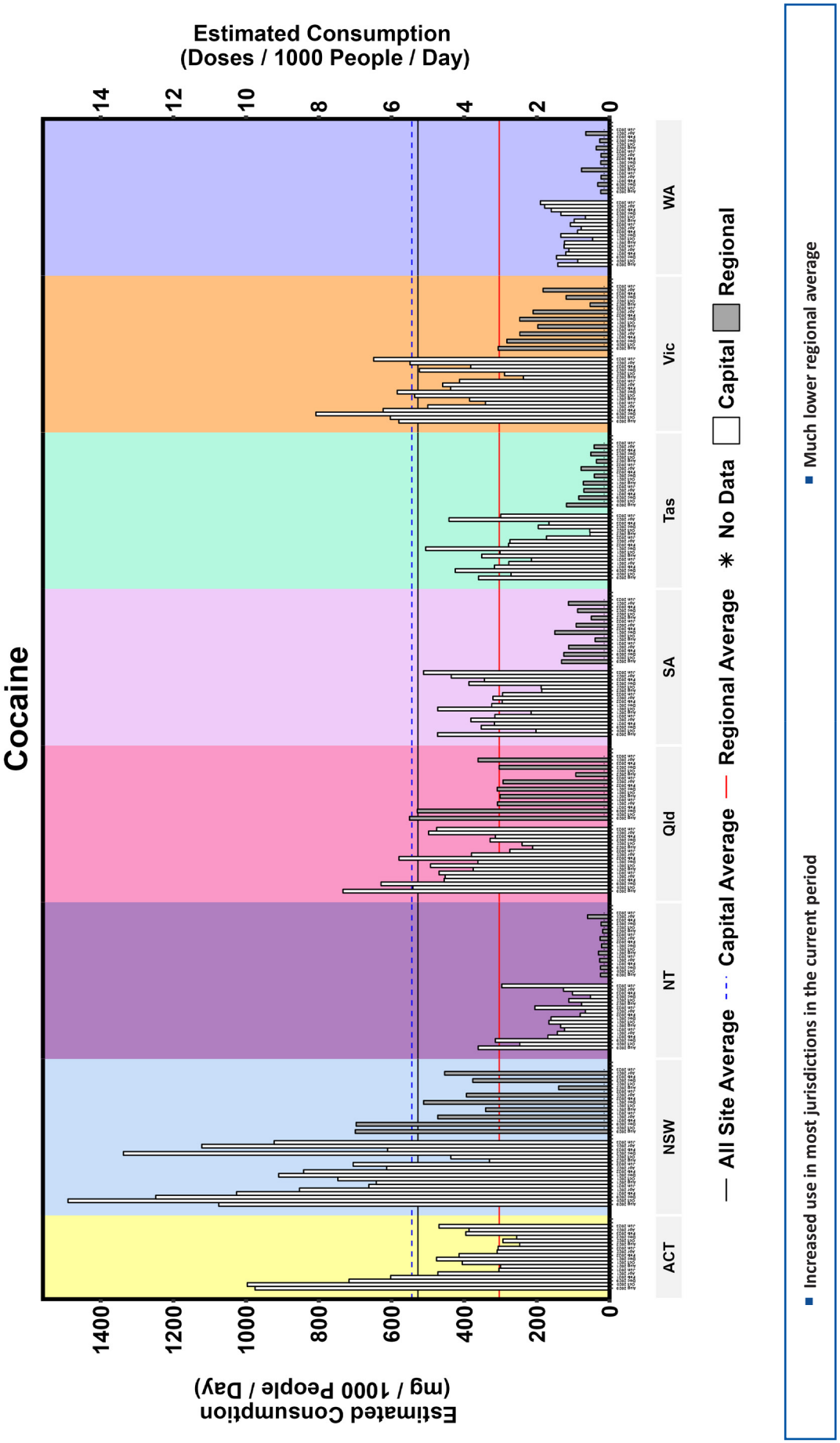


Figure 35: Estimated average consumption of cocaine by state/territory, August 2020 to June 2023.

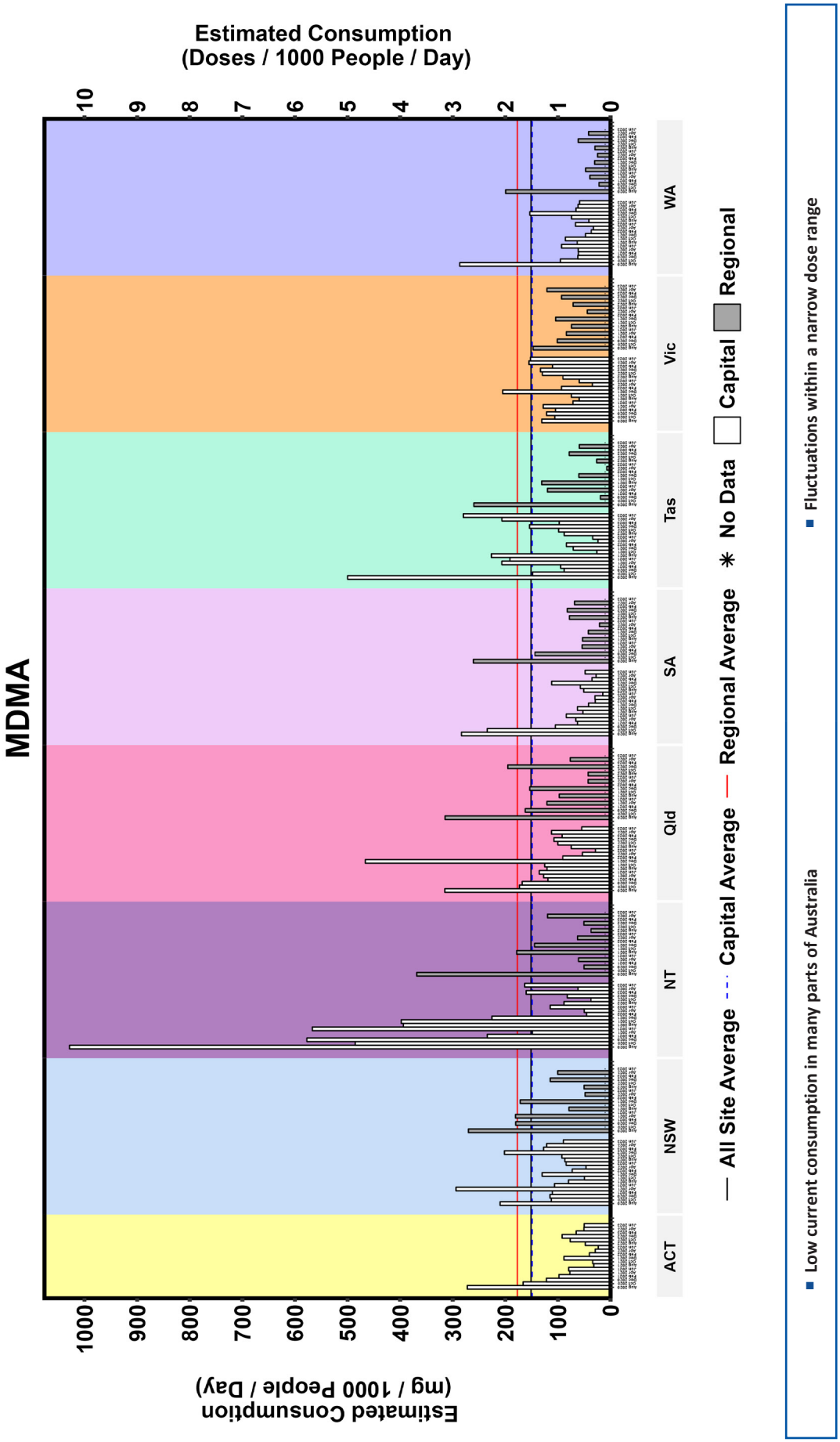


Figure 36: Estimated average consumption of MDMA by state/territory, August 2020 to June 2023.

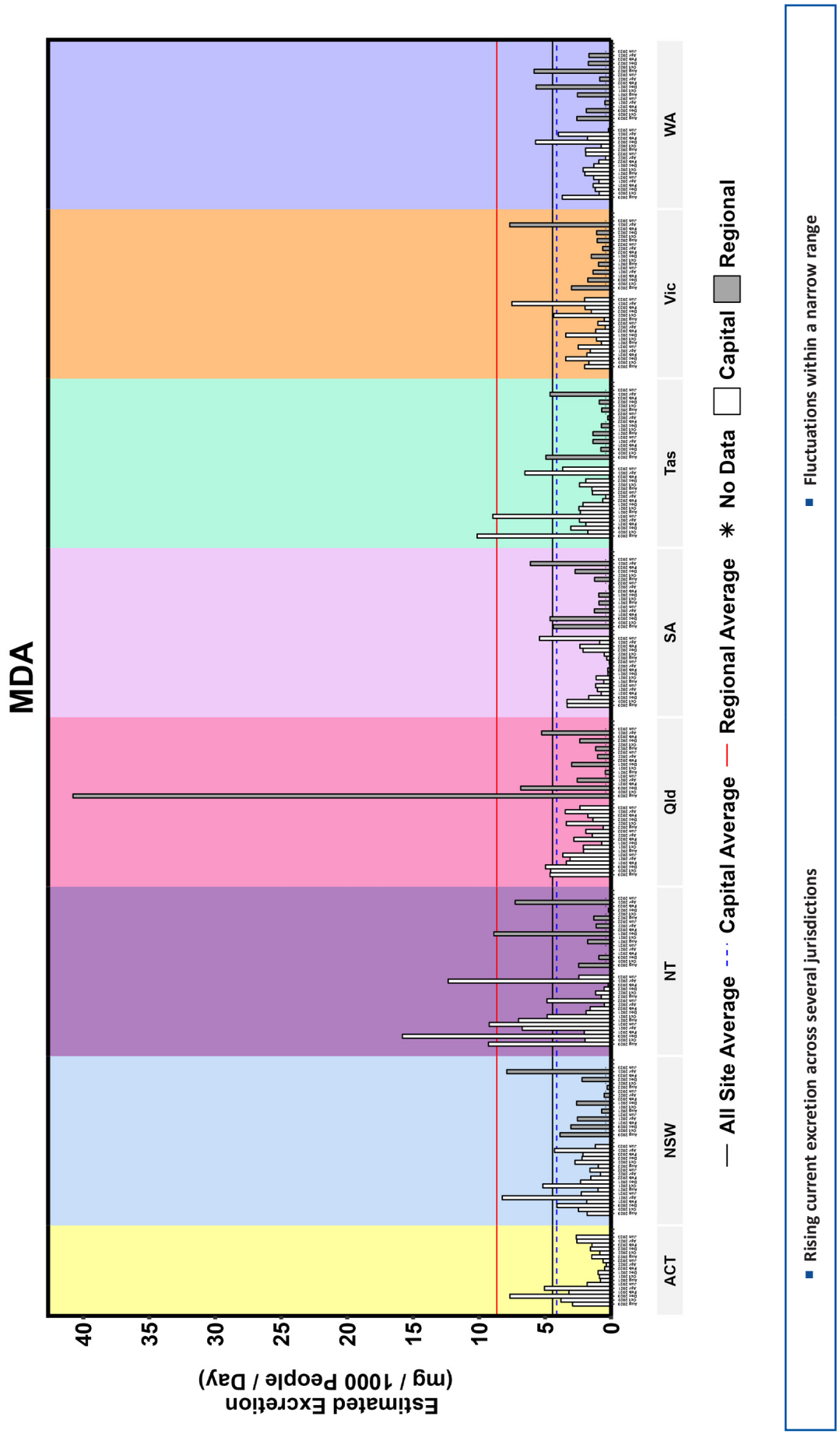


Figure 37: Estimated average excretion of MDA by state/territory, August 2020 to June 2023.

