NATIONAL WASTEWATER DRUG MONITORING PROGRAM

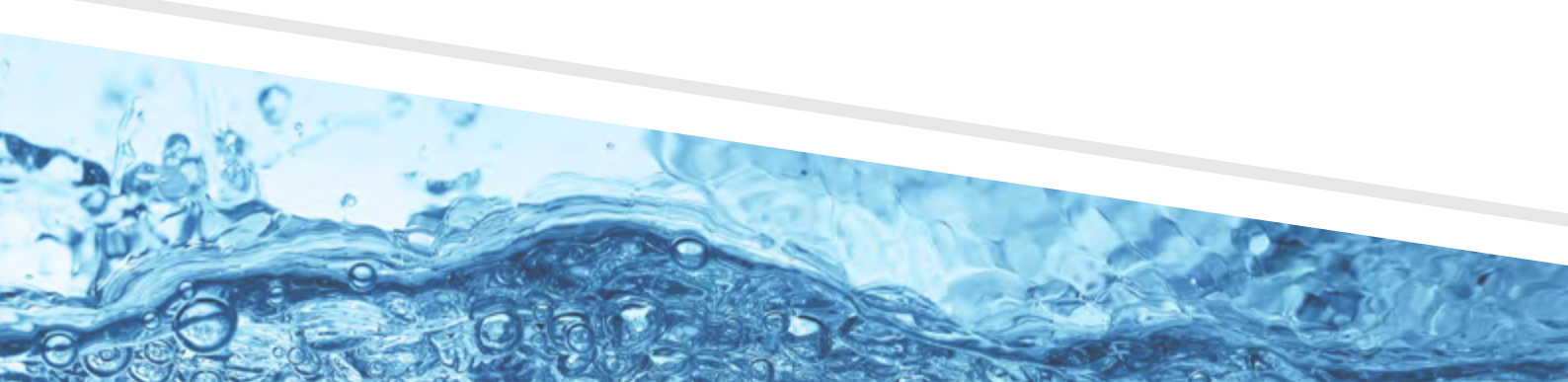
REPORT 14

AUSTRALIAN CRIMINAL INTELLIGENCE COMMISSION

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

University of South Australia

CONTENTS



CEO FOREWORD

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

The National Wastewater Drug Monitoring Program (the Program) is an Australian Government funded initiative that continues to evolve. Wastewater analysis 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, because logically the level of harm to the community is a function of the quantity of the substance that is consumed. Understanding drug consumption at a population level supports effective allocation of resources to priority areas. It also allows the progress of demand, supply and harm reduction strategies to be monitored.

The other dimension to wastewater analysis is its ability to generate insights into jurisdictional and local drug markets. The ACIC has developed partnerships to merge wastewater data with other drug data in locations of interest to develop a more granular appreciation of high risk markets. Per capita drug use in regional areas remains higher than capital city consumption for many drugs measured by the Program and the harms generated by these markets are significant. Longitudinal data continues to demonstrate the challenges facing different regional cities and towns and also unique characteristics of local drug markets. For this reason, wastewater analysis can form a meaningful part of bespoke solutions for regional locations.

TRENDS IDENTIFIED DURING THIS REPORTING PERIOD

In April 2021, 56 wastewater sites were monitored nationally. Based on 2016 Census data, these sites cover approximately 56 per cent of the Australian population. This reporting period again demonstrated varying trends in drug consumption, both nationally and within jurisdictions. Unfortunately, for example, there are ongoing signs of a recovery in the methylamphetamine market. Conversely, overall MDMA consumption continued a decreasing trend which commenced in August 2020. Of note, in April 2021 average capital city MDMA consumption exceeded regional consumption for the first time since August 2017. Oxycodone and fentanyl and consumption decreased to the lowest levels recorded by the Program during this reporting period. The overall trend in heroin consumption has been down since August 2020.

There is little doubt that at least some of these changes to drug consumption have been influenced to an extent by COVID restrictions, but there have also been more traditional and longer term influences on consumption. It is worth noting that any impacts of the resolution of Operation Ironside are unlikely to be reflected in wastewater data for this period. The ACIC is closely monitoring data for the subsequent period, which will be reported on in Report 15 in February 2022, for indications that the resolution may have had an impact on some drug markets and if this differs between jurisdictions.

INTERNATIONAL DRUG COMPARISONS

Section 5 of the report provides updated 2020 data from the Sewage Core Group Europe (SCORE), which now extends to Europe, North America, South Africa and Oceania. All of the contributing countries must sample and analyse wastewater in accordance with exacting and consistent criteria, so the results are directly comparable. The results confirm the strong preference in world terms by Australian illicit drug users for illicit stimulants (methylamphetamine, MDMA and cocaine) and the domination of our domestic stimulant market by methylamphetamine. Australia had the second highest methylamphetamine consumption compared to 23 other countries. Of the 26 countries reporting cocaine and MDMA consumption, Australia ranked 16th and seventh respectively. For the first time, cannabis has been included in the drugs monitored as part of the SCORE analysis. Of the 16 countries reporting cannabis consumption, Australia ranked seventh.

TESTING THE WATERS 5 INTERNATIONAL CONFERENCE

The ACIC and its partner universities hosted a highly successful international conference in Brisbane in late September 2021, reflecting the prominent role played globally by Australian wastewater epidemiology. The conference brought together a very impressive line-up of Australian and international experts, highlighting the variety of disciplines that are involved in wastewater analysis. There is also a similarly broad range of stakeholder participants in the related areas of public health, addiction and prevention, drug administration and law enforcement.

The comprehensive range of subject matters covered included long term monitoring and spatial trends; new and improved analytical methods and novel applications for wastewater monitoring. It also looked at how wastewater data can be merged with other drug related data and its application to inform interventions designed to reduce harm to the community, a key focus for the ACIC. The conference also reflected on the valuable contribution that wastewater analysis has made to the worldwide response to COVID-19.

There is no doubt that wastewater analysis is important to everyday Australians and benefits them directly. For example, the fact that the ACIC releases public reports on the results of the Program every 4 months means that interested members of the community can develop a common and informed understanding of trends in drug consumption.

Through the clever application of science, Australia is collectively achieving significant outcomes, both domestically and internationally. The conference provided an opportunity to promote international collaboration and ensured that wastewater analysis will continue to evolve.

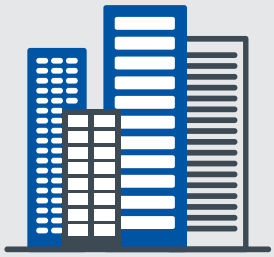
ACKNOWLEDGEMENT

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

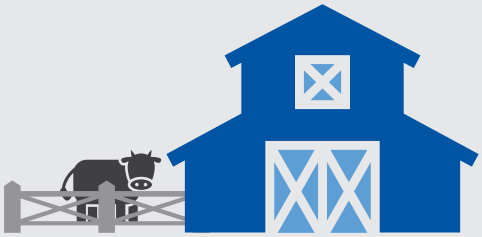
Michael Phelan APM
Chief Executive Officer
Australian Criminal Intelligence Commission

SNAPSHOT

The April 2021 collection covers around **56 per cent** of Australia's population—about **13 million Australians.**



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



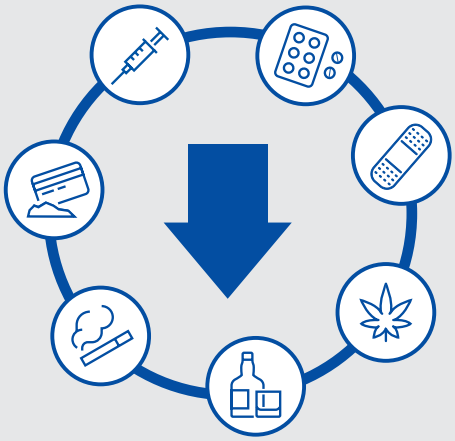
Regional **alcohol, nicotine, methylamphetamine, oxycodone, fentanyl** and **cannabis** average consumption exceeded capital city consumption.

April and June 2021 highlights:

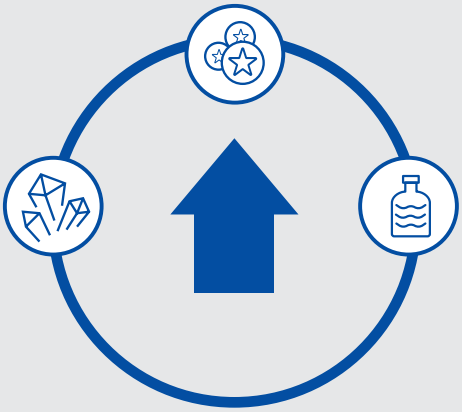
- signs of recovery in the **methylamphetamine** market
- **fentanyl** and **oxycodone** consumption decreased to the lowest levels recorded
- **heroin** consumption continued to decline

Capital city **MDMA** consumption exceeded regional consumption for the first time since August 2017.

Between December 2020 and April 2021, the population-weighted average capital city consumption of:

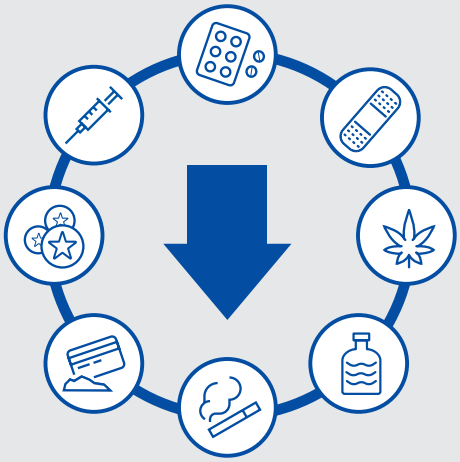


alcohol, nicotine, cocaine, heroin, oxycodone, fentanyl and cannabis **decreased**

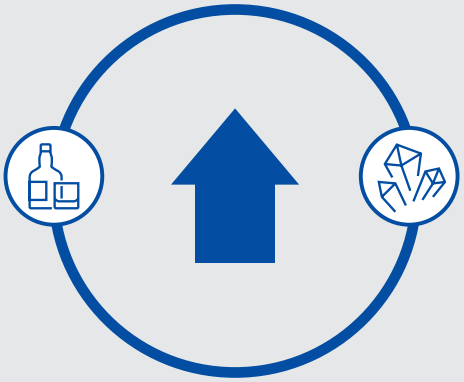


methylamphetamine, MDMA and ketamine **increased**

Between December 2020 and April 2021, the population-weighted average regional consumption of:



nicotine, cocaine, MDMA, heroin, oxycodone, fentanyl, cannabis and ketamine **decreased**



alcohol and methylamphetamine **increased**

INTERNATIONAL DRUG COMPARISONS

Methylamphetamine consumption in Australia ranked **second** of 24 SCORE countries

Cocaine consumption in Australia ranked **sixteenth** of 26 SCORE countries

MDMA consumption in Australia ranked **seventh** of 26 SCORE countries

Cannabis consumption in Australia ranked **seventh** of 16 SCORE countries

INTRODUCTION

This is the 14th in a series of National Wastewater Drug Monitoring Program (the Program) reports to be publicly released by the Australian Criminal Intelligence Commission (ACIC), under budgetary arrangements that will see reports delivered until early 2024. The Program provides a measure, rather than an estimate, of the consumption of a number of illicit drugs, as well as licit drugs including nicotine, alcohol and some pharmaceuticals. It gives us valuable insight into the trends and emerging issues in drug consumption across Australia and can identify new sources of threat.

The 14th report presents data on Australia's drug consumption for 12 substances and includes data for April (capital city and regional sites) and June (capital city sites) 2021. Longitudinal data captured by the Program increases our understanding of drug use nationally, in specific locations and over time. Findings presented in the report provides law enforcement, policy, regulatory and health agencies with additional, objective data on the use of methylamphetamine and other drugs. These data create opportunities to shape the response to the demand and supply sides of illicit drug markets, particularly in high-use areas, and inform harm reduction strategies. They permit priorities to be set and modified in a manner that is consistent with constantly evolving drug markets and broader world circumstances.

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

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

The ACIC continues to review the appropriateness 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 2021, 56 wastewater treatment plants participated nationally.[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 two universities.

The breakdown of sites by jurisdiction for April 2021 is as follows:

2 Sampling also occurred in June 2021 at capital city sites, with 20 participating wastewater sites nationally, covering approximately 48 per cent of the Australian population.

Participation from all states and territories is vital to informing our understanding of the national picture of drug use and demand. In the event that one or more states and territories decide(s) not to participate in the national program in the future, the ACIC, in consultation with the universities, will identify replacement sites from participating states and territories to ensure that the largest possible segment of the national population is sampled. Accordingly, the location of sites within and between states and territories may change over the life of the Program, although the intention is to ensure as much continuity as possible in relation to site participation.

REPORTING

Program reports are completed 3 times a year and made public. In accordance with current wastewater analysis conventions, the terms of the contract, and to protect the integrity of the Program, the exact locations of wastewater treatment plants sampled are not publicly released by the 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, cannabis and ketamine (for which reliable dose figures are not available), are expressed in terms of both the number of doses and the weight or volume consumed per capita of the respective substances, to facilitate comparison between substances.

EXPLOITATION OF PROGRAM DATA

The Program is based on a well-established and internationally recognised methodology. The ACIC considers that 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 14 of the Program measures the drug use of approximately 56 per cent of the Australian population.[3]

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

3 The April 2021 population estimate is based on the Australian Bureau of Statistics 2016 Census data and catchment data supplied by the operators of the wastewater facilities and service providers.

Wastewater data are used with other available data sources to develop a comprehensive and accurate understanding of drug markets nationally and in the states and territories. Wastewater analysis data collected by the Program has been used to estimate the street value of methylamphetamine, cocaine, MDMA and heroin consumed annually in Australia; to explore the relationship between drug consumption and different types of crime; and to assess the impact of law enforcement and health initiatives aimed at reducing drug supply and demand.

The ACIC engages with academic institutions, industry and public sector agencies to identify further data applications. Opportunities identified include informing responses in high risk areas; measuring drug use in specific local areas and estimating the size of discrete illicit markets. Advantages of the Program are that the data are collected on an ongoing basis, are reported regularly, and the Program is sufficiently flexible to allow for focusing collection activity in different geographic locations and at more regular intervals in response to identified need.

RESULTS FROM THE COLLECTION

The growing body of longitudinal data permits the ACIC and other stakeholders to closely monitor trends in drug consumption across Australia. Drug data available to the ACIC over almost two decades has underlined the strong demand for illicit stimulants in Australia. However, wastewater data since 2016 permits us to understand that demand for the respective illicit stimulants varies over time and across jurisdictions.

In the current report, one of the more interesting insights is the continued recovery of the methylamphetamine market in both capital cities and regional areas since August 2020. In April 2021, the long term trend of average regional methylamphetamine consumption exceeding capital city consumption was restored. Conversely, cocaine consumption in both capital city and regional areas has reduced since December 2020. Similarly, the overall trend in consumption of MDMA since December 2019 has been one of a considerable decline in both capital city and regional consumption. Of note, average capital city MDMA consumption exceeded regional consumption in April 2021 for the first time since August 2017.