4.2.3 OPIOIDS

Oxycodone consumption in the current reporting period increased in all capital cities and some regional areas (Figure 38). This is in contrast to the general decline in use over the past 2 years. Average per capita regional oxycodone consumption is much higher than in the capital cities, Tasmania being an exception. The capital city of Tasmania and regional parts of Queensland and Victoria were the highest consumers of oxycodone on a population basis in early 2023, but in this report, the Australian Capital Territory reached comparable levels.

Fentanyl consumption did not follow any consistent pattern in the current reporting period (Figure 39). Use declined in some capital cities and regional areas and remained steady or increased in others. 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 reflect the declines in several parts of the country observed in the previous reporting period (December 2022 and February 2023). This was most noticeable in the Australian Capital Territory and regional Victoria, where heroin consumption has been relatively high over the past 2 years. Heroin use remains high in the capital cities of New South Wales and Victoria compared to other parts of the country. Much less heroin is being used in most regional areas of Australia.

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. In the current reporting period, heroin consumption in the capital city declined sharply, mostly due to levels falling to below the method reporting limits.

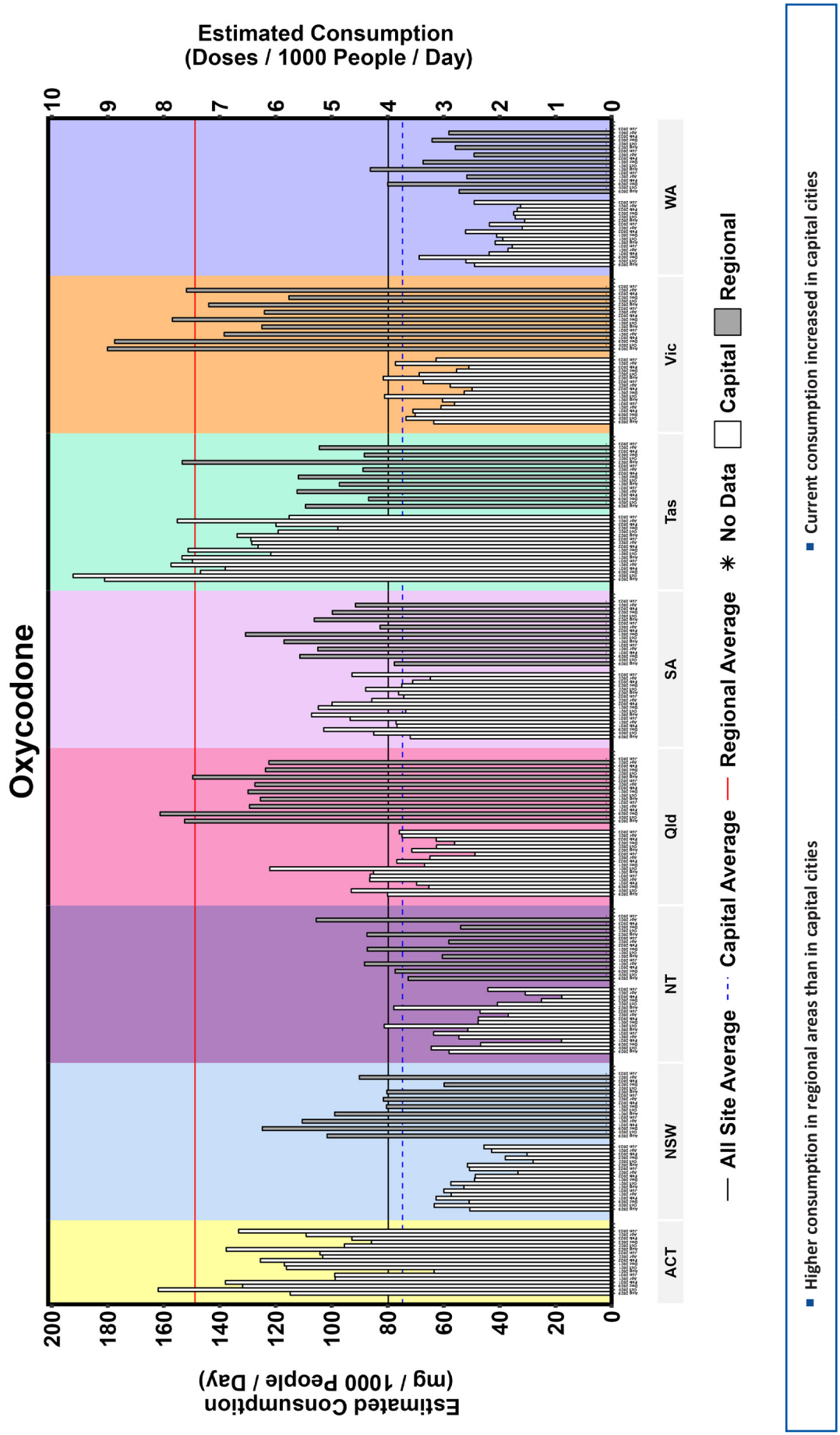


Figure 38: Estimated average consumption of oxycodone by state/territory, August 2020 to June 2023.

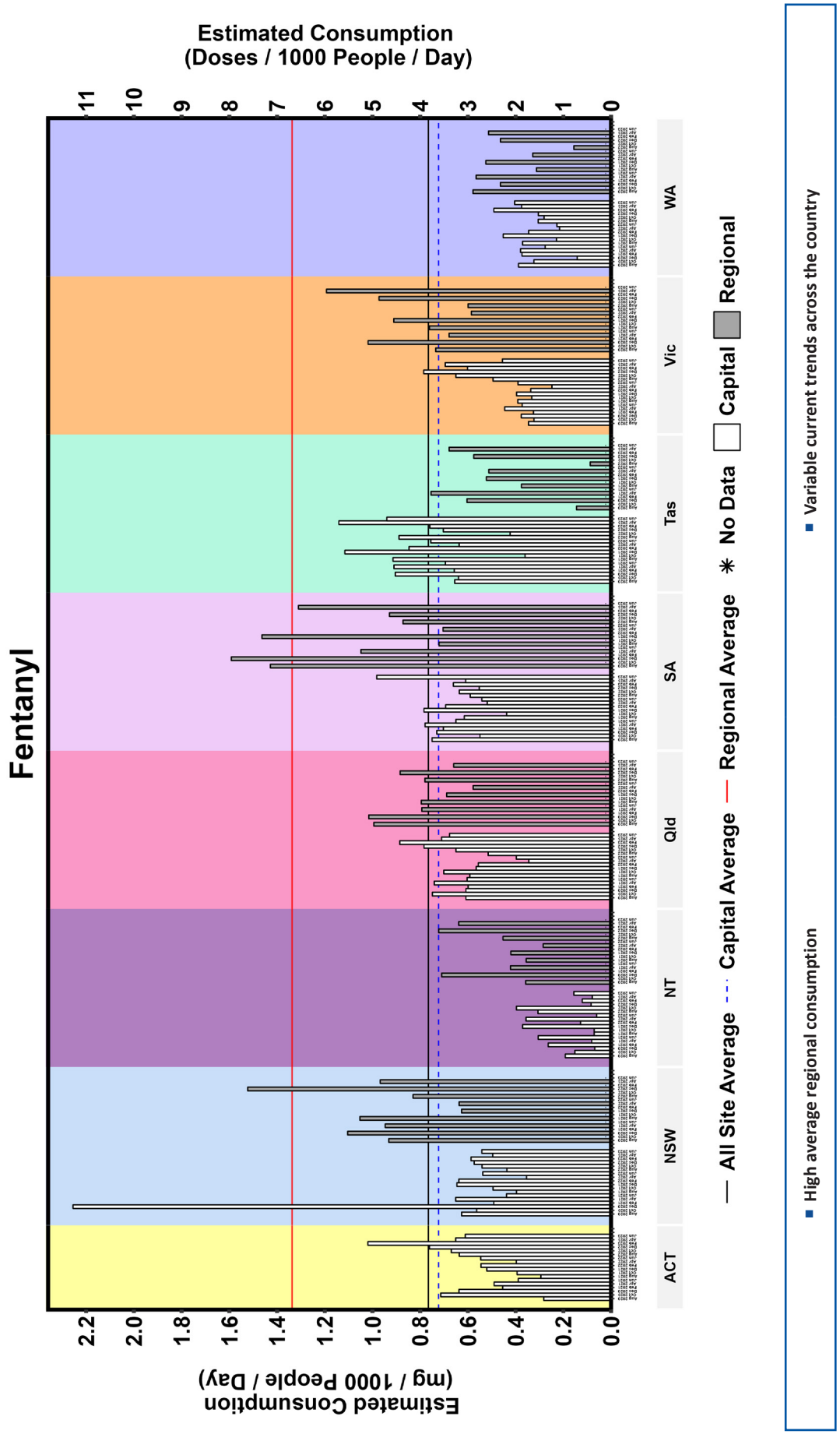


Figure 39: Estimated average consumption of fentanyl by state/territory, August 2020 to June 2023.

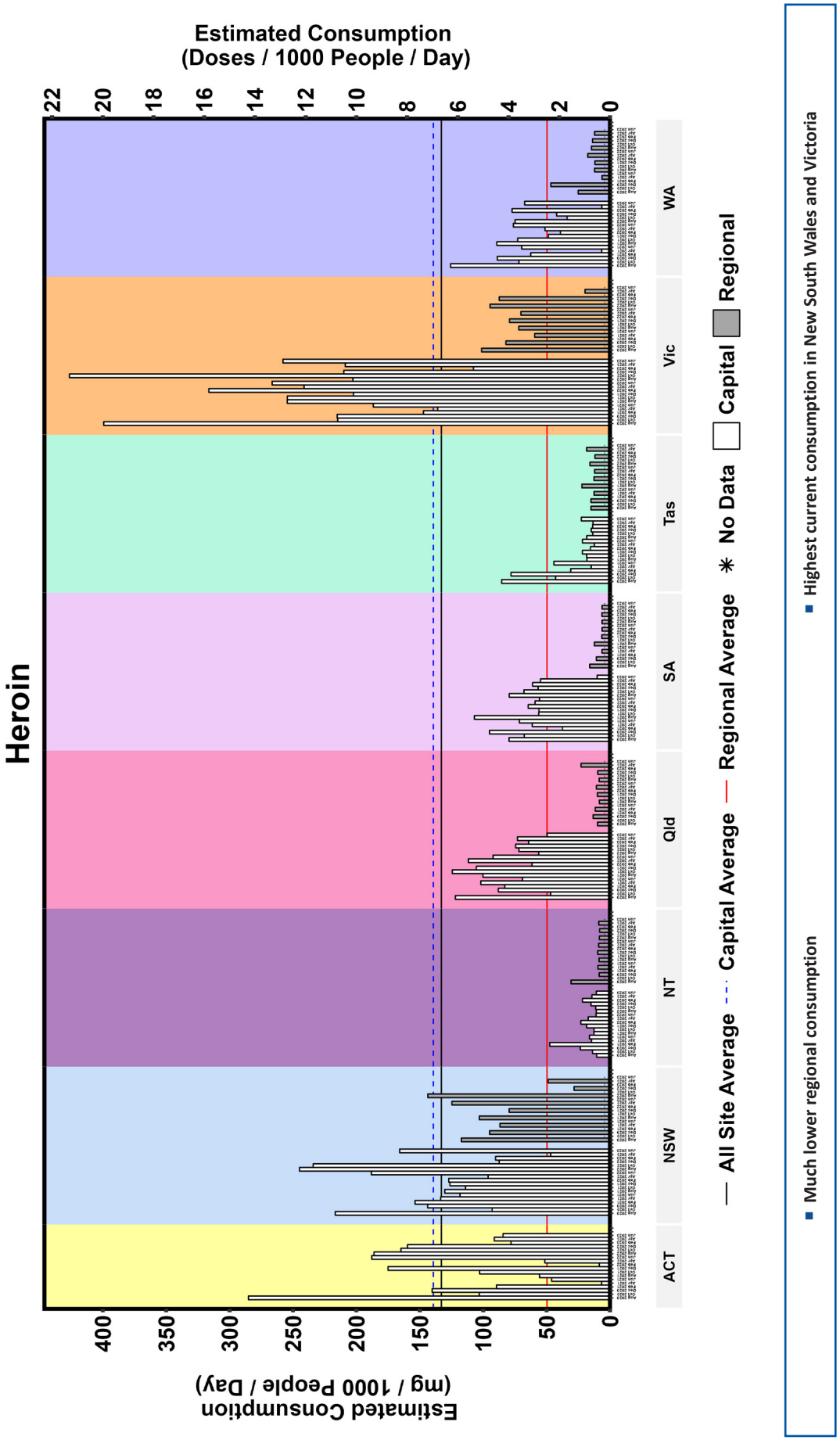
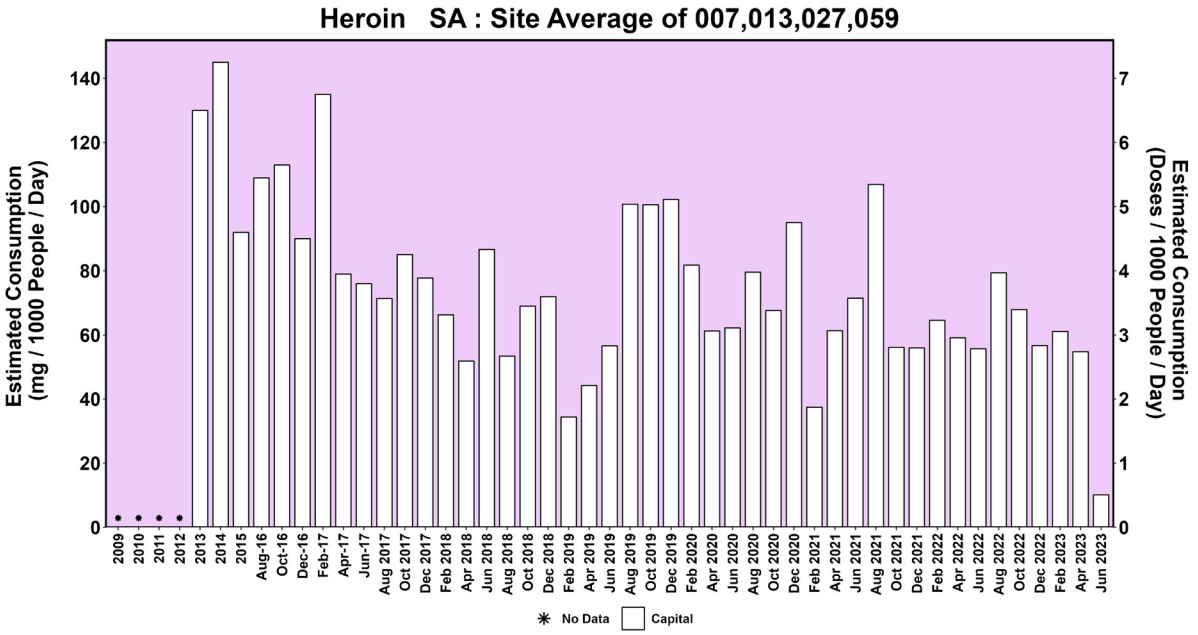


Figure 40: Estimated average consumption of heroin by state/territory, August 2020 to June 2023.

Figure 41: Change in heroin consumption for South Australia.



4.2.4 CANNABIS

Cannabis consumption in regional Australia continued to be higher than in the capital cities in this reporting period, with the exception of Tasmania (Figure 42). A sharp increase was evident in the Northern Territory. Regional use in the Northern Territory, South Australia and Western Australia is currently the highest in Australia. Population weighted cannabis consumption in sites covering the capital cities of New South Wales and Victoria consistently shows lower levels than in the smaller capital cities.

Cannabis consumption has been monitored in the capital city of South Australia since 2011. An overall increasing trend in consumption was observed until early 2019 (Figure 43). Since then, consumption of the drug in the capital of the state has fluctuated.

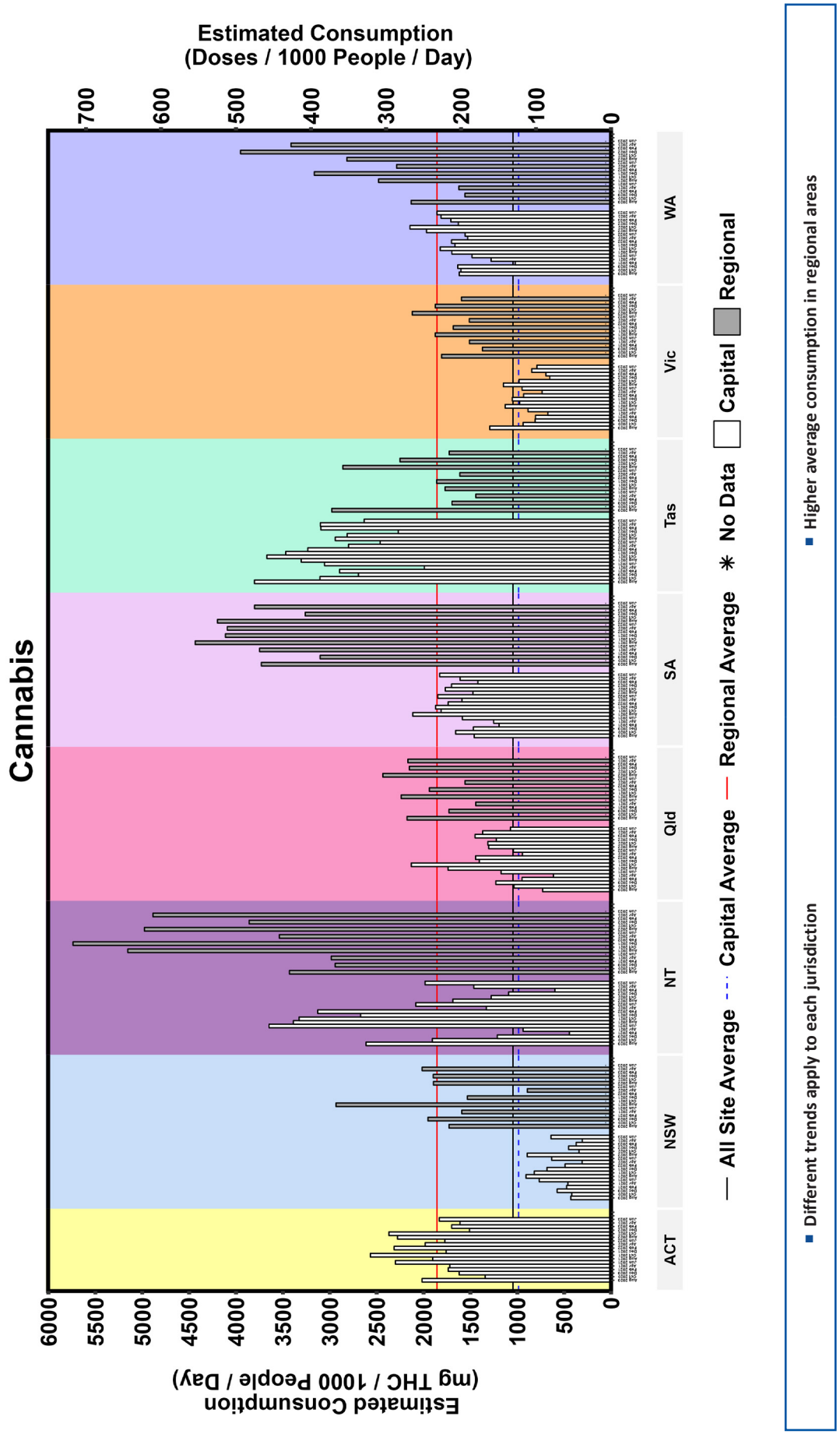
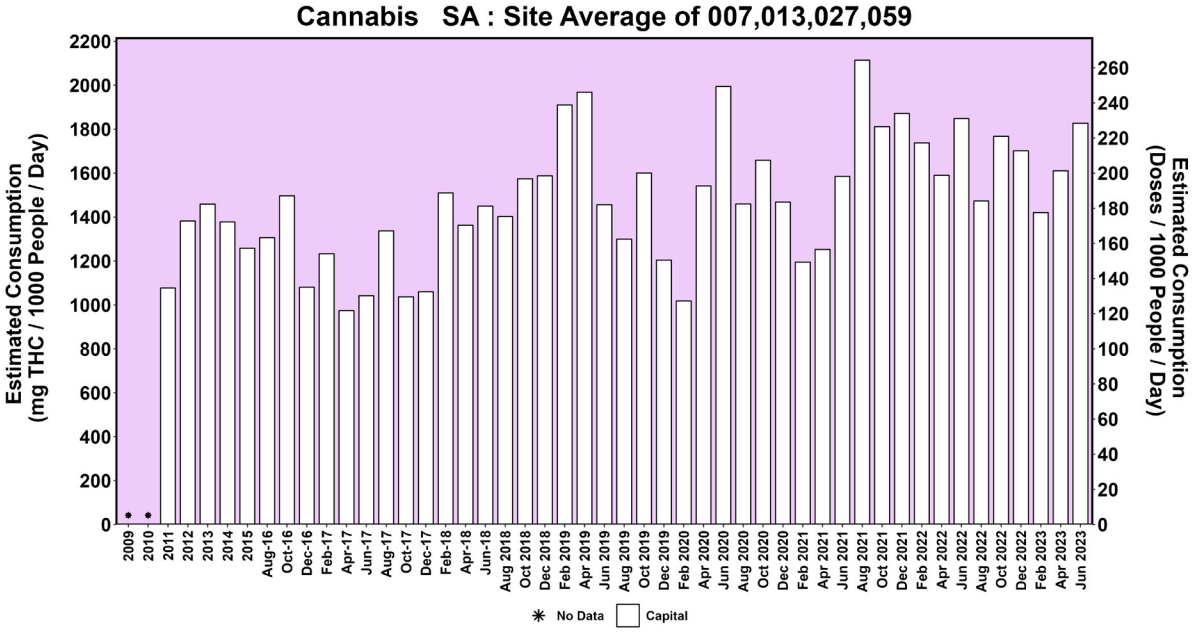


Figure 42: Estimated average consumption of cannabis by state/territory, August 2020 to June 2023.