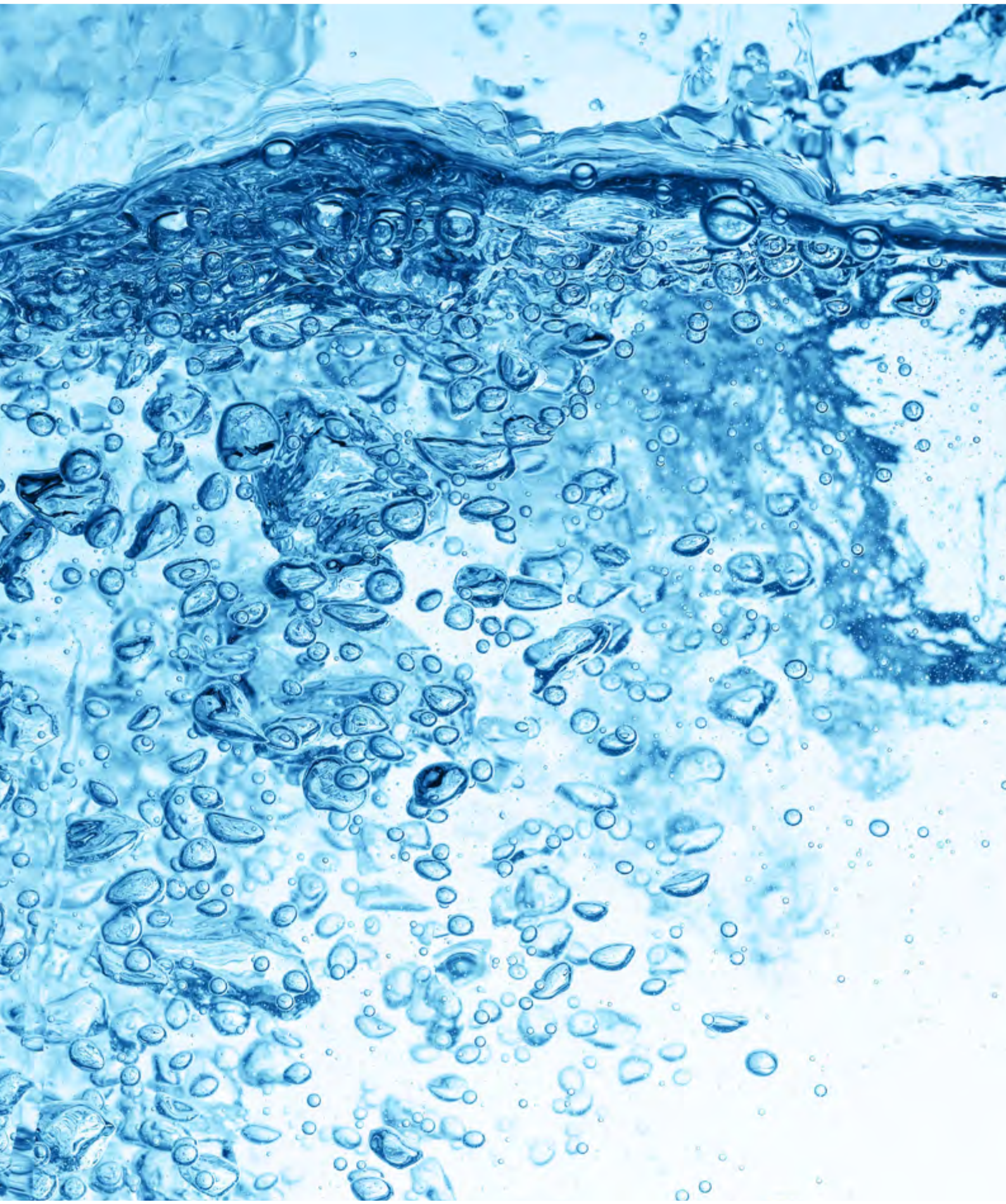
One of the advantages of wastewater analysis is that the process has been standardised by a European network of laboratories called SCORE. The SCORE network permits comparison between analytical results obtained in 32 countries in Europe, Oceania, North America and Africa. These results confirm the considerable consumption of illicit stimulants in Australia, even in world terms and that our illicit stimulant consumption is dominated by methylamphetamine.

Consumption of the pharmaceutical opioids, fentanyl and oxycodone, continued to decrease to record low levels. Similarly, average consumption of heroin has declined in regional areas since April 2020 and average capital city consumption declined considerably between August 2020 and April 2021.

The domestic cannabis market is characterised by significant levels of consumption which have fluctuated within a narrow range over the life of the Program. Over the first 3 years that cannabis was monitored, average regional consumption has peaked in August each year. Cannabis has now been included in the list of substances which are compared internationally by SCORE. These results showed that average consumption in Australia was mid-range when compared with 15 other countries.

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

Wastewater data are an important part of the suite of datasets available to increase our understanding of drug consumption, demand and supply in Australia. Making data from the Program publicly available assists to enrich understanding and informs the national conversation on drug trends and related demand. This 14th report of the Program builds on national drug consumption data contained in preceding reports to identify temporal trends in drug use across states, territories and the nation. This, and future reports, continue to build and shape understanding on trends and changes in patterns of use, creating an increasingly detailed picture of drug consumption in Australia.



RESEARCH FINDINGS

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACIC	Australian Criminal Intelligence Commission
ACT	Australian Capital Territory
DASSA	Drug and Alcohol Services South Australia
LC-MS/MS	Liquid chromatography tandem mass spectrometry
LOD	Limit of detection
LOQ	Limit of quantification
MDA	3,4-methylenedioxyamphetamine
MDMA	3,4-methylenedioxymethylamphetamine
NSW	New South Wales
NT	Northern Territory
NWDMP	National Wastewater Drug Monitoring Program
Qld	Queensland
SA	South Australia
SPE	Solid phase extraction
Tas	Tasmania
THC	Tetrahydrocannabinol
THC-COOH	11-nor-9-carboxy-tetrahydrocannabinol
Vic	Victoria
WA	Western Australia
WWTP	Wastewater treatment plant

TERMINOLOGY

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

MDMA is commonly known as ecstasy.

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

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

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

1: EXECUTIVE SUMMARY

The Australian Criminal Intelligence Commission (ACIC)'s National Wastewater Drug Monitoring Program (NWDMP) reports on selected substances of concern in most populated regions of Australia. The program commenced in August 2016. The current version of the NWDMP focuses on twelve licit and illicit drugs, including nicotine, alcohol, methylamphetamine, cocaine and MDMA (ecstasy), with heroin included from Report 3, cannabis from Report 6 and ketamine from Report 13. Estimates of drug usage in a population are being 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. Site names are not included in this report to maintain treatment plant confidentiality. Site codes stay assigned to each WWTP throughout the course of the Program.

For this fourteenth report, wastewater samples were collected for up to seven consecutive days during weeks in April and June 2021. The April 2021 collection involved regional and capital city catchments, while June 2021 covered capital cities only. A total of 20 WWTPs in capital cities and a further 36 regional sites participated in the Program for the April 2021 period, covering a population of 13 million Australians. Data from this report equates to coverage of approximately 56 per cent of Australia's population for April 2021 and 48 per cent for June 2021 (capital city sites only). A total of 6,968 individual daily samples have been collected and analysed since the beginning of the Program, with new results from 515 additional samples added in this report. 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 use over a week in April 2021 was compared with historical data included in previous reports. The April 2021 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 2021.

The spatial trends in the current reporting period and longer-term temporal trends may have been impacted by the COVID-19 pandemic. Victoria announced limited restrictions in early June 2021 to contain a small number of infections in the capital city. Results from the sampling in other parts of the country were generally unaffected by lockdowns and border restrictions at that time. The results outlined in this report need to be understood in this context.

After normalising the amount of drug measured in wastewater for population size and average dose consumed, alcohol and nicotine remained consistently the highest consumed drugs in all states and territories in April 2021. Cannabis was not included in the comparison but will be once better estimates of a typical dose are available. The consumption of nicotine was substantially higher in regional areas compared to capital cities and very variable between sites. The rise in nicotine use in some jurisdictions since the start of the Program in 2016 accelerated after the start of the COVID pandemic, but in the current reporting period, use declined in most states and territories. Overall, nicotine use remains highest in the Northern Territory and Tasmania. Alcohol consumption in regional areas was similar to the capital cities. Compared to nicotine, alcohol use was more consistent across regional parts of the country. The Northern Territory and Tasmania had the highest capital city use of alcohol in April 2021. Alcohol consumption has been relatively steady since the start of the Program, averaging out short-term fluctuations. South Australia has been the most obvious exception, with declining longer-term alcohol intake. For the current reporting period, alcohol consumption has continued at levels within the ranges observed prior to the outbreak of the pandemic.

Methylamphetamine use in April 2021 was very variable across the country and it was noticeable that the capital city and regional averages were not as different as in previous reports, with regional consumption again exceeding capital city consumption. One regional catchment in each of South Australia and Victoria had the highest overall levels in the country in April 2021. Nationally the average daily levels of methylamphetamine use remained at approximately 40 doses per thousand people for both December 2020 and April 2021.

Cocaine consumption in Australia in April 2021 remained highest in the New South Wales capital city and to a lesser extent regional parts of the state. Several catchments in Queensland and Victoria also had above average consumption. Consistent with previous findings, the regional levels were on average below the capital cities. The temporal information indicates that the increasing long-term trend over the life of the Program was largely reversed from mid-2020 once the initial effects of COVID-19 had become apparent. Cocaine use has been declining over the past year in almost every state and territory.

MDMA use remained relatively low compared to the previous two stimulants. Regional use was lower than in the capital cities, with the highest capital city consumption found at one site in each of New South Wales and Tasmania, and the highest regional consumption found at a single site in each of New South Wales, Queensland and Tasmania. The recent trend in MDMA use is a decline, with historically low levels being observed in many parts of the country. The stimulant, and metabolite of MDMA (ecstasy), MDA was present at relatively low levels too, with no consistent spatial pattern being evident. A capital city site in New South Wales recorded the highest levels, while regional averages overall were below the capital cities. MDA use has declined almost everywhere.

Oxycodone and fentanyl are prescription pharmaceutical opioids with abuse potential. Oxycodone consumption was substantially higher in regional parts of the country in April 2021 compared to the capital cities, consistent with previous findings. Tasmania had the highest consumption of the capital cities, while Victoria had the highest regional consumption. When considered in the context of temporal data, oxycodone consumption remains at historically low levels in nearly all parts of the country. The average consumption of fentanyl showed the same pattern as previous reports, with regional use exceeding that in the capital cities. The use of the opioid has been declining in many parts of the country and fentanyl was again found at historically low levels in the current reporting period.

Heroin consumption in April 2021 was high in a regional site in New South Wales, two capital city sites in Queensland and most of Victoria. After the historical high levels recorded in Victoria and many parts of the country in August 2020, heroin use has declined up to and including April 2021. Average use of the drug was lower in regional areas compared to the capital cities.

The cannabis metabolite, 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH) is a specific marker for cannabis consumption. Regional cannabis use was high in most jurisdictions compared to the respective capital cities, especially in New South Wales where there was a marked difference between regional and capital city consumption. Historically, high average cannabis consumption was found in the Northern Territory, South Australia and Tasmania. In April 2021, cannabis use declined in Tasmania compared to the peaks in 2020. Use of the substance increased in many jurisdictions after the initial COVID restrictions were put in place in March 2020. However, the increase was temporary for the most part, with current levels of consumption returning to the range recorded over the life of the Program.

Ketamine is a pharmaceutical compound of growing concern due to its abuse potential. With the drug being included for the first time in Report 13, results are only available for four collection periods of capital city wastewater (December 2020, February 2021, April 2021 and June 2021) and two regional collections (December 2020 and April 2021). Early indications are that ketamine use is low across the country, with the capital city average higher than regional Australia. There was a much wider spread of use over the collection week than might be expected for a substance with medical applications. It is too early to understand normal patterns for this substance.

With the release of the latest Sewage Analysis Core group Europe (SCORE) results containing international wastewater data from 2020, some comparative findings were included in this report. While the Australian data in the Program includes many more sites than any other country in the SCORE dataset, the comparison shows that Australia ranks third after Croatia (1 site) and the United States of America (USA; 1 site) in terms of overall illicit stimulant use and second after the USA in terms of methylamphetamine use. Cocaine and MDMA consumption in Australia ranks lower amongst SCORE countries than methylamphetamine. For the first time, Australian data has been compared with cannabis consumption data from 15 countries across Europe and the USA. Australia ranked seventh, with the USA ranking first.

2: INTRODUCTION

2.1 PREAMBLE

Wastewater analysis is a technique for monitoring the population-scale consumption of substances. The University of Queensland and University of South Australia were commissioned to provide drug consumption data to the ACIC for an initial three-year program from 2016 to 2019, including nine public reports. The two universities have been re-commissioned to provide data for a further four years, including 12 more public reports. Sampling has occurred at wastewater treatment plants, bimonthly in the case of capital city sites and every four months for regional sites. The aim has been to acquire data on the population-scale use of substances that cause potential harm, either through addiction, health risks, or criminal and anti-social behaviour. The intention is to build on the baseline data of substance use across Australia to establish trends. This latest NWDMP report compares consumption data from previous reports with results obtained subsequently from all sites in April 2021 and capital cities in June 2021. The report presents patterns of substance use across Australia, showing differences in levels between capital cities and regional centres, within and between states and territories, and nationally.

Compounds of concern include nicotine from nicotine intake (cigarettes, gum, patches, e-cigarettes, etc.), ethanol from alcohol consumption, pharmaceutical opioids with abuse potential, illicit substances such as methylamphetamine, MDMA, cocaine and heroin, as well as ketamine. Amphetamine and MDA were not included in the initial reports. The former is a by-product of methylamphetamine pyrolysis as well as one of its metabolites. Amphetamine is also a prescribed drug, but can be used as an illicit substance. However, we found the levels of amphetamine corresponded largely with the expected values from the excretion of methylamphetamine. Similarly, MDA is a metabolite of MDMA but can also be used as an illicit drug. However, since the proportion of MDA derived from MDMA is known, the difference between measured MDA and MDMA metabolite has been included in the NWDMP since Report 3. The amount of MDA was calculated by subtracting 1.65 mg of MDA for every 100 mg of MDMA consumed (Pizarro et al. 2002; Khan & Nicell 2011) and is expressed in units of mg excreted per day per 1,000 people. Cannabis was measured by its urinary metabolite, THC-COOH. Cannabis results are expressed only as mg consumed per day per 1,000 people and will also be expressed as dose per day per 1,000 people when better estimates of a typical dose become available. Ketamine is being measured via its metabolite, norketamine. Ketamine results are reported here as amount (mg) of drug excreted per day per 1,000 people due to the absence of clear information available in literature around suitable factors to estimate consumption of the substance in wastewater.