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

Levels of ketamine excretion rose tangibly in the current reporting period in some jurisdictions (Figure 44). The Northern Territory capital city site shows large variability between collection periods compared to other jurisdictions and it currently has one of the highest excretion levels nationally, together with capital city Victoria. Overall, more ketamine is used per capita in the capital cities, as evident from the respective national averages. South Australia has had the lowest use levels over the past 2 years.

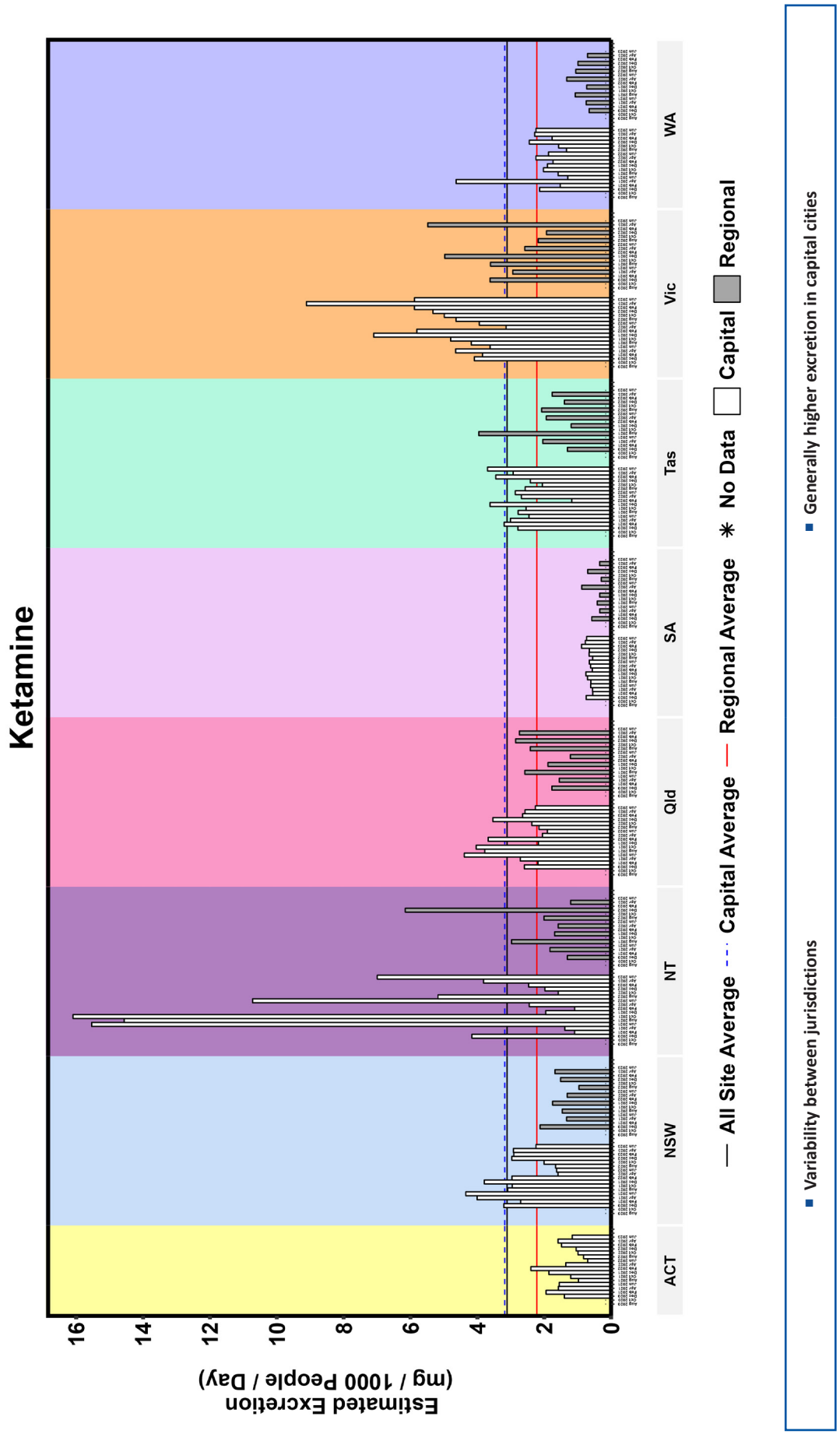


Figure 44: Estimated average excretion of ketamine by state/territory, August 2020 to June 2023.

4.3 NATIONAL CAPITAL CITY AND REGIONAL AVERAGES

In order to show national trends for 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 in regional Australia has shown a decline since August 2020 (Figure 45). In the capital cities, cyclical fluctuations have been a feature. The downward trend in nicotine use in regional areas of the country has resulted in the population weighted national averages converging. Alcohol consumption was relatively steady until August 2021, but since then, levels have declined in regional areas, with little change in the capital cities. Consumption of alcohol in the current reporting period remains low in the context of the life of the Program. Regional alcohol consumption has been above that in the capital cities for the most part.

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 August 2020, average consumption in capital cities and regional areas has been very similar. In the current reporting period, capital city use is higher than in regional Australia.

MDMA consumption rates decreased after a peak in December 2019 and reached a record low in April 2022 (Figure 46). Consumption of the drug then increased until December 2022, but has decreased again in the current reporting period. MDMA was consumed at a slightly higher per capita level in regional areas prior to the end of 2020, but the pattern has reversed since then.

Cocaine consumption mostly occurs in the capital cities and levels have fluctuated over time (Figure 47). Use of the drug increased between 2016 and June 2020, followed by a decline to August 2022 to historically low levels. In late 2022, cocaine consumption increased sharply in the capital cities and regional areas and there was a further increase in regional areas in the current reporting period, although capital city consumption has decreased slightly.

MDA excretion showed sporadic spikes up to midway through the Program, particularly in regional areas of the country (Figure 47). After August 2020, use of MDA in regional Australia declined to levels similar to that in the capital cities. Currently, excreted levels of the drug are slightly higher than the low levels of the previous year.

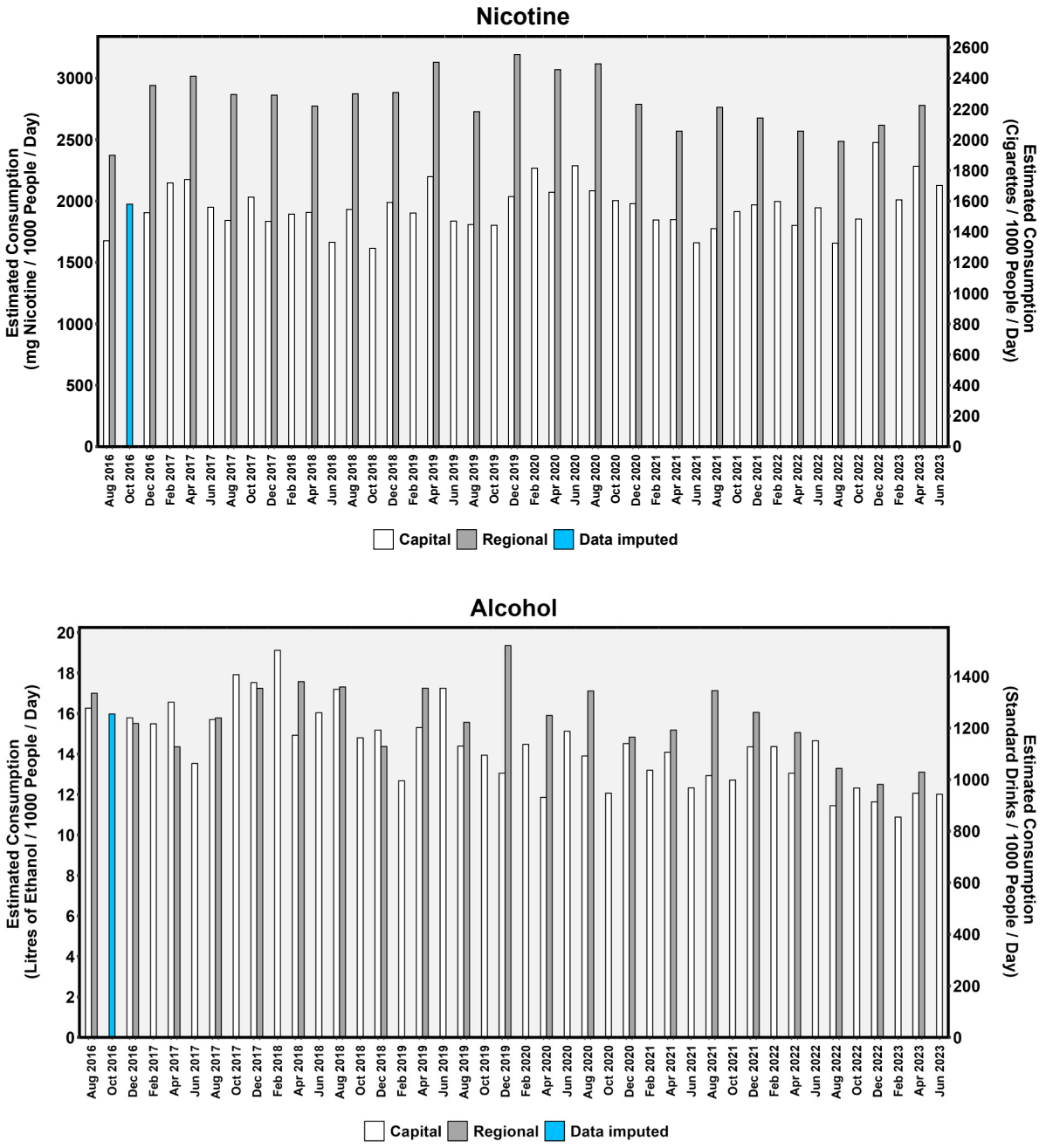
The pharmaceutical opioids, oxycodone and fentanyl, both show very large differences in consumption between capital cities and regional Australia (Figure 48). Capital city populations consume both drugs at substantially lower levels compared to regional areas. Oxycodone consumption reached a peak during 2018, followed by a decline to April 2020. Consumption of the drug has subsequently remained relatively stable, including the current reporting period. Fentanyl consumption has largely followed a similar trend. However, fentanyl use rose in both regional and capital city areas of Australia over the course of 2022. Current levels are slightly lower.

Heroin, ketamine and cannabis display different patterns in a national context (Figure 49 and Figure 50, respectively). Heroin consumption is much lower in regional Australia and has declined over the course of the past year. In the capital cities, heroin use fluctuated within a broad range up to October 2022, but has declined since.

The NWDMP first introduced analysis of ketamine 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 fluctuated within a relatively narrow band, considering the small daily excreted loads measured in wastewater. That said, there was record high capital city and regional excretion of ketamine in April 2023.

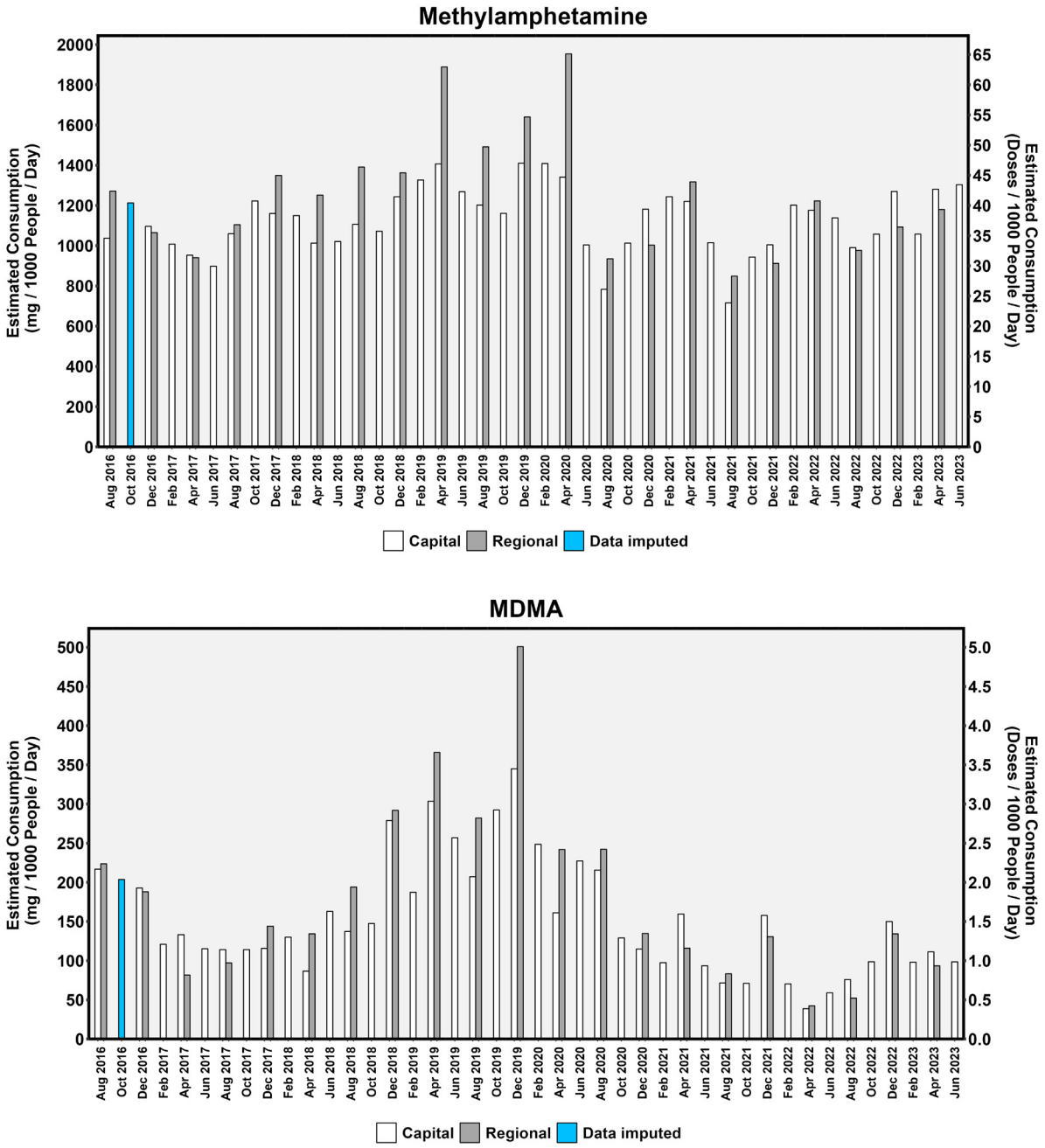
Cannabis consumption has been much lower in capital cities compared to regional Australia (Figure 50). Current consumption of the drug in regional Australia is more than double the level in capital cities and is being maintained at levels towards the higher end of historical values. Capital city use of the drug has fluctuated and presently falls within a consistent range spanning the last 3 years.

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



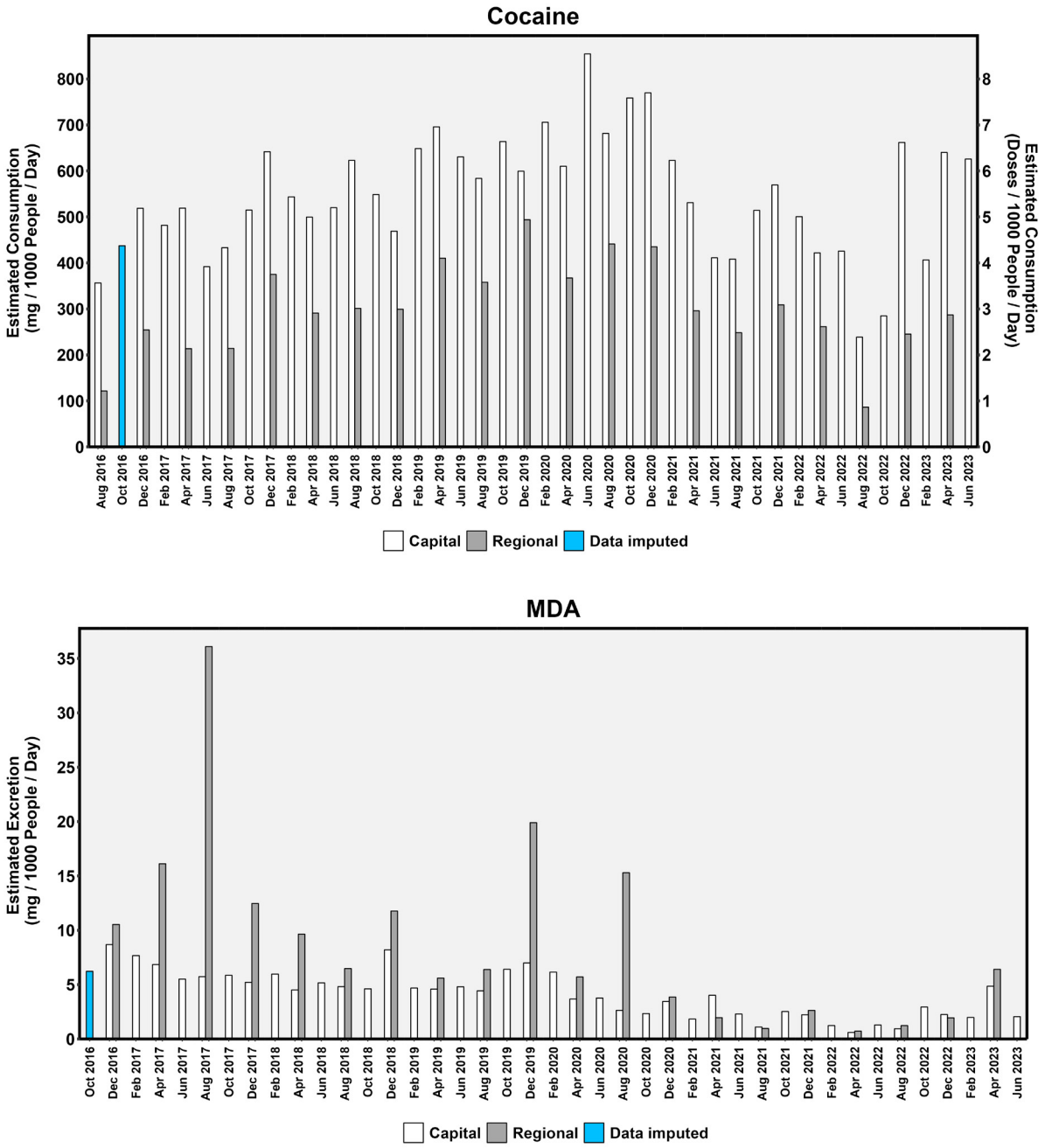
As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

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



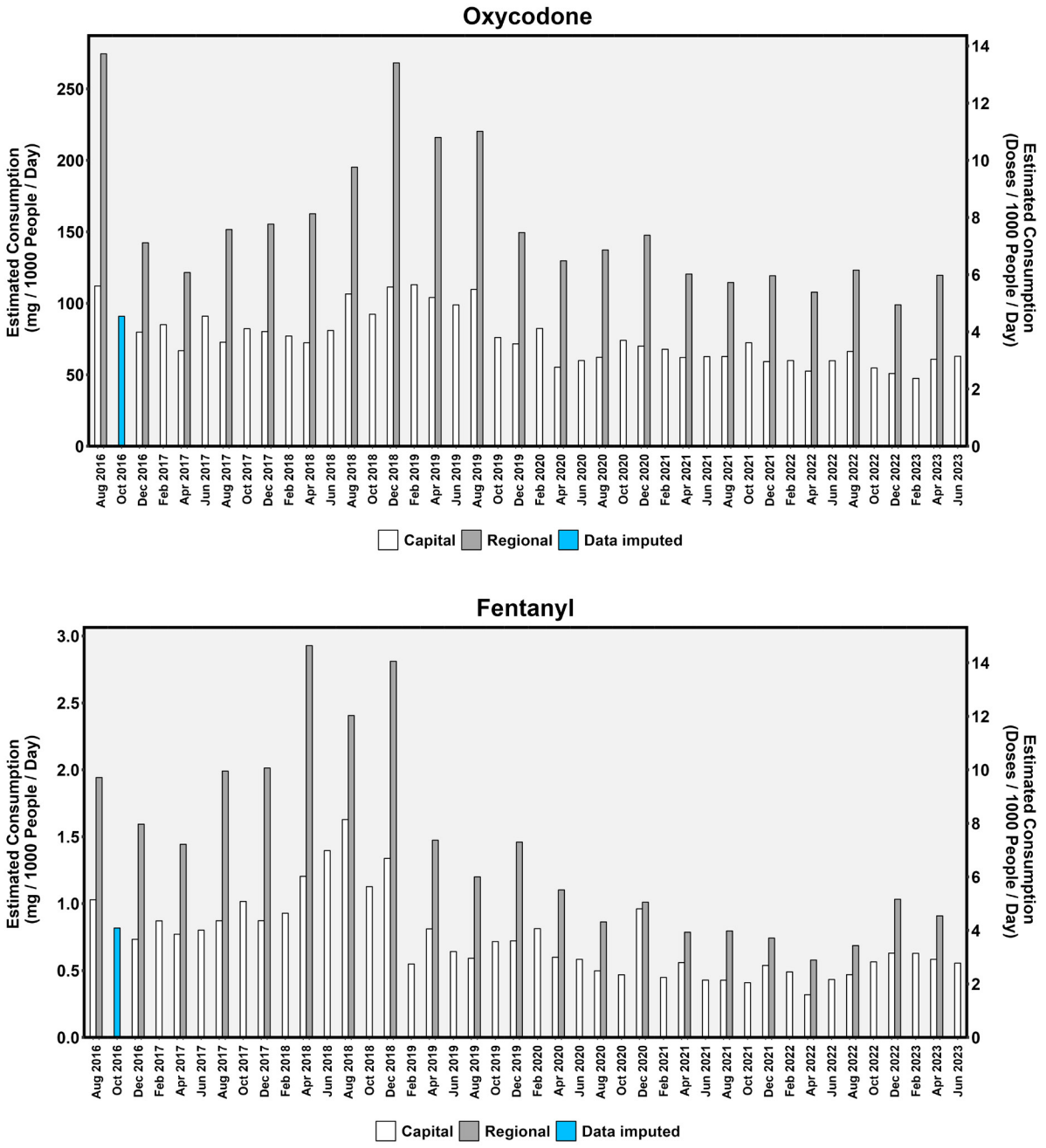
As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

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.