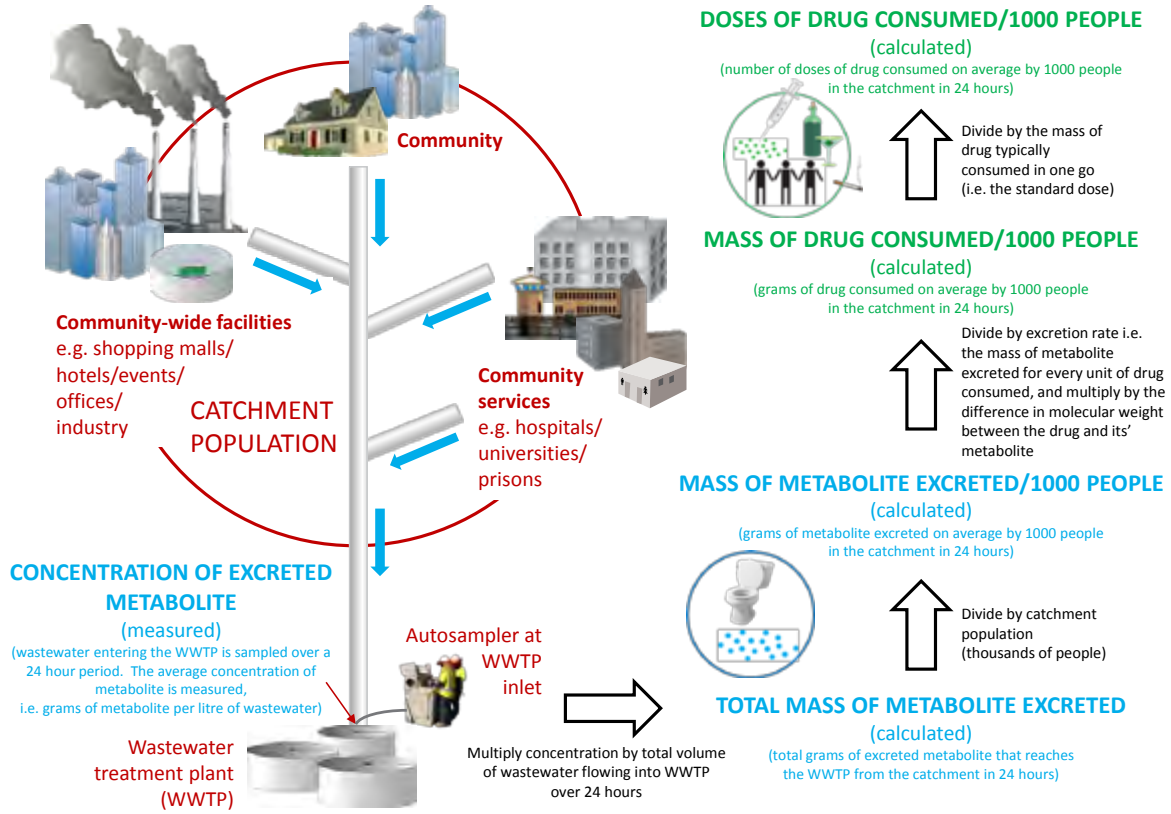
3: METHODS

The method underlying wastewater-based monitoring of drug use in a given population is based on the principle that any given compound that is consumed (irrespective of whether it is swallowed, inhaled/smoked or injected) will subsequently be excreted. This may be either in the chemical form it was consumed and/or in a chemically modified form that is referred to as a metabolite. Once the excreted compound or metabolite is flushed, it will enter the sewer system, assuming the toilet forms part of a wastewater catchment.

The drugs and their metabolites of interest were included in the first NWDMP report (available at www.acic.gov.au), as well as an in-depth description of the methodologies involved.[4] Collectively, waste products in the sewer system arrive at a WWTP where wastewater samples are collected over a defined sampling period. Measuring the amount of a target compound in the wastewater stream allows for a back-calculation factor to be applied to determine the amount of drug that was used over the collection period (Figure 1). The method is non-invasive and is done on a population-scale level, so individuals are not targeted, and privacy is respected.

4 Information in relation to heroin appears in Report 3.

Figure 1: Schematic of the population catchment area and methodology employed to convert measured concentration of substances in wastewater to mass loads or doses consumed per day per normalised population.



To obtain an estimate of drug use, representative samples are collected over a given period (typically 24 hours) using autosamplers that collect time or flow proportional samples. Wastewater treatment plant operators aid with collecting the samples from the influent autosampler (where the wastewater enters the treatment plants). Details of the calculation methods are given in Report 1. From the August 2018 collection period, operators collected a second daily influent sample with sodium metabisulphite (0.5% m/v) as preservative to allow for the detection of the cannabis metabolite.

Collected wastewater samples were analysed at the University of South Australia and The University of Queensland laboratories. The steps routinely performed in our laboratories are based on filtration of the samples followed by an enrichment/concentration step where the concentrated sample is injected, or (for chemicals with sufficiently high concentrations) direct injection of samples into the analytical instruments. The instrumental analysis consists of chromatographic separation and subsequent compound specific detection. A summary of the extraction and analytical methods is given in Report 1. An updated excretion table including THC-COOH and dose can be found in Appendix 1. Methods to extract and analyse the cannabis metabolite are outlined in Tscharke et al. (2016). 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-six WWTPs across Australia participated in the NWDMP for the April 2021 collection period (Figure 2). Of these, 20 sites were located in capital cities and a further 36 were regional sites, 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 2: Participating WWTPs in April 2021 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.

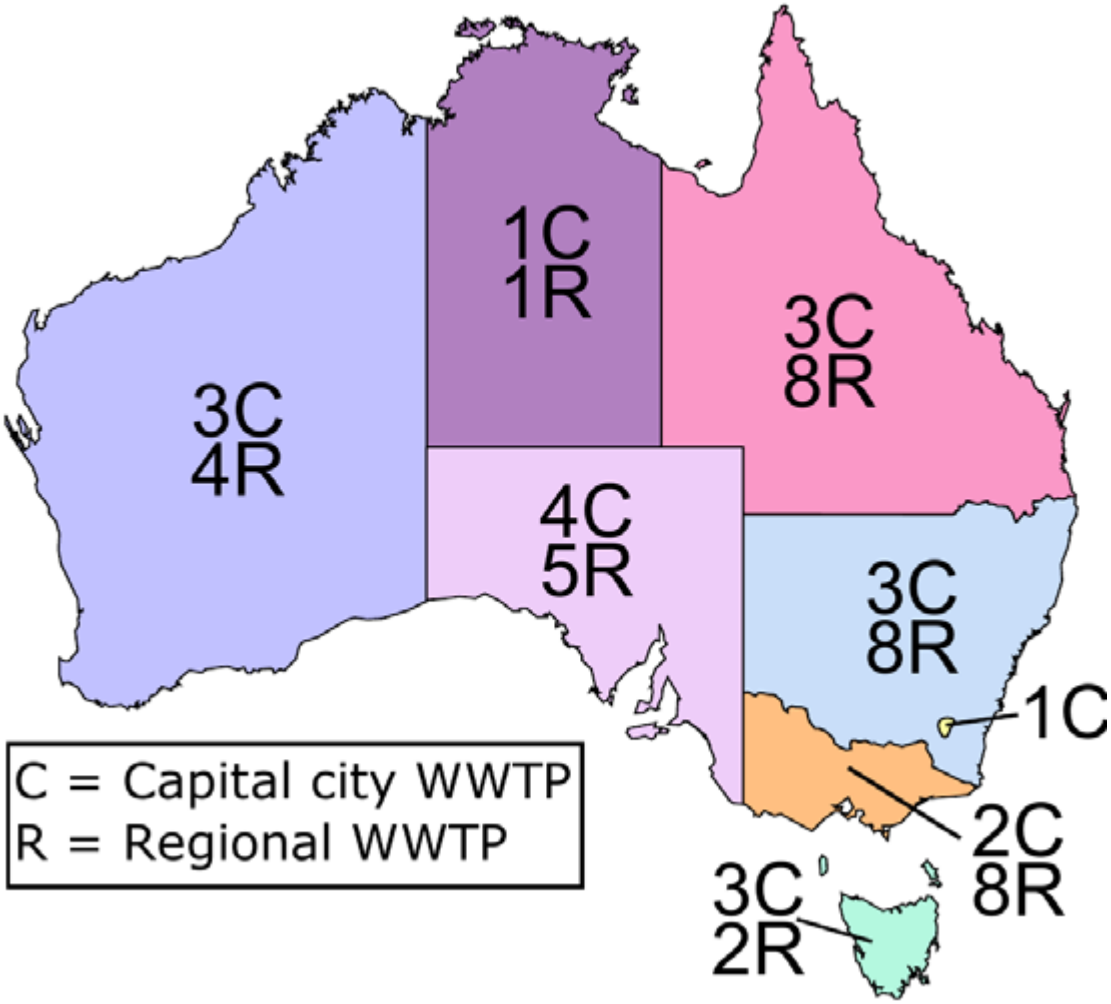


Table 1: Number of participating WWTPs for the periods covered in this report. One collection period aims to collect data from both regional (R) and capital city (C) sites, while the other collection period aims to collect data from capital city sites only.

State or territory	April 2021 Capital	April 2021 Regional	June 2021 Capital
ACT	1	0	1
NSW	3	8	3
NT	1	1	1
Qld	3	8	3
SA	4	5	4
Tas	3	2	3
Vic	2	8	2
WA	3	4	3
Sites	**20**	**36**	**20**
Population (millions) C & R	**11.2**	**1.8**	**11.2**
% of Australian Population	**47.9**	**7.9**	**47.9**
Total population (millions)	**13.0**		**11.2**
% of Australian population	**55.8**		**47.9**

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

3.2 SAMPLE COLLECTION AND PREPARATION

Daily composite samples were collected by treatment plant staff on seven consecutive days, or where seven days was not feasible, across as many consecutive days as possible. Regional sites in South Australia have only been providing weekend samples since April 2018, which should be considered when interpreting historical results where the number of sampling days was five—see Appendix 3, Report 6. In addition, 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. 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 3. This includes information on interpreting the consumption data presented on the vertical axes in all graphs in this report. In some graphs, the values plotted in the graph can be read as either mass of drug consumed (left axis) or doses of drug consumed (right axis). For the specific cases of MDA and ketamine, the amount of the drugs excreted following consumption is not known, and therefore can only be expressed as how much of the drug was excreted into the sewer network, e.g. the mg excreted per 1,000 people per day. For cannabis, the approximate dosage is not well defined, and results are expressed as mg consumed per 1,000 people per day.

Bubble charts are included to represent the relative extent of consumption in capital city and regional areas for each jurisdiction. See Figure 4 for a description for how to interpret the bubble charts.

Instrumental method limits of detection and limits of quantification: Since the wastewater samples contain very low quantities of particular drugs, the limit of detection (LOD) was determined analytically as the lowest concentration of that drug that could be determined in the sample (using the methods described in Report 1). A drug may be present at a concentration below the LOD. However, trace quantities may be present at undetectable levels. The limit of quantification (LOQ)[5] is a concentration (higher than the LOD), above which we have high confidence that the concentration measured on the analytical instrument is accurate. Above the LOD but below the LOQ there may be some uncertainty as to the actual concentration. To be conservative (a drug may be present but there is uncertainty as to its concentration) and in line with current practice, for back calculations to estimate per capita consumption, a concentration below the LOD was included as a value of LOD/√2. A concentration above the LOD but below LOQ, is included at the midpoint between the LOD and LOQ (i.e. (LOD + LOQ)/2). The frequency of detection of each analyte of interest is included in Appendix 3.

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

Weekly pattern of drug use: The pattern of drug use over the sampling week for the sites in this report cannot be elucidated from the data included in the current report. This is because the starting day of the collection week did not always correspond for every plant. We present only maximum, minimum and average (for the individual sites) (e.g. Figure 3) and only population-weighted average values for all other graphs. Consistent patterns of drug use in Australia from previous wastewater-based epidemiology studies indicate that some 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).

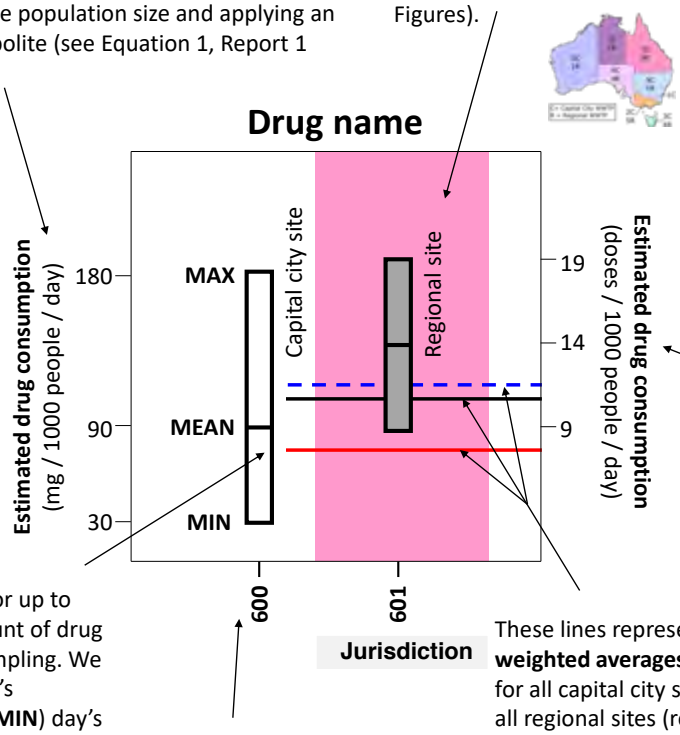
Figure 3: Explanation of the graphical representation of data for individual sites and bubble maps. General concepts relevant to all graphs in the report are also outlined (unique site codes, explanation of vertical axes, colour coding).

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

To convert the mass consumed (left axis) to the estimated doses consumed (right axis), we divide the estimated mass consumed by the standard dose amount. Dose amount and excretion factors are given in Appendix 1. 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).



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).

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

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 grey 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 4: 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).