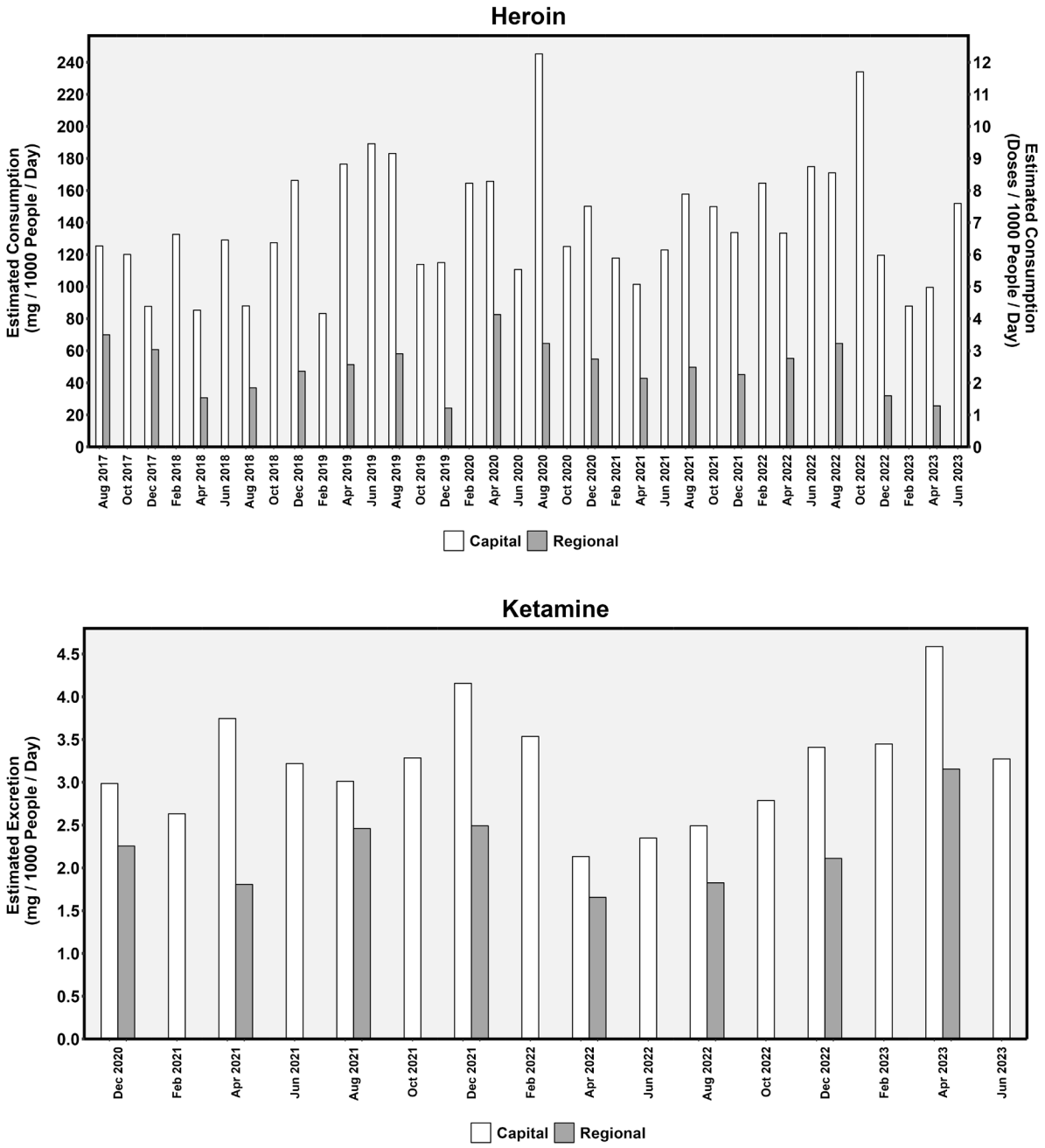
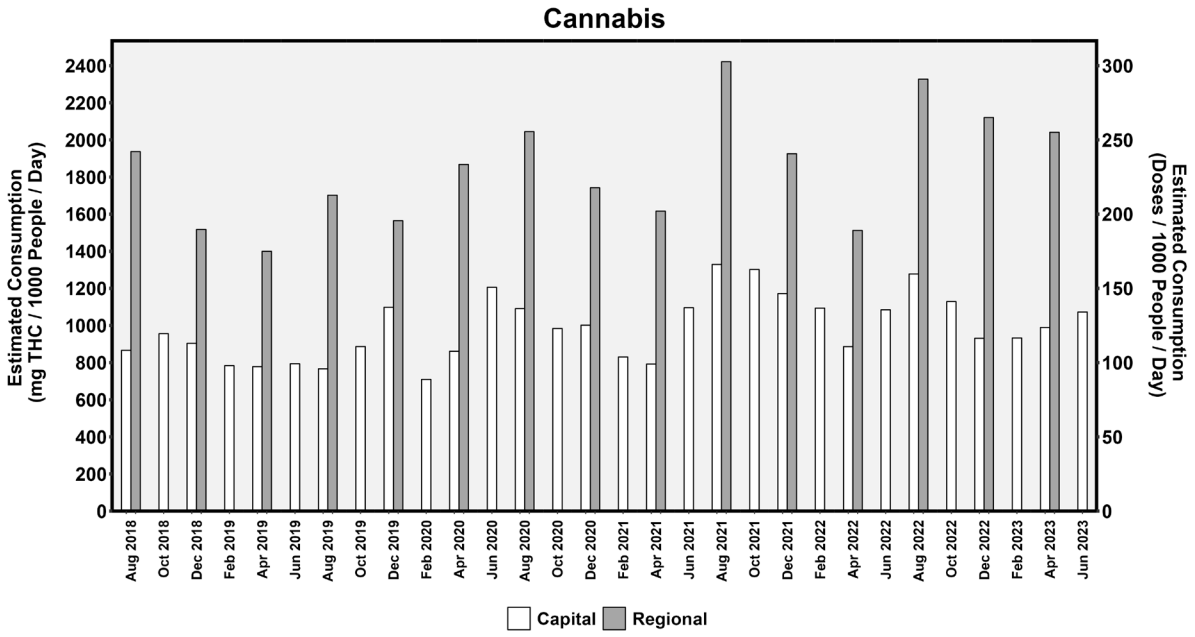


Figure 50: The population-weighted average of all sites for cannabis.



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. 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.

In terms of the substances with available dose information, cannabis ranked the highest, with methylamphetamine next (Figure 51 to Figure 54). The scale of use of cannabis is substantially higher than the other substances included in the figures. As such, the graphs have been split into 2 parts for some of the less consumed drugs to remain visible. This was the case across all regions of Australia, with the scale of cannabis consumption consistently higher for both capital cities and regional areas. The use of methylamphetamine in capital city New South Wales has generally been closest to that of cannabis of any jurisdiction (Figure 51). The increase in methylamphetamine in the current reporting period in this jurisdiction accentuates the difference between the drug and others included in the graph. 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 June 2023 for capital sites and to April 2023 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 the respective drugs.

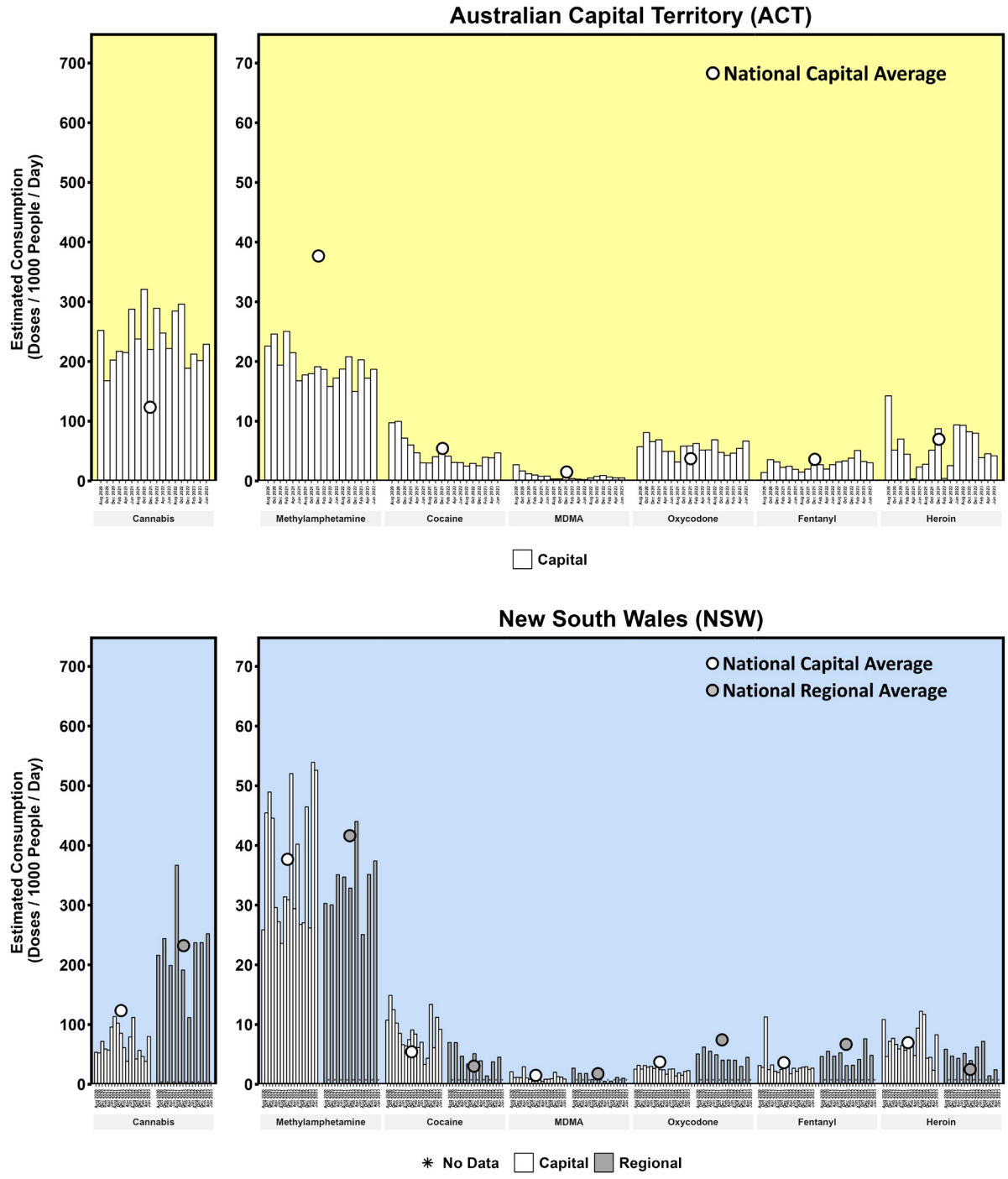


Figure 52: Profile of average drug consumption by state or territory, August 2020 to June 2023 for capital sites and to April 2023 for regional sites.