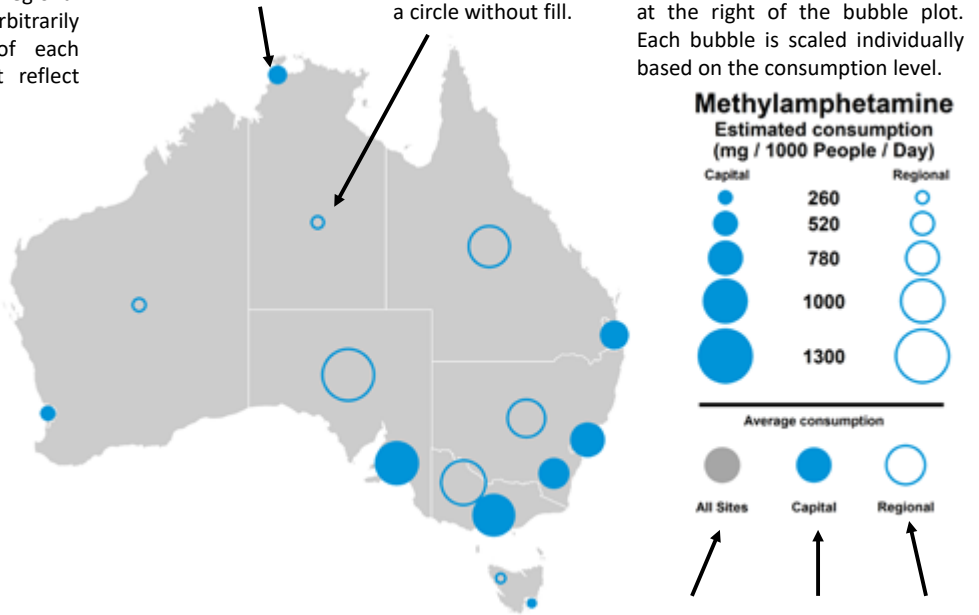
Bubbles:
Capital city site averages are drawn over the capital city of a jurisdiction and the regional site averages are drawn in the middle of the State or Territory. Regional bubbles are drawn arbitrarily close to the centre of each jurisdiction and do not reflect location of sites.

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 use at the individual site level for April 2021 (Section 4.1), temporal trends for states and territories for the past two years (Section 4.2) and within each state and territory (Section 4.3). April 2021 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 and the collection week, and the days of the month, did not correspond in all instances. A list of the detection frequencies for each drug can be found in Appendix 3. This report retained the current population estimates introduced in Report 4 by integrating the specific wastewater catchment areas against the high-resolution population data released from the 2016 Census. The uncertainties in individual population estimates have less impact when data are averaged, for example when broader comparisons at the state/territory or international level are undertaken. The uncertainties in population numbers may be particularly evident in smaller regional communities or sites where short-term population changes occur due to employment opportunities, tourism or festival events.

4.1 INDIVIDUAL SITE COMPARISON OF DRUG USE IN APRIL 2021

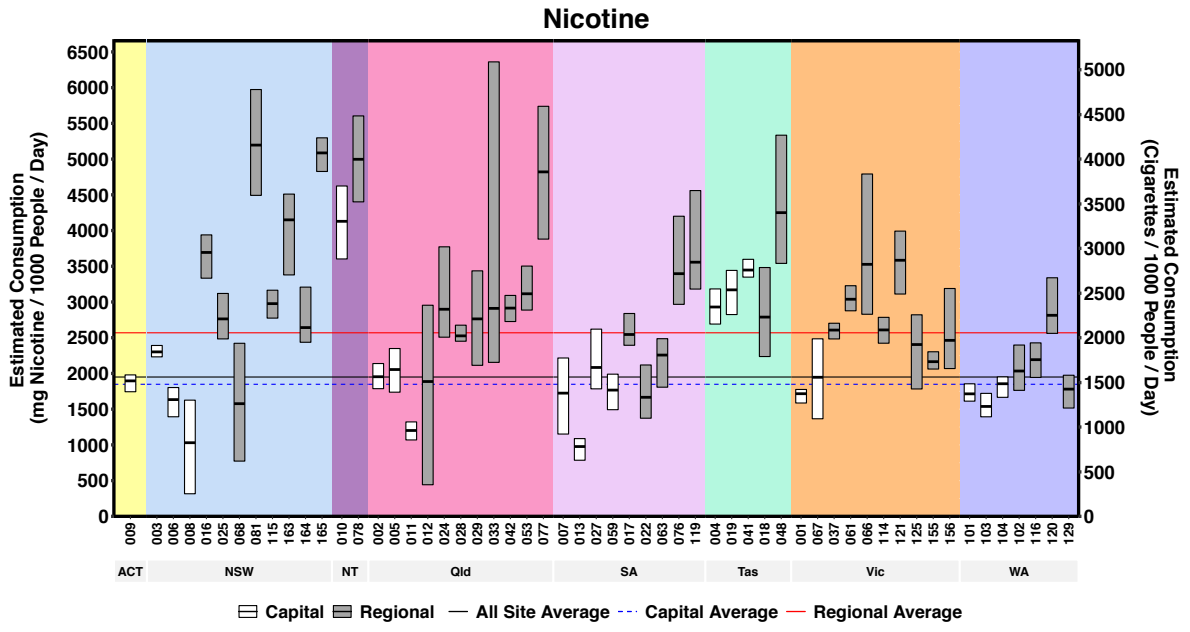
4.1.1 NICOTINE AND ALCOHOL

Nicotine is the main psychoactive substance present in tobacco products. Two nicotine metabolites, cotinine and hydroxycotinine, were used to represent the consumption of tobacco. 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. The April 2021 results show that nicotine consumption varied widely between sites across the country (Figure 5). Average use in regional Australia was substantially higher than in the capital cities (red horizontal and dotted blue lines, respectively). The Northern Territory capital city had the highest consumption of capital cities, followed by Tasmania. Nicotine use in regional catchments showed large fluctuations between different sites and over the sampling week, but no obvious patterns were evident across the country.

Alcohol consumption was measured using a specific metabolite of ethanol. In April 2021 there was very little difference between the average consumption of alcohol in regional and capital city sites (Figure 6). No clear spatial patterns were evident for the most part. The mean capital city values were highest in the Northern Territory and sites in Tasmania. Sites in South Australia generally had below average alcohol consumption.

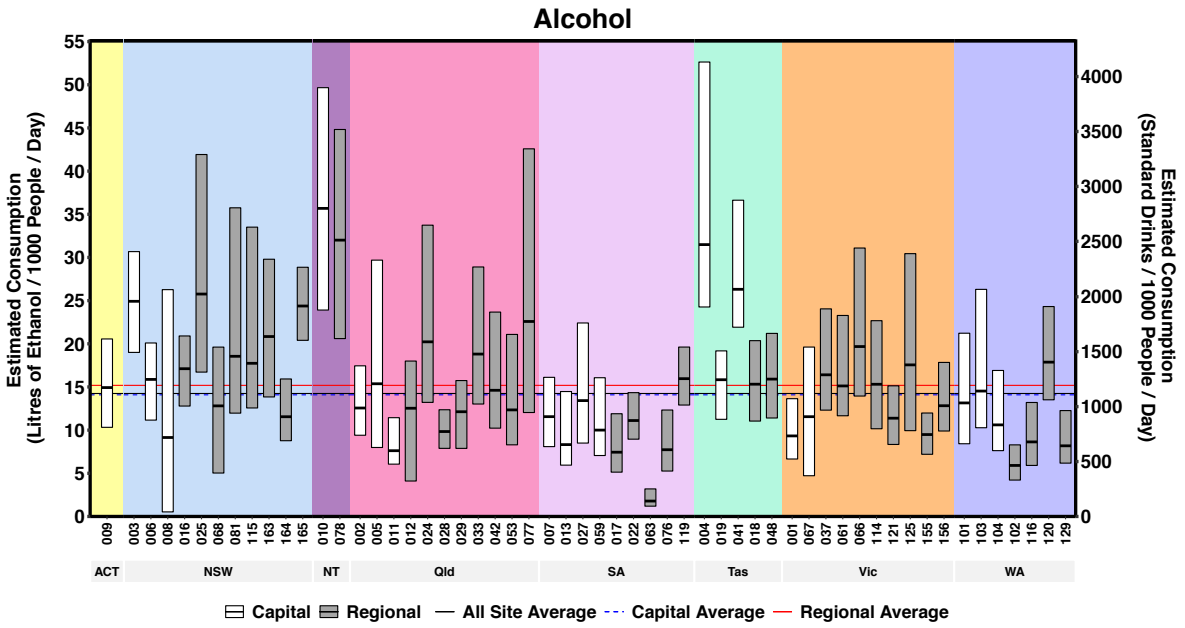
The relative consumption levels can be represented in a pictorial way by showing the relative scale of use of nicotine (Figure 7) and alcohol (Figure 8) as capital city or regional 'bubbles' for each state and territory. The above average consumption of nicotine and alcohol in the Northern Territory is evident from the size of the bubbles in that region. These findings need to be understood in the context of there being only one capital city catchment and a single regional site included for this territory.

Figure 5: Estimated nicotine consumption for April 2021 in mass of nicotine consumed per day (left axis) and number of cigarettes per day (right axis) per thousand people. The number of collection days varied from 5-7.



- High regional average
- Variable across Australia

Figure 6: Estimated alcohol consumption for April 2021 in volume consumed per day (left axis) and standard drinks per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Small differences between national averages
- Wide weekly spread a common feature

Figure 7: Estimated average nicotine consumption per jurisdiction for April 2021 in number of cigarettes per day per thousand people. The number of collection days varied from 5-7.

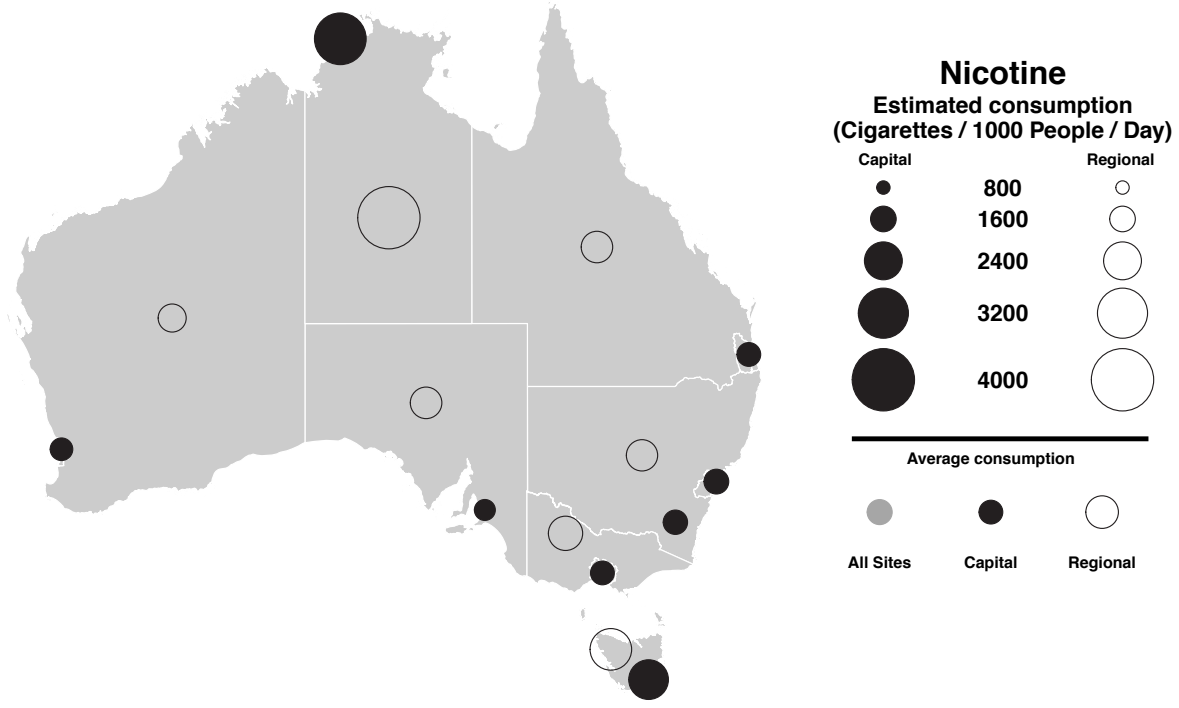
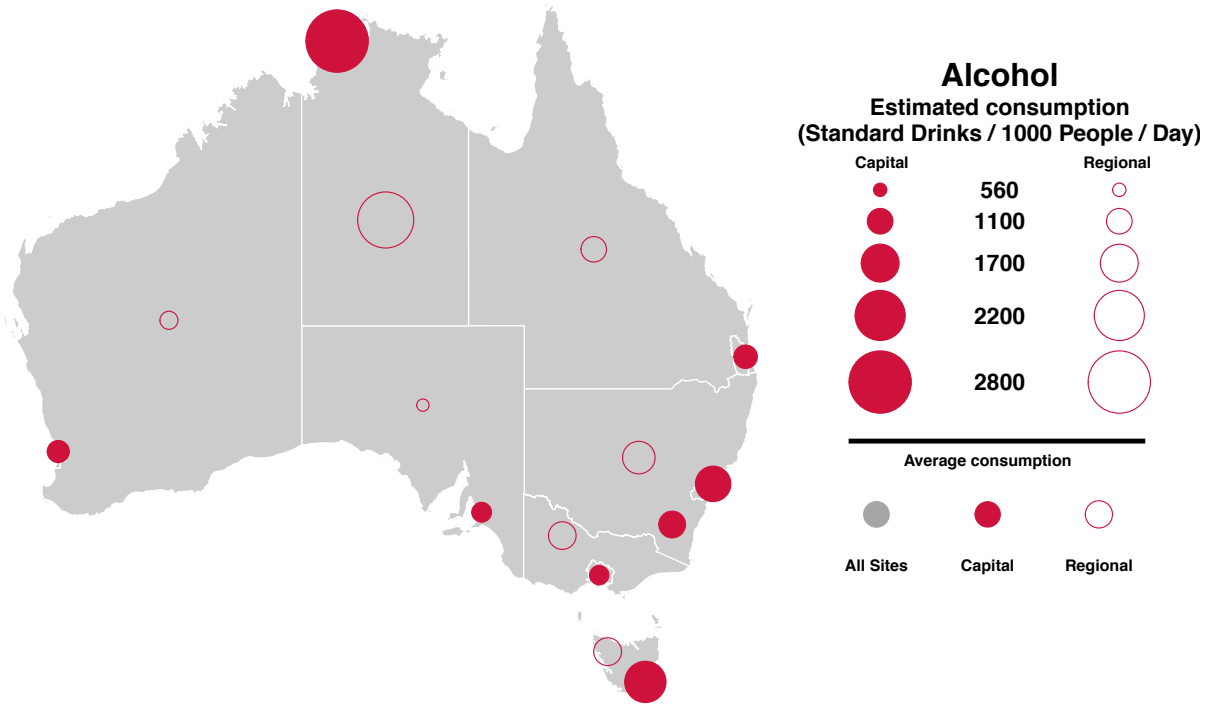


Figure 8: Estimated average alcohol consumption per jurisdiction for April 2021 in number of standard drinks per day per thousand people. The number of collection days varied from 5-7.



4.1.2 STIMULANTS

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

4.1.2.1 METHYLAMPHETAMINE

Methylamphetamine levels varied considerably across sites, both in terms of capital cities and regional catchments (Figure 9). The average amounts of the drug in regional Australia were slightly higher than in the capital cities. The spread across the sampling week was generally less than the other stimulants, consistent with the habitual use associated with methylamphetamine. This was even more apparent in capital city catchments, except Site 8 in New South Wales. South Australia had some of the highest mean capital city levels of the drug, while regional centres in this state, as well as Queensland and Victoria, had the highest daily use. The Australian Capital Territory, parts of Northern Territory, Queensland and Tasmania showed use well below the national averages for April 2021.

4.1.2.2 AMPHETAMINE

The measured concentration of amphetamine in the April 2021 samples mostly fell within a range which is consistent with the reported excretion rates following methylamphetamine consumption (Gracia-Lor et al. 2016). The results were largely in agreement with our previous findings (see Appendix 4 of Report 1). Therefore, we assumed that the levels of amphetamine in wastewater samples were predominantly due to the metabolism of methylamphetamine. It is possible that some of the measured amphetamine could be the result of ingestion of the drug, but the high levels of methylamphetamine means a firm conclusion is not possible.

4.1.2.3 COCAINE

Benzoylecgonine, the specific metabolite of cocaine, was used to estimate the consumption of the stimulant. Capital city areas on average had substantially higher cocaine use than regional centres (Figure 10). Compared to methylamphetamine, daily doses per thousand people were substantially less (approximately 5 vs 40) and the spread over the collection week was wider. New South Wales had the highest capital city figures for consumption in the nation, while regional centres in the state varied from amongst the highest to the lowest levels. Cocaine consumption was generally low in most other parts of Australia, particularly the Northern Territory, Western Australia and regional parts of South Australia. Tasmanian regional sites were unable to provide weekend samples. As a larger proportion of cocaine may be consumed on weekends, the results may be under-representing consumption in that state.

4.1.2.4 MDMA (3,4-METHYLENEDIOXYMETHYLAMPHETAMINE)

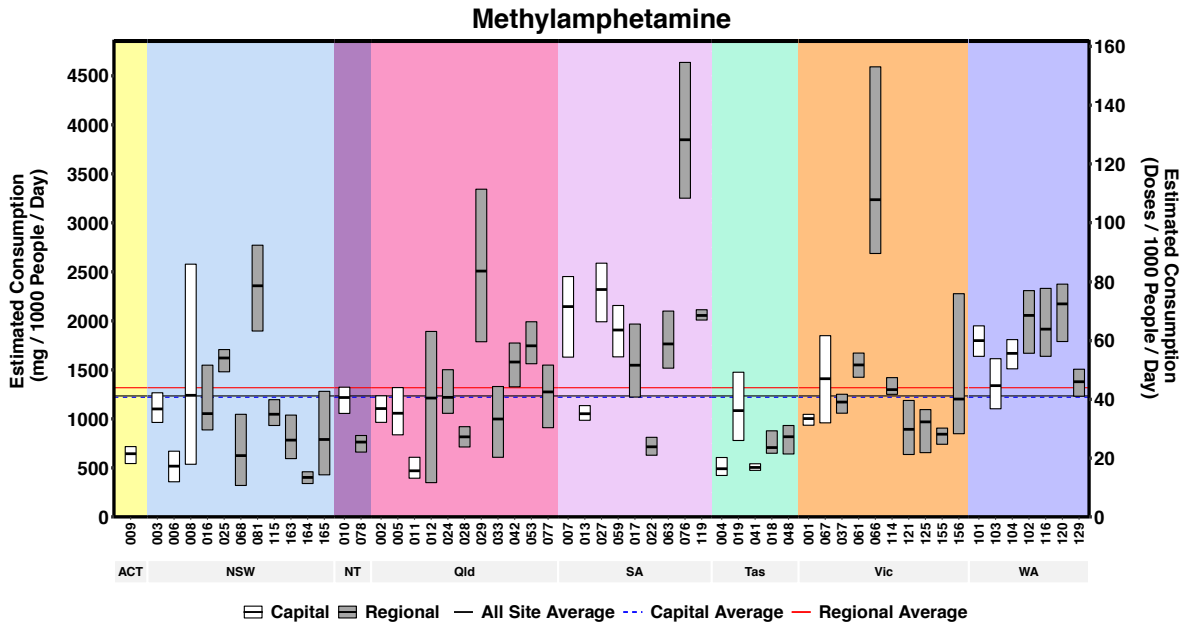
The average consumption of MDMA was lower than the previous two stimulants (Figure 11). Apart from a site in each of the capital cities of New South Wales and Tasmania, use of the drug was low across the country. The regional Australian average was lower than that of the capital cities. A direct comparison of regional and capital city sites in Tasmania is inappropriate as the regional centres did not sample on weekends when MDMA consumption is typically higher. See Appendix 2 for a list of the number of samples collected per site. The Northern Territory, South Australia and most of Western Australia had levels well below the national average.

4.1.2.5 MDA (3,4-METHYLENEDIOXYAMPHETAMINE)

MDA is both a drug in its own right and a metabolite of MDMA. Since the proportion of MDA eliminated after MDMA consumption is known, this proportion of MDA attributable to MDMA metabolism was subtracted from the total measured amount of MDA for each site. Results for MDA were expressed as mg excreted per 1,000 people per day (daily mass load) and not as consumption, due to the lack of metabolic information of MDA elimination following MDA consumption. Levels of the drug were mostly low across Australia (Figure 12). The capital city average was higher than the regional national average. Site 8 in New South Wales was the only catchment with relatively high use of MDA, but considering the excreted amount compared to other stimulants, levels at that site were still at the lower end of drug use.

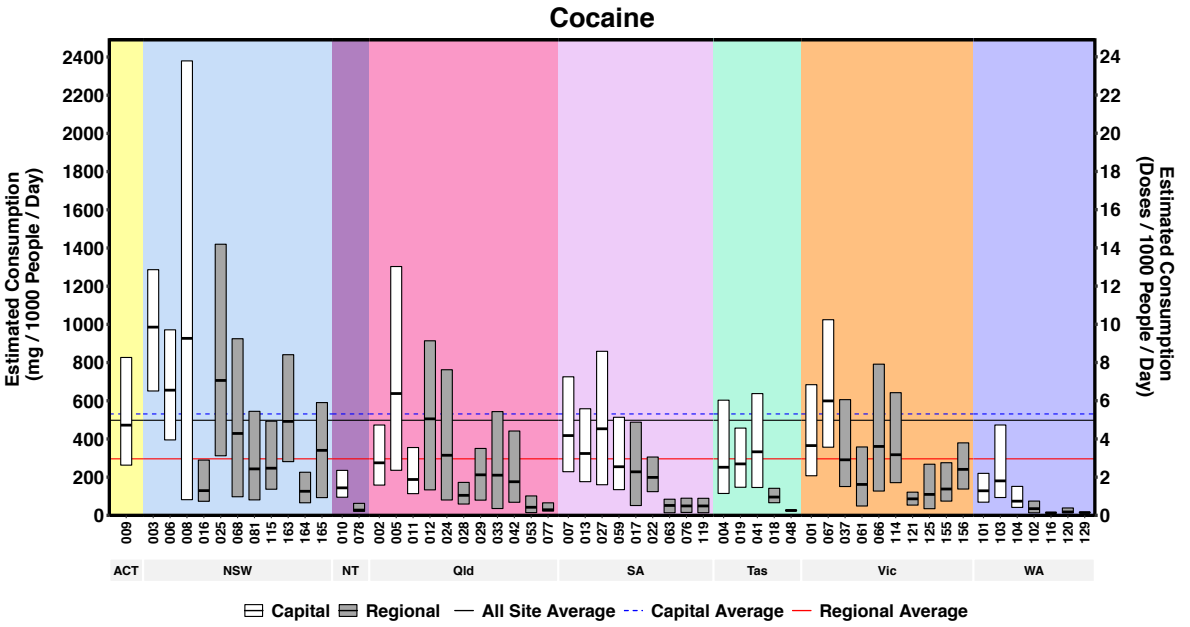
The scale of use of each stimulant is expressed as a bubble graph to compare regional and capital city use of methylamphetamine (Figure 13), cocaine (Figure 14), MDMA (Figure 15) and MDA (Figure 16) across the country. Methylamphetamine remains the dominant illicit stimulant nationally and in all jurisdictions, with cocaine consumption being highest on the eastern seaboard.

Figure 9: Estimated methylamphetamine consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



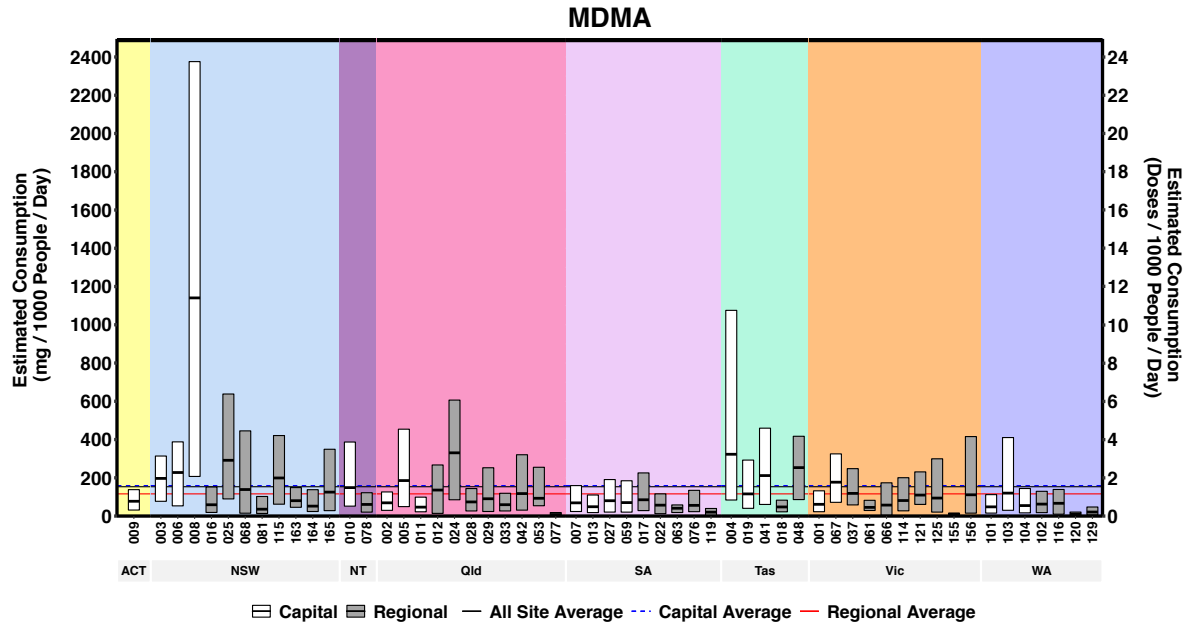
- Higher regional consumption
- High variability across the nation

Figure 10: Estimated cocaine consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



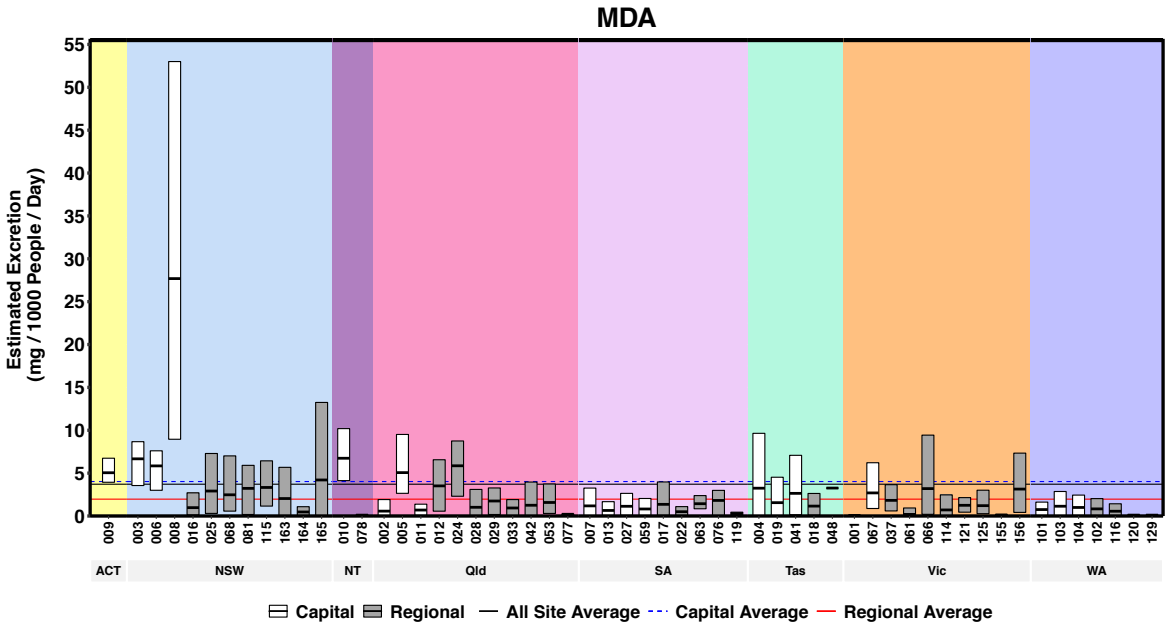
- Higher capital city consumption
- High overall consumption in New South Wales

Figure 11: Estimated MDMA consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Mostly low levels of use nationally
- Lower regional use

Figure 12: Estimated MDA excretion for April 2021 in mass excreted per day per thousand people. The number of collection days varied from 5-7.