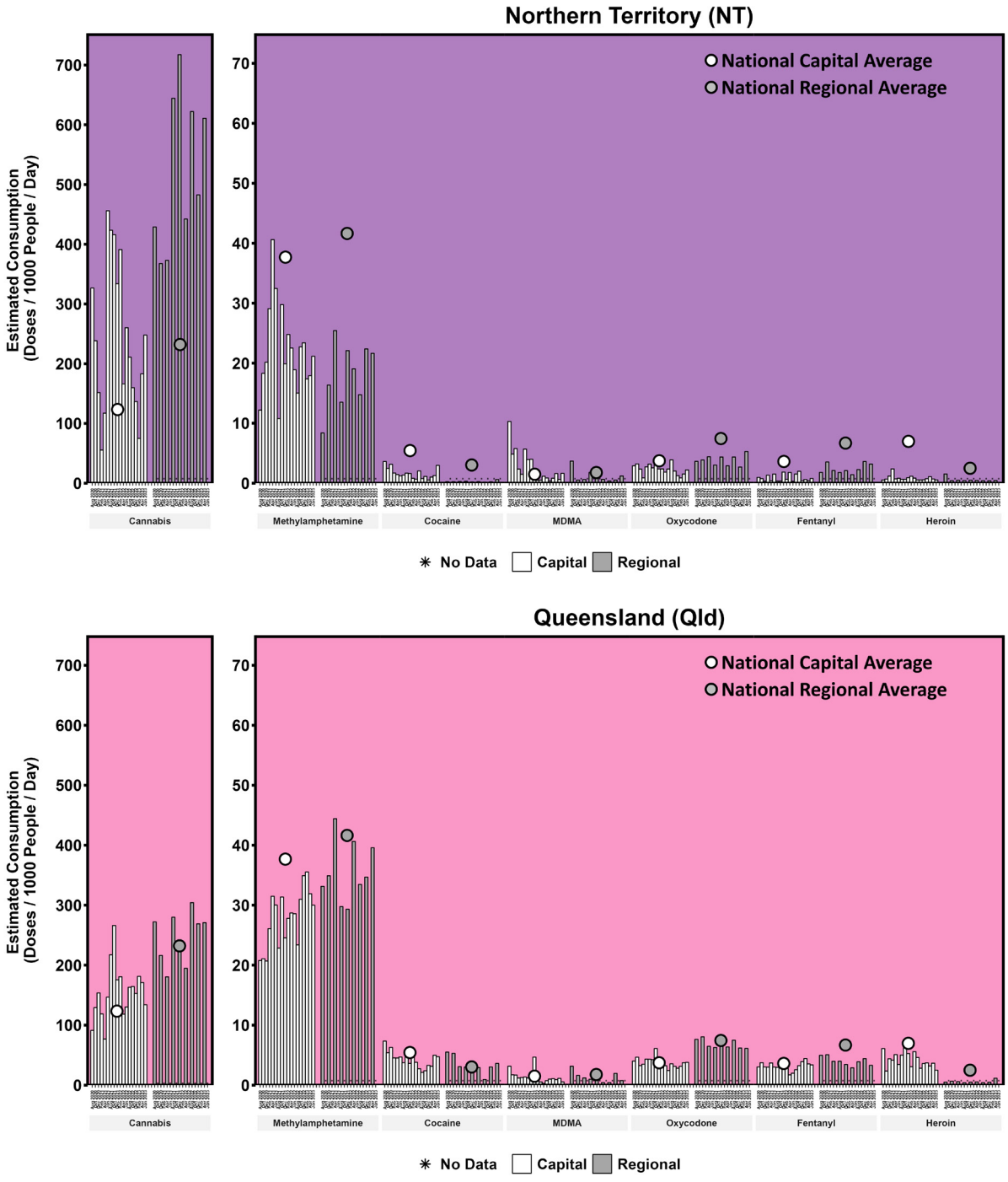


Figure 53: Profile of average drug consumption by state or territory, August 2020 to June 2023 for capital sites and to April 2023 for regional sites.

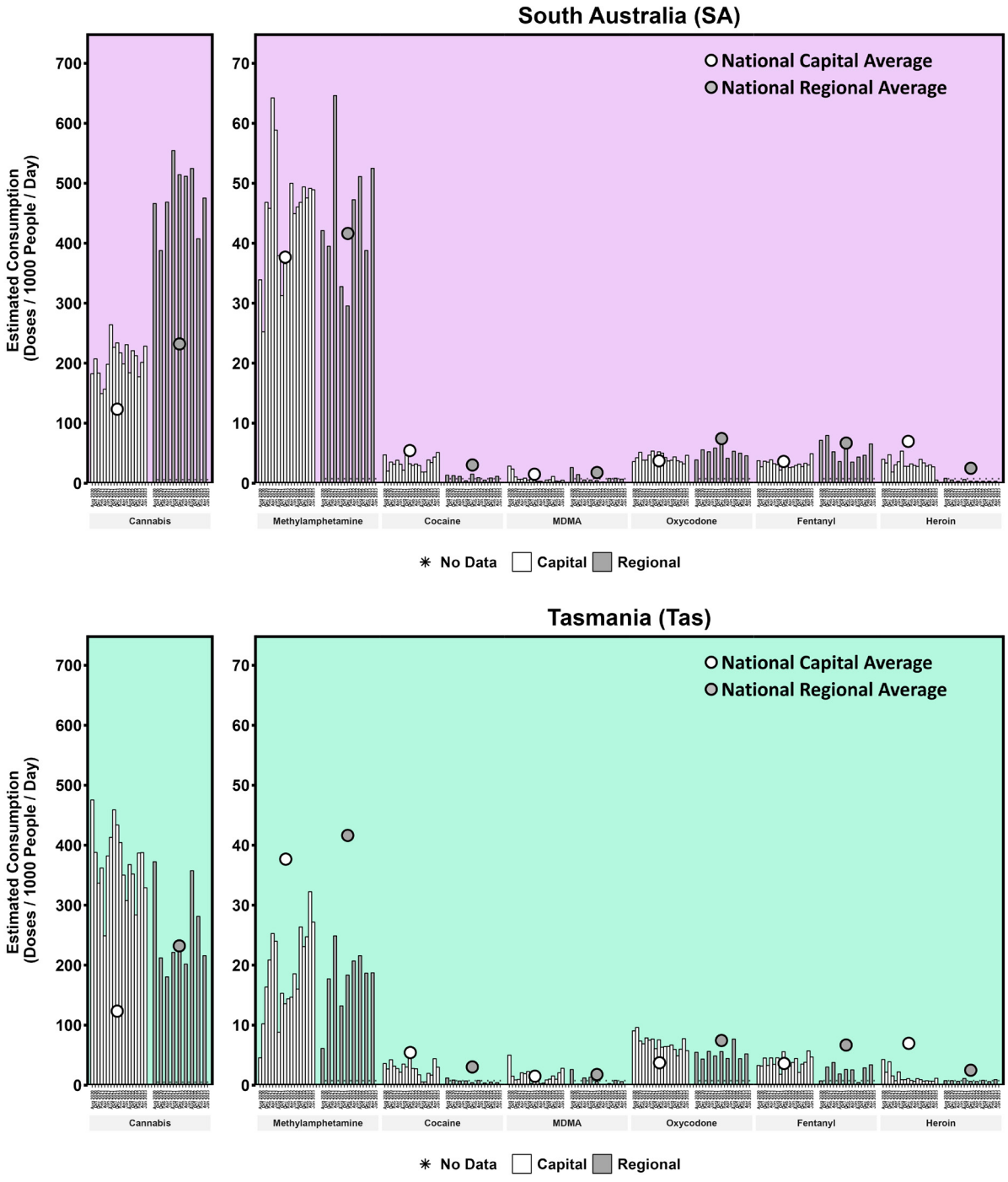
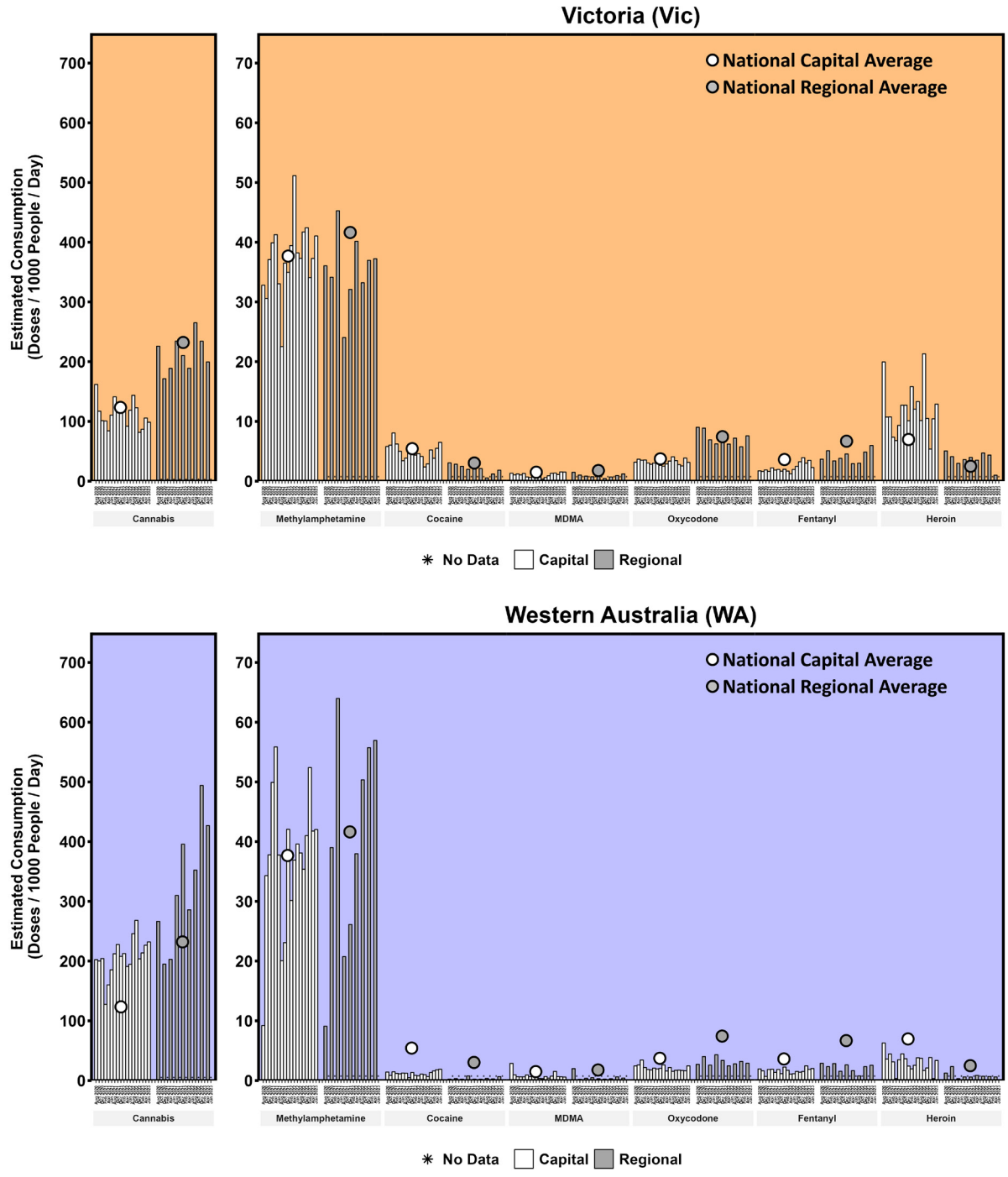


Figure 54: Profile of average drug consumption by state or territory, August 2020 to June 2023 for capital sites and to April 2023 for regional sites.