- Relatively low levels overall
- Lower regional averages

Figure 13: Estimated average methylamphetamine consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

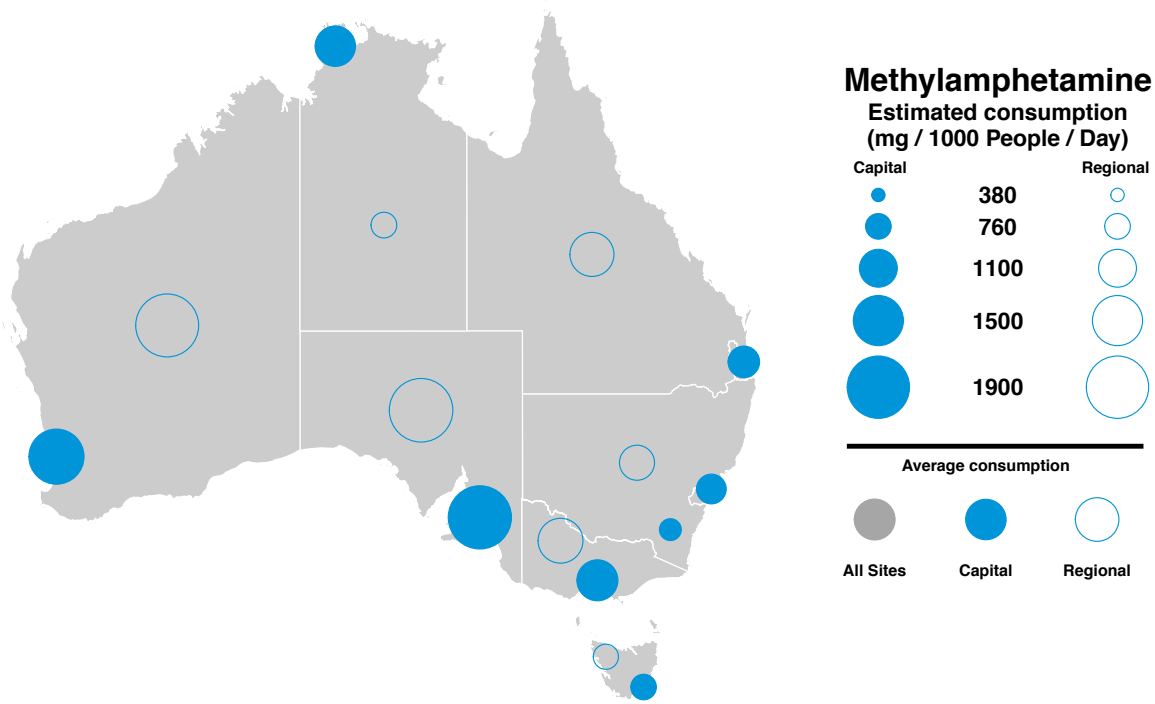


Figure 14: Estimated average cocaine consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

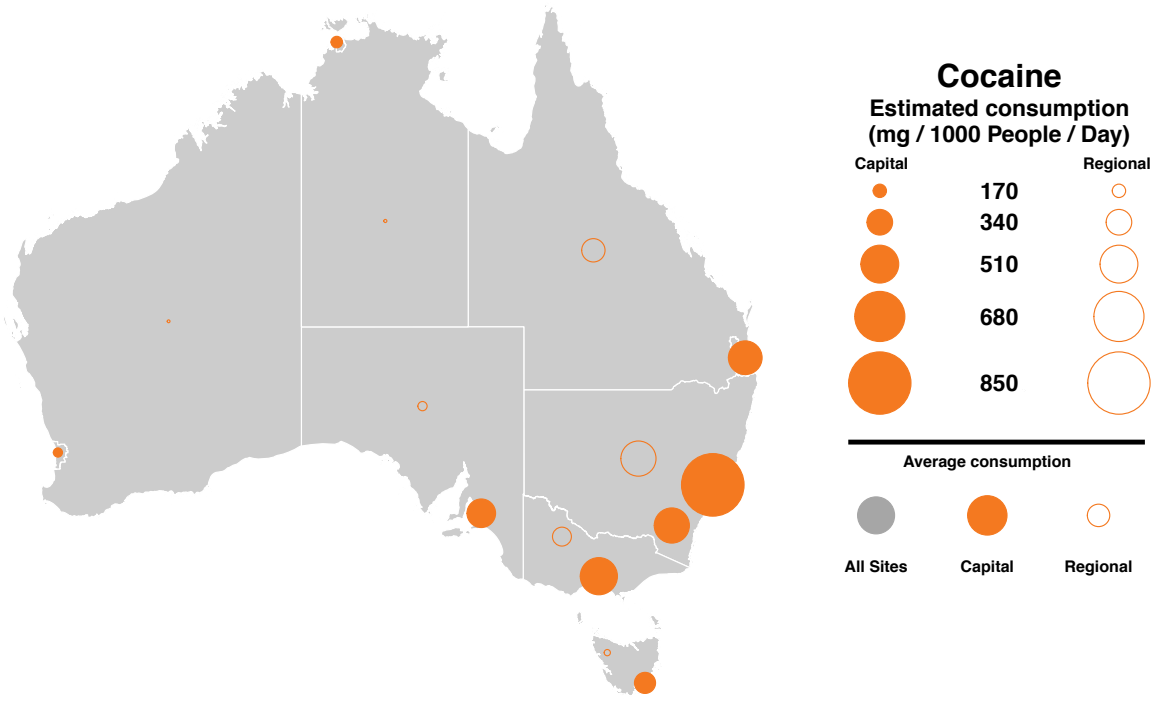


Figure 15: Estimated average MDMA consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

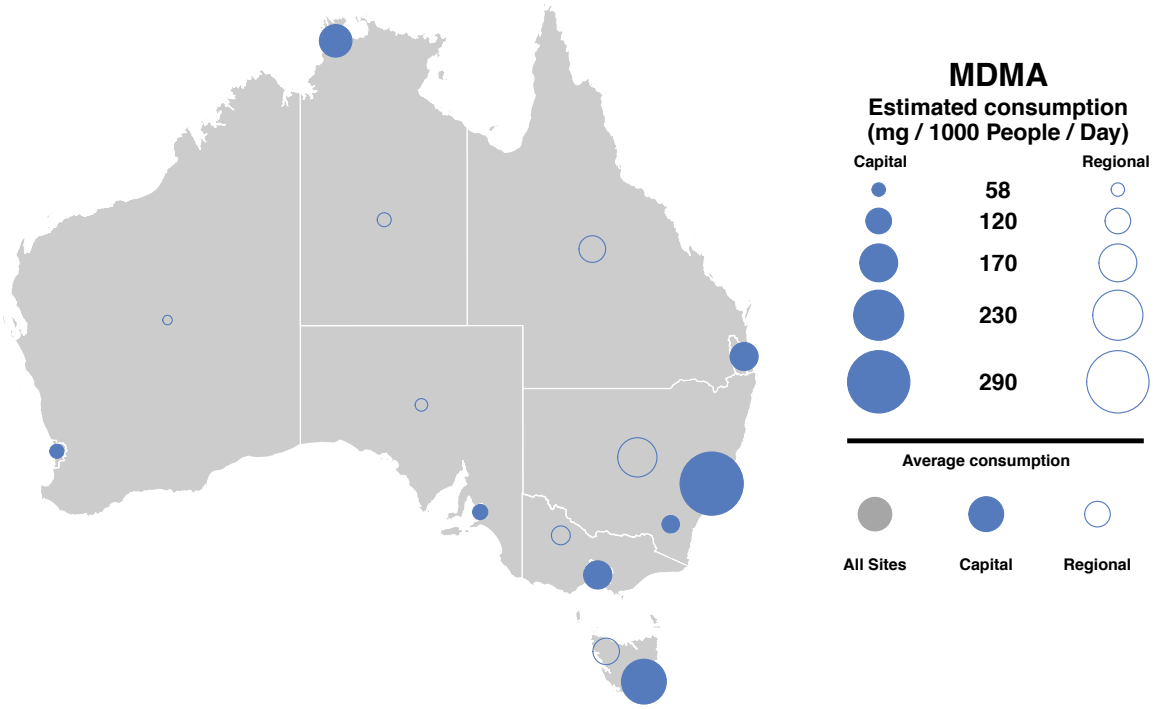
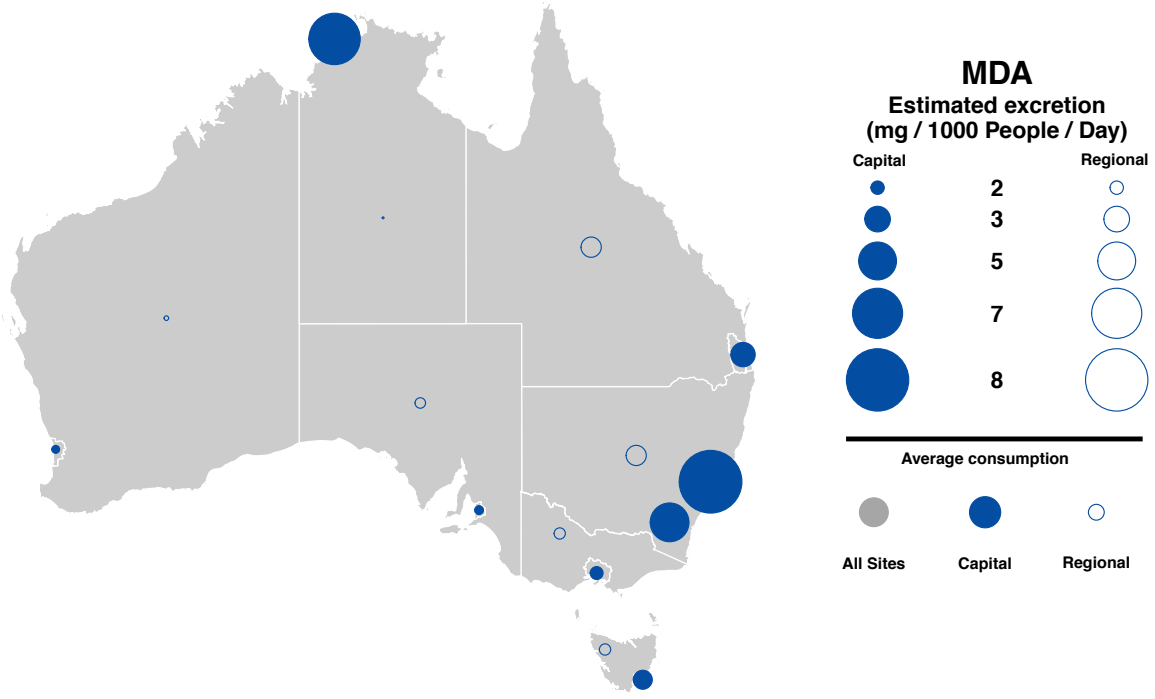


Figure 16: Estimated average MDA excretion per jurisdiction for April 2021 in mg excreted per day per thousand people. The number of collection days varied from 5-7.



4.1.3 OPIOIDS

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

4.1.3.1 PHARMACEUTICAL OPIOIDS

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

Oxycodone consumption across Australia in April 2021 was highly variable. A feature of the national use of oxycodone was the very large difference between averages in the capital cities and regions (Figure 17). Western Australia had relatively low overall consumption levels compared to the national averages. Capital city catchments with above average consumption of oxycodone included the Australian National Territory, South Australia and Tasmania. The spread of use over the April 2021 collection week was small in the capital cities, with bigger daily variations evident in many regional centres.

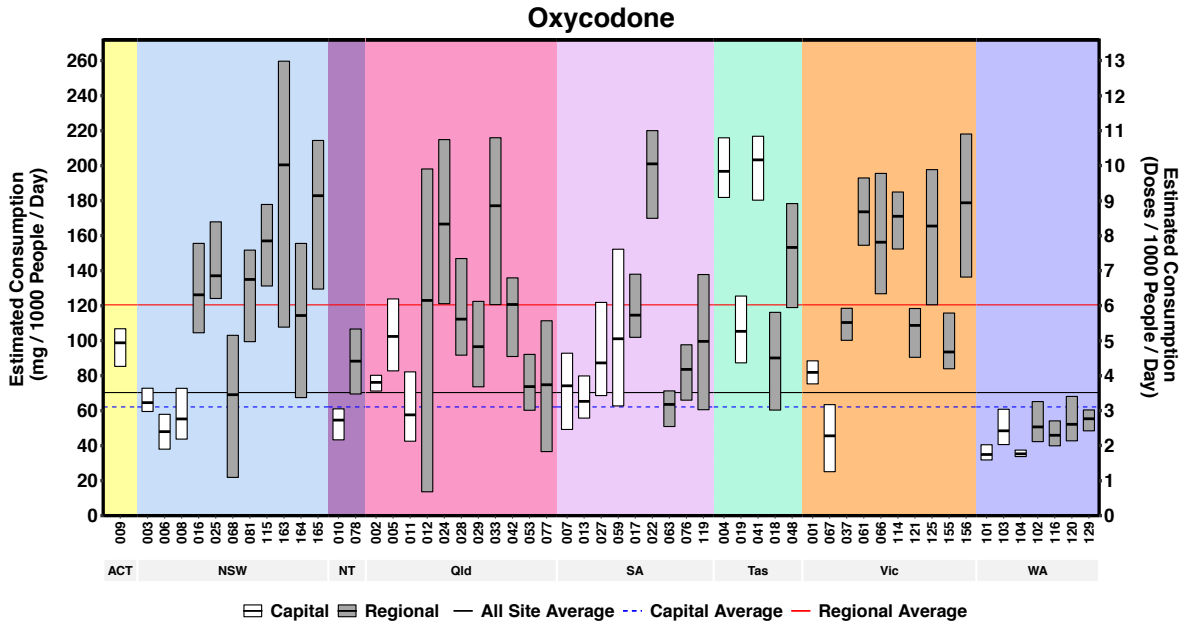
Fentanyl use was also characterised by higher average regional consumption, albeit not as distinct as oxycodone (Figure 18). A few regional catchments in New South Wales had the highest levels of use, with large differences evident between collection days in one area (Site 81). This is unusual for treatment of medical conditions on a population scale. Specific days at some sites had levels below the quantification limits of the method.

The relative scale of oxycodone and fentanyl use was apparent when results were aggregated by jurisdiction and capital or regional area and presented in bubble graph form. Higher oxycodone consumption rates were apparent in regional areas and in capital city Tasmania (Figure 19). Fentanyl consumption was relatively low in most capital cities compared to regional areas, apart from Tasmania (Figure 20).

4.1.3.2 HEROIN

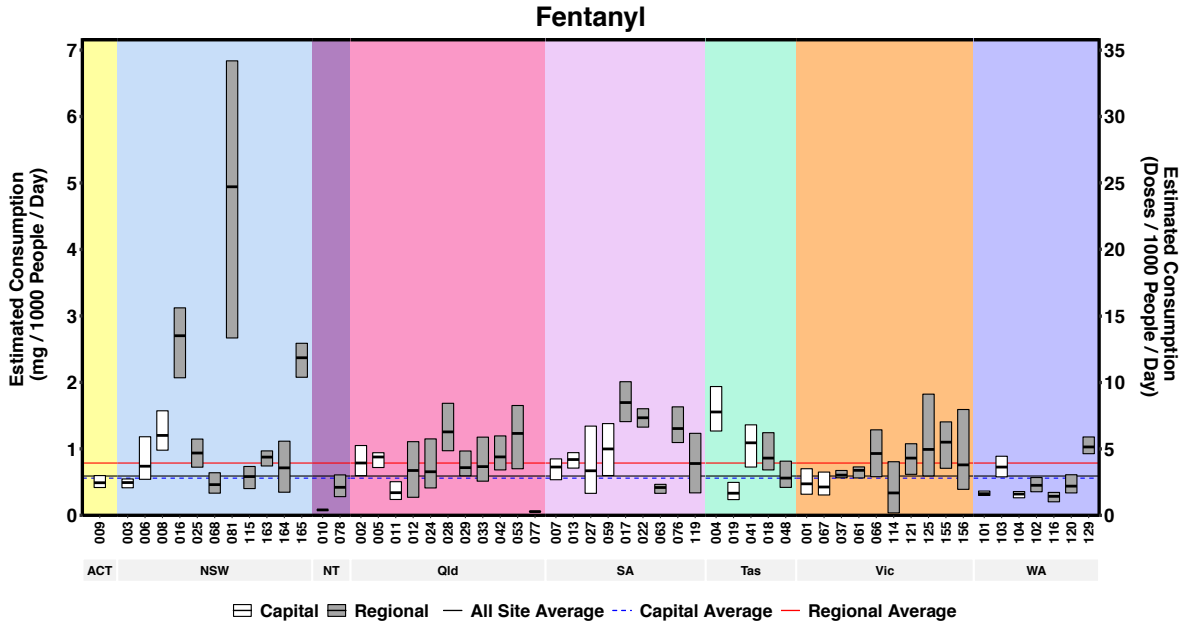
Heroin is metabolised in the body and excreted in low amounts as the unique metabolite, 6-monoacetylmorphine (6-MAM). Since the compound is characteristic of heroin metabolism, it can be used to distinguish heroin from other opioids such as morphine and codeine. Use of heroin in regional areas was generally much less than in the capital cities (Figure 21). Capital city sites in New South Wales, Queensland and Victoria had very high consumption levels across the sampling week, well above most other catchments. Some regional sites in New South Wales and Victoria had levels well above the average as well. Regional use of the drug tended to be low in other parts of the country. Many regional sites had daily levels at or below limits of quantification. The elevated heroin consumption in capital city Victoria, New South Wales and Queensland is clearly evident from the bubble graph (Figure 22).

Figure 17: Estimated oxycodone consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Higher regional average
- Tasmania highest of the capital cities

Figure 18: Estimated fentanyl consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Similar regional and city averages
- Highest use in New South Wales

Figure 19: Estimated average oxycodone consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

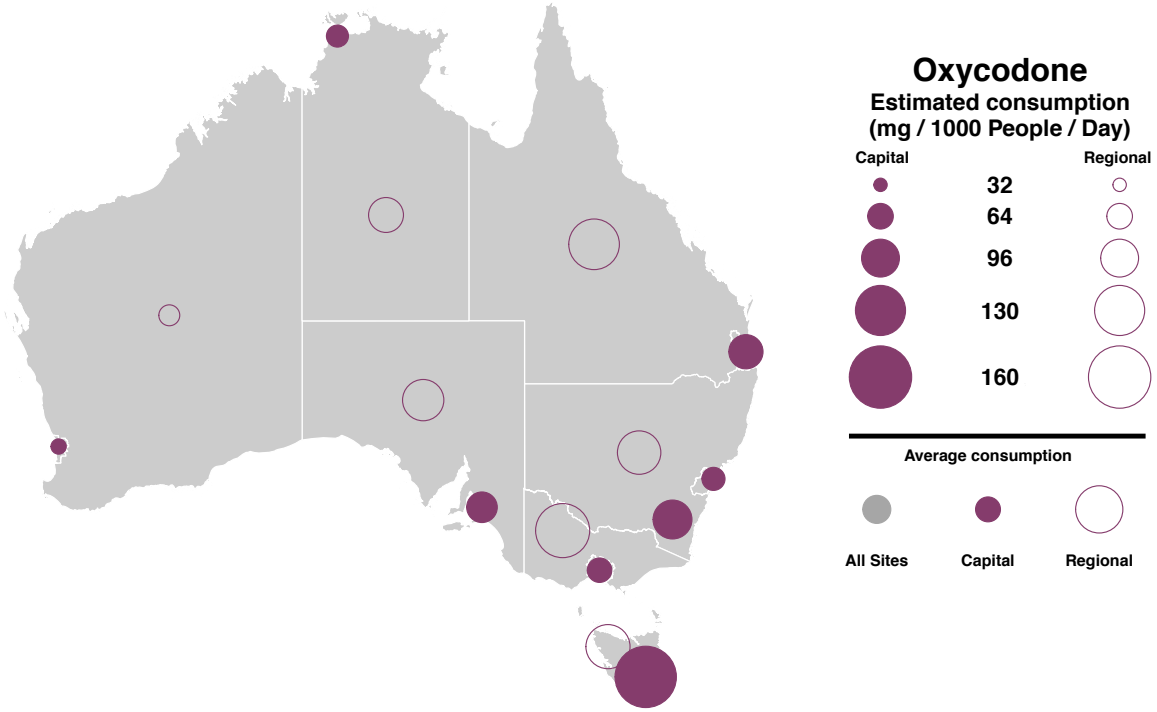


Figure 20: Estimated average fentanyl consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.

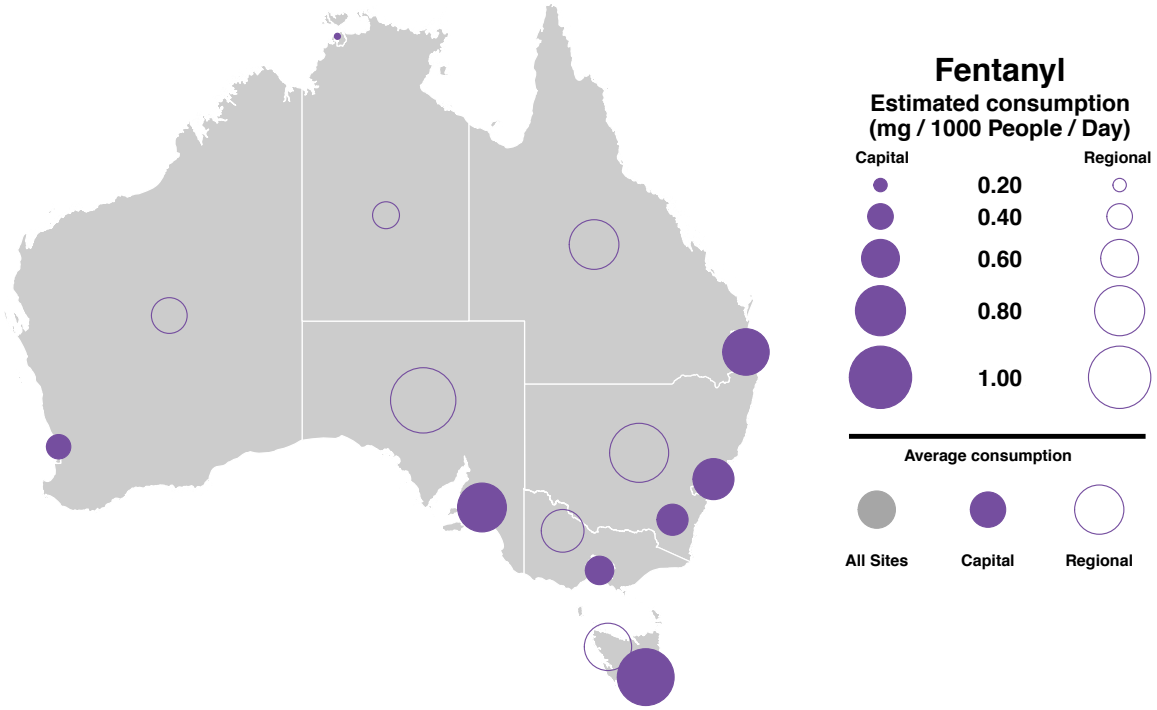
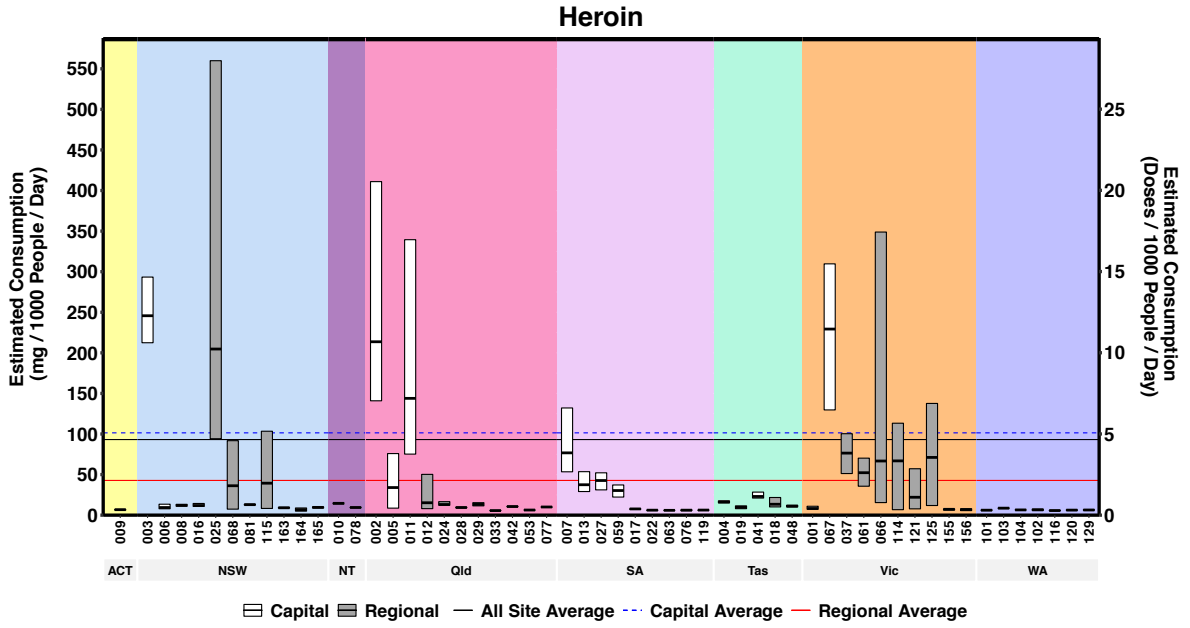
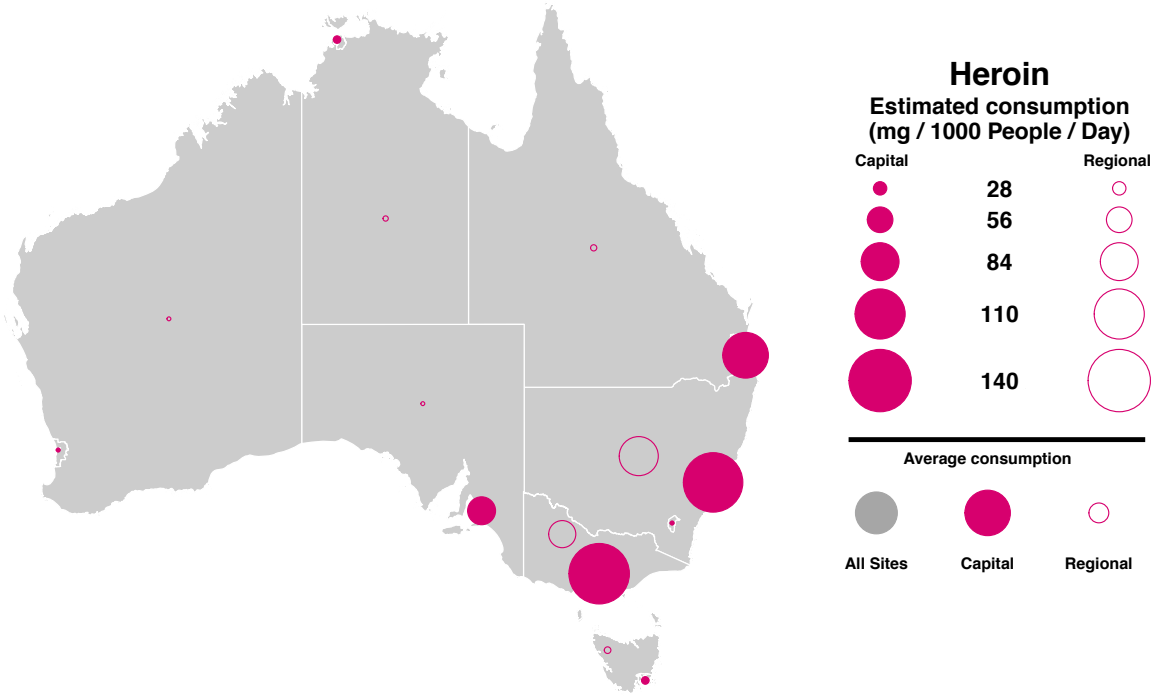


Figure 21: Estimated heroin consumption for April 2021 in mass consumed per day (left axis) and doses per day (right axis) per thousand people. The number of collection days varied from 5-7.



- Lower regional consumption, often not detected
- High consumption in capital cities on the eastern seaboard

Figure 22: Estimated average heroin consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.



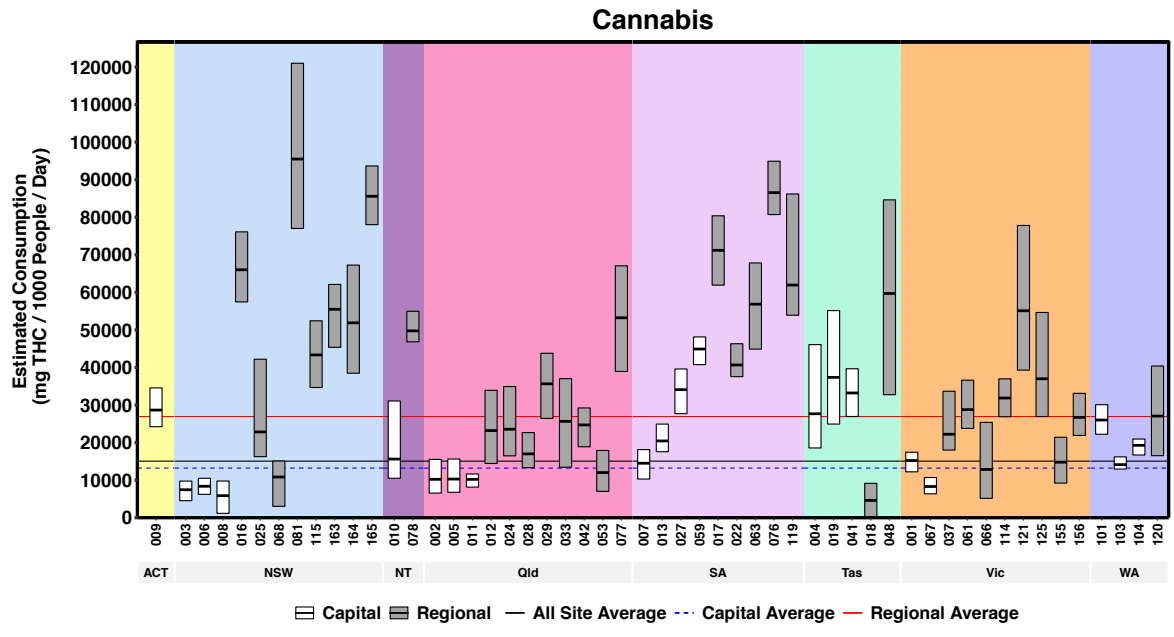
4.1.4 CANNABIS

Tetrahydrocannabinol (THC) is the main psychoactive compound found in cannabis. The compound is metabolised and largely cleared through the intestine. A small proportion (0.6 per cent) is excreted through the kidneys as 11-nor-9-carboxy-tetrahydrocannabinol (THC-COOH). The latter is known to adsorb to various surfaces, including sewer infrastructure. Therefore, in terms of wastewater analysis, the sewer design and collection method may play a part in the reportable levels of the target metabolite used for the purposes of the NWDMP. Upon collection, samples need to be preserved to avoid degradation of THC-COOH, without using acidification (McCall et al. 2016). This is one reason why cannabis consumption is not reported on a regular basis in other countries where wastewater analysis is routinely conducted. Acidification is a common preservation technique. For the NWDMP, separate samples are collected each day and preserved specifically for THC-COOH analysis.