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6: REFERENCES

Bade, R., Ghetia, M., Nguyen, L., Tscharke, B. J., White, J. M., & Gerber, C. (2019). Simultaneous determination of 24 opioids, stimulants and new psychoactive substances in wastewater. MethodsX, **6**, 953-960.

Boerner, U., Abbott, A., and Roe, L. (1975). The metabolism of morphine and heroin in man. Drug metabolism reviews **4**(1): 39-73.

Campos-Manas, M.C, Van Wichelen, N., Covaci, A., Van Nuijs, A.L.N., Ort, C., Been, F., Castiglioni, S., Hernandez, F. & Bijlsma, L. (2022). Analytical investigation of cannabis biomarkers in raw urban wastewater to refine consumption estimates. Water Res. **223**, 119020.

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

Freeman, T.P & Lorenzetti, V. (2020). 'Standard THC units': a proposal to standardize dose across all cannabis products and methods of administration. Addiction **115**(7), 1207.

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

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

Khan, U. and Nicell, J.A. (2011). Refined sewer epidemiology mass balances and their application to heroin, cocaine and ecstasy. Environment International **37**: 1236-1252.

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

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

Lai, F.Y., Anuj, S., Bruno, R., Carter, S., Gartner, C., Hall, W., Kirkbride, K.P., Mueller, J.F., O'Brien, J.W., Prichard, J., Thai, P.K. and Ort, C. (2015). Systematic and day-to-day effects of chemical-derived population estimates on wastewater-based drug epidemiology. Environ Sci Technol **49**(2): 999-1008. DOI: 10.1021/es503474d.

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

McCall, A.K., Bade, R., Kinyua, J., Lai, F.Y., Thai, P.K., Covaci, A., Bijlsma, A.L.N. and van Nuijs, C.O. (2016). Critical review on the stability of illicit drugs in sewers and wastewater samples. Water Research **88**: 933-947.

O'Brien, J.W., Tscharke, B.J., Bade, R., Chan, G., Gerber, C., Mueller, J.F., Thomas, K.V. and Hall, W.D., (2021). A wastewater-based assessment of the impact of a minimum unit price (MUP) on population alcohol consumption in the Northern Territory, Australia. Addiction **117**(1) 243-249. DOI: 10.1111/add.15631.

Pizarro, N., Ortuño, J., Jarré, M., Hernández-López, C., Pujadas, M., Llebaria, A., Joglar, J., Roset, P.N., Mas, M., Segura, J., Camí, J. and De la Torre, R. (2002). Determination of MDMA and its metabolites in blood and urine by gas chromotography-mass spectrometry and analysis of enantiomers by capillary electrophoresis. Journal of Analytical Toxicology **26**(3): 157-165.

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

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

Sharma, P., Murthy, P. and Bharath, M.M.S. (2012) Chemistry, Metabolism, and Toxicology of Cannabis: Clinical Implications. Iranian J Psychiatry **7**(4): 149-156.

Sullivan, M. A., Vosburg, S. K. and Comer, S. D. (2006). Depot naltrexone: antagonism of the reinforcing, subjective, and physiological effects of heroin. Psychopharmacology **189**(1): 37-46.

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

Wall, M.E. & Perez-Reyes, M. (1981). J Clin Pharmacol. **21**:178S-189.

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

7: APPENDICES

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

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

Analyte/metabolite	Drug	Limit of detection (LOD) [ng/L]	Limit of quantification (LOQ) [ng/L]	Excretion factor	Standard dose pure drug (mg)
Amphetamine	Amphetamine	12	16	0.394[a]	30[b]
Cocaine	Cocaine	17	50	0.075[b]	100[b]
Cotinine	Nicotine	33	100	0.3[c]	1.25[c]
Norfentanyl	Fentanyl	0.1	0.1	0.3[d]	0.2[d]
MDA *	MDA	1	4	n.a.	n.a.[#]
MDMA	MDMA	1.5	2	0.225[b]	100[b]
Mephedrone	Mephedrone	0.4	0.8	n.a.	n.a.
Methylamphetamine	Methylamphetamine	33	100	0.39[g]	30[b]
Methylone	Methylone	0.01	0.1	n.a.	n.a.
Hydroxycotinine	Nicotine	17	50	0.44[c]	1.25[c]
Noroxycodone	Oxycodone	0.1	1	0.22[f]	20[d]
Ethyl Sulphate	Alcohol (ethanol)	167	500	0.00012[e]	10g[e]
Benzoylecgonine	Cocaine	33	100	0.35[g]	100[b]
6-Monoacetylmorphine	Heroin	0.5	1.0	0.013[h]	20[i]
THC-COOH	THC (Cannabis)	30	180	0.1[##]	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 OF EACH SITE FOR APRIL AND JUNE 2023

Site	Capital or regional	April 2023	June 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: 025	Regional	7	–	30,000 to 150,000
NSW: 068	Regional	7	–	> 150,000
NSW: 081	Regional	7	–	< 30,000
NSW: 115	Regional	7	–	30,000 to 150,000
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
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)

Site	Capital or regional	April 2023	June 2023	Population
Vic: 001	Capital	7	7	> 150,000
Vic: 067	Capital	7	7	> 150,000
Vic: 037	Regional	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: 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	35	–		
Capital Sites	20	20		
Total Sites	**55**	**20**		
Regional Samples	241	–		
Capital Samples	134	136		
Total Samples	375	136		
Cumulative Samples	**9,975**	**10,111**		

APPENDIX 3: PROPORTION OF SAMPLES ABOVE LOD (%) FOR EACH DRUG AND PERIOD ASSESSED[5]

Drug	Capital or regional	April 2023	June 2023
Alcohol	Capital	100	100
Alcohol	Regional	100	–
Cannabis	Capital	100	100
Cannabis	Regional	99	–
Cocaine	Capital	99	100
Cocaine	Regional	88	–
Fentanyl	Capital	92	91
Fentanyl	Regional	80	–
Heroin	Capital	53	55
Heroin	Regional	9	–
Ketamine	Capital	98	99
Ketamine	Regional	87	–
MDA	Capital	100	75
MDA	Regional	88	–
MDMA	Capital	100	100
MDMA	Regional	98	–
Methylamphetamine	Capital	100	100
Methylamphetamine	Regional	100	–
Nicotine	Capital	100	100
Nicotine	Regional	100	–
Oxycodone	Capital	100	100
Oxycodone	Regional	100	–

5 Percentage detections for previous collection periods are available in Appendix 4 of Report 6 and Appendix 3 of Reports 7 to 19.

CONCLUSIONS

CONCLUSIONS

For the 20th report of the National Wastewater Drug Monitoring Program, wastewater analysis was conducted in April (capital city and regional sites) and June 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 was the most consumed illicit drug in Australia, followed by methylamphetamine.[6]

METHYLAMPHETAMINE

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

COCAINE

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

3,4-METHYLENEDIOXYMETHYLAMPHETAMINE (MDMA)

When comparing data for December 2022 and April 2023, the population-weighted average consumption of MDMA decreased in both capital city and regional sites. Average capital city MDMA consumption further decreased from April to June 2023. In April 2023, average capital city MDMA consumption exceeded regional consumption. In April 2023, Tasmania had the highest estimated average capital city MDMA consumption, while Victoria 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 December 2022 and April 2023, MDA excretion[7] increased in both capital city and regional sites. Average capital city MDA excretion then decreased from April to June 2023. In April 2023, average regional MDA excretion exceeded average capital city excretion. In April 2023, the Northern Territory[8] had the highest estimated average capital city excretion of MDA, while New South Wales had the highest average regional excretion.

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

7 The term excretion (as opposed to consumption) is used for MDA and ketamine in this report due to the absence of clear information in the scientific literature around suitable factors to estimate consumption of the substances in wastewater.

8 As the Northern Territory only has 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.

HEROIN

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

CANNABIS

When comparing data for December 2022 and April 2023, the population-weighted average consumption of cannabis increased in capital city sites and decreased in regional sites. Average capital city cannabis consumption further increased from April to June 2023. Average regional cannabis consumption continued to exceed average capital city consumption. In April 2023, Tasmania had the highest estimated average capital city consumption of cannabis, while the Northern Territory[9] had the highest average regional consumption.

KETAMINE

When comparing data for December 2022 and April 2023, the population-weighted average excretion of ketamine increased in both capital city and regional sites to the highest levels recorded by the Program. Average capital city ketamine excretion then decreased from April to June 2023. Average capital city ketamine excretion continued to exceed regional ketamine excretion. In April 2023, Victoria had the highest estimated average capital city and regional ketamine excretion.

OXYCODONE

When comparing data for December 2022 and April 2023, average consumption of oxycodone increased in both capital city and regional sites. Average capital city oxycodone consumption further increased from April to June 2023. Average regional oxycodone consumption exceeded average capital city consumption. In April 2023, Tasmania had the highest estimated average capital city consumption of oxycodone, while Victoria had the highest average regional consumption.

FENTANYL

When comparing data for December 2022 and April 2023, average consumption of fentanyl decreased in both capital city and regional sites. Average capital city fentanyl consumption further decreased from April to June 2023. Average regional fentanyl consumption continued to exceed average capital city consumption. In April 2023, Tasmania had the highest estimated average capital city consumption of fentanyl, while South Australia had the highest average regional consumption.

9 As the Northern Territory only has 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 December 2022 and April 2023, the population-weighted average consumption of nicotine decreased in capital city sites and increased in regional sites. Average capital city nicotine consumption further decreased from April to June 2023. Average regional nicotine consumption continued to exceed average capital city consumption. In April 2023, Tasmania had the highest estimated average capital city consumption of nicotine, while the Northern Territory[10] had the highest average regional consumption of nicotine.

ALCOHOL

When comparing data for December 2022 and April 2023, the population-weighted average consumption of alcohol increased in both capital city and regional sites. Average capital city consumption remained relatively stable between April and June 2023. Average regional alcohol consumption exceeded average capital city consumption. In April 2023, the Northern Territory[11] had the highest estimated average capital city and regional consumption of alcohol.

NEXT REPORT

The 21st report of the National Wastewater Drug Monitoring Program is scheduled for public release in February 2024.

10 As the Northern Territory only has 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.

11 Ibid.