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

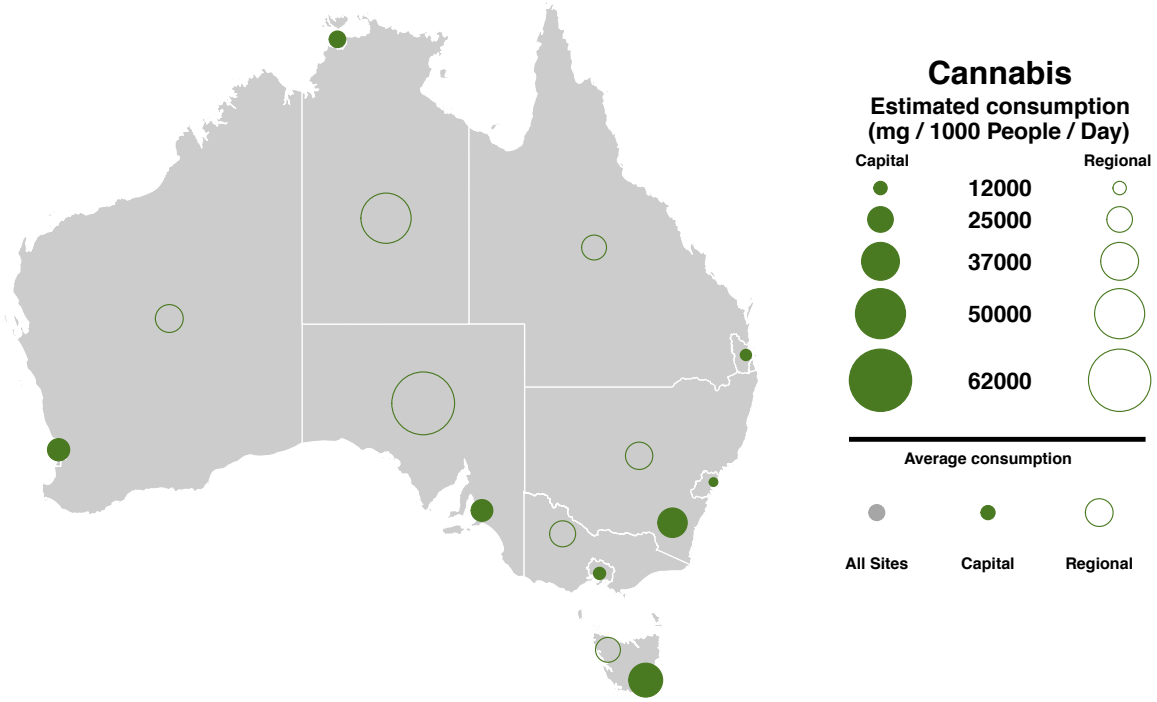
Very large spatial differences were evident across Australia (Figure 23). The average use across regional Australia in April 2021 exceeded capital city consumption. The highest mean values were observed in regional New South Wales and South Australia, while sites in South Australia and Tasmania recorded the highest levels of consumption in capital cities. In contrast, capital city New South Wales and Queensland had very low levels of cannabis use, below the national average. The bubble plot and jurisdictional differences of cannabis use across Australia show the generally higher consumption in regional areas (Figure 24).

Figure 23: Estimated cannabis consumption for April 2021 in mass consumed per day (left axis). The number of collection days varied from 5-7.



- **High regional consumption**
- **Variable use across the country**

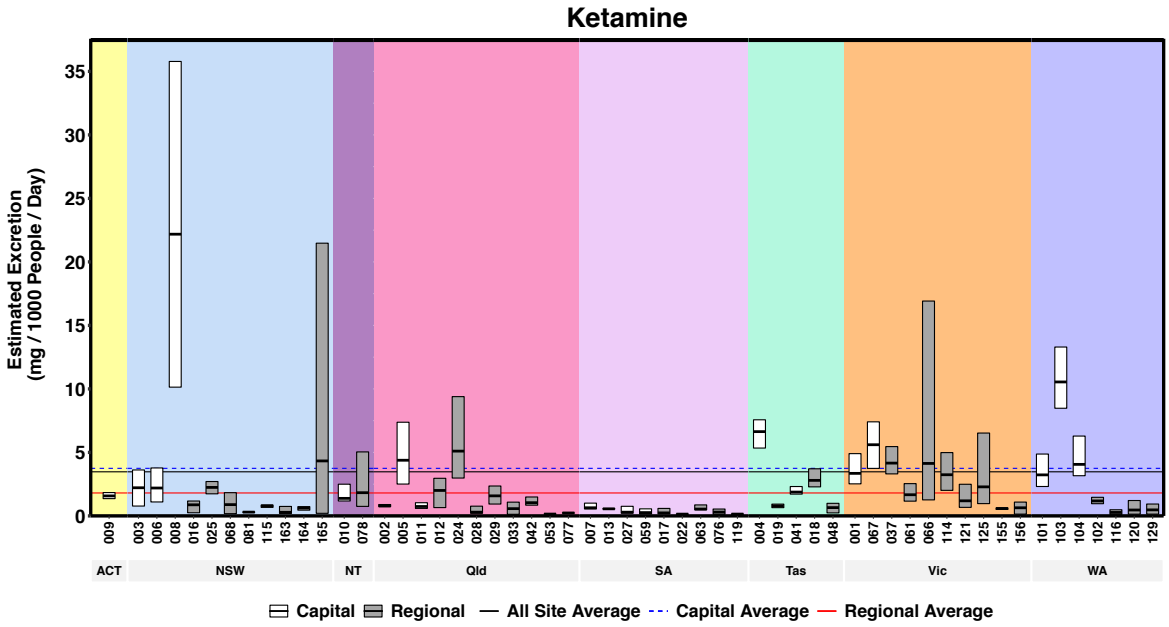
Figure 24: Estimated average cannabis consumption per jurisdiction for April 2021 in mg consumed per day per thousand people. The number of collection days varied from 5-7.



4.1.5 KETAMINE

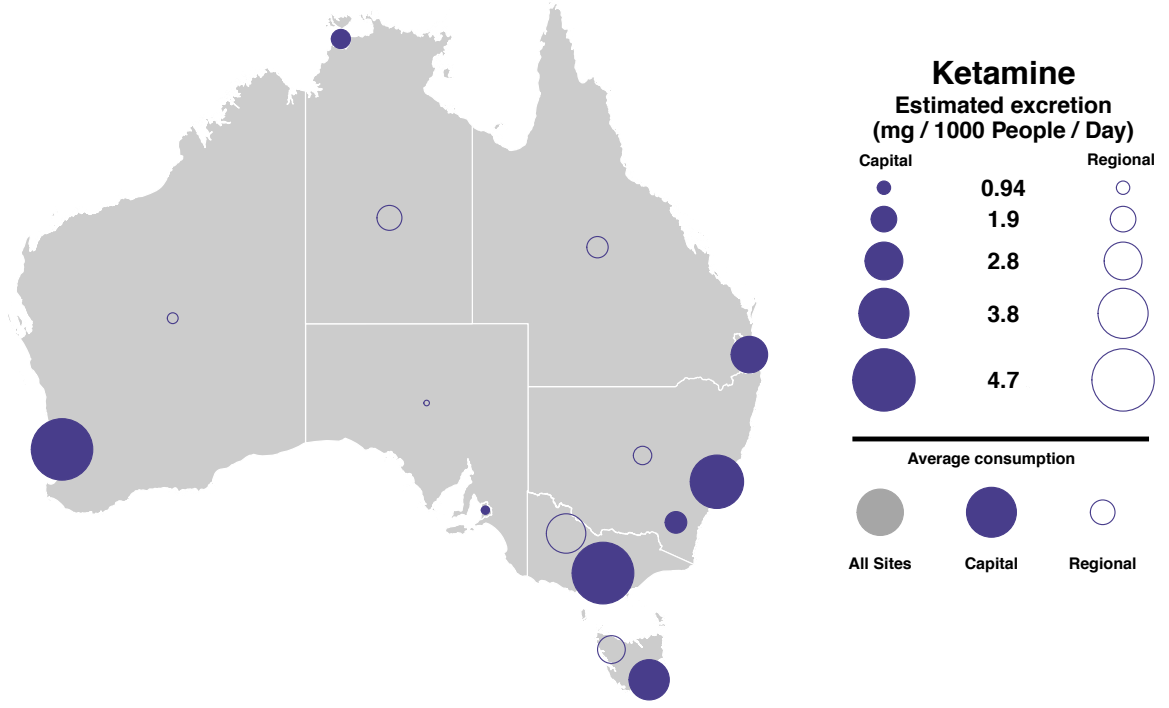
Ketamine, measured as its metabolite, norketamine, is used medically for the management of acute pain, often associated with surgery or trauma. It has veterinary applications as well. Due to its sedative and hallucinogen effects, the drug has been associated with illicit substance abuse and is listed as a novel psychoactive substance by the United Nations Office on Drugs and Crime (UNODC). The reported proportion of ketamine and its metabolites in wastewater leaves 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. The regional average for ketamine was lower than the capital cities, partly because values fell below the method detection limits on certain days at various catchments. On a spatial level, use was well above the averages at a few sites, particularly in parts of New South Wales, Victoria and Western Australia (Figure 25). Although the wide weekly spread at these sites appears to be inconsistent with medical use on a population scale, the low overall values may distort the scale of the variations to some extent. A bubble plot shows the relative scale of ketamine use across Australia (Figure 26).

Figure 25: Estimated ketamine consumption for April 2021 in mass excreted per day (left axis) per thousand people. The number of collection days varied from 5-7.



- Lower regional average
- Higher levels in specific catchments

Figure 26: Estimated average ketamine consumption per jurisdiction for April 2021 in mg excreted per day per thousand people. The number of collection days varied from 5-7.



4.2 TEMPORAL CHANGES IN DRUG CONSUMPTION ESTIMATES BY JURISDICTION

The total level of each drug outlined in the preceding reports per state or territory was compared with subsequent collection periods included in the current report. The data relating to capital cities in this section have been updated to include both the April and June 2021 collections, while regional areas were updated for April 2021. 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 the previous report and so has less data points than the other substances. Although every effort was made to assess the same sites for each period, the individual sites and the number of sites used to generate the population-weighted averages may have changed between periods. Comparing between time points should be done with caution. This would be most evident for the regional averages, which had more variation in participation between each period (see Appendix 2 and Appendix 3, Report 6 and Appendix 2 in this report). Due to the larger number of data points collected by the Program, the current reporting period is populated with data since August 2018. Data dating back to 2016 for each substance of interest is made 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.

4.2.1 NICOTINE AND ALCOHOL

Over the first two years of the program, nicotine consumption remained largely steady in most parts of the country (Figure 25). Depending on the state or territory, increased use became apparent in the past year. In the current sampling periods of April and June 2021, increases were seen across the country. These increases were more pronounced in the regional populations of the country. The high regional use of nicotine is reflected in the average use remaining well above capital city levels.

The difference between average capital city and regional centre consumption of alcohol within each state or territory remained minimal compared to nicotine. South Australia continued to be the only state where regional alcohol use was lower than in the capital city (Figure 26). Consumption levels remained essentially steady in states such as New South Wales, Queensland, Tasmania and Victoria, while a decrease in use in South Australia and the Northern Territory in the current period was observed. Western Australia saw a decline in consumption at the start of 2018 which has remained steady since then.

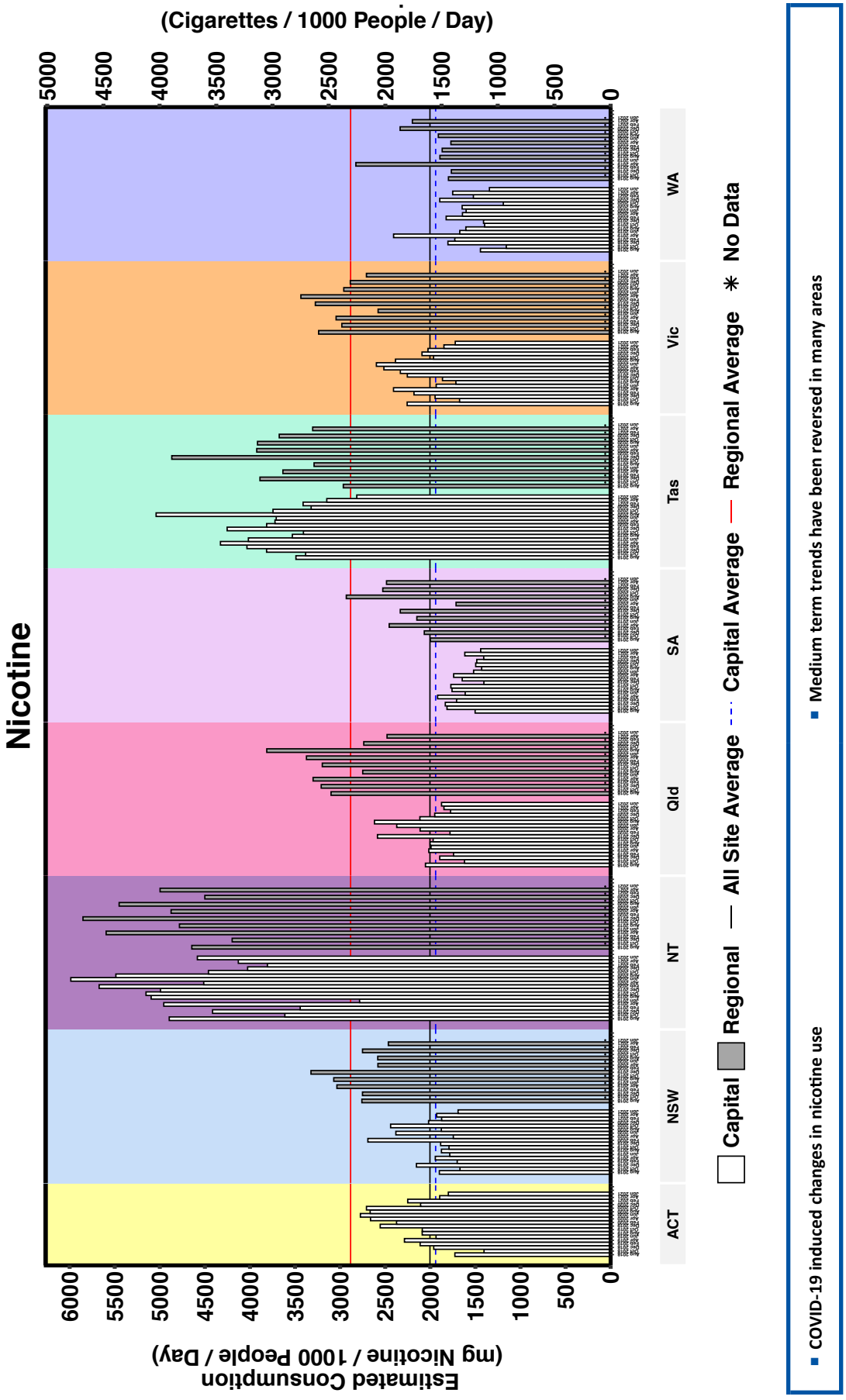


Figure 27: Estimated average consumption of nicotine by state/territory, August 2018 to June 2021, where 1 cigarette provides 1.25 mg of nicotine.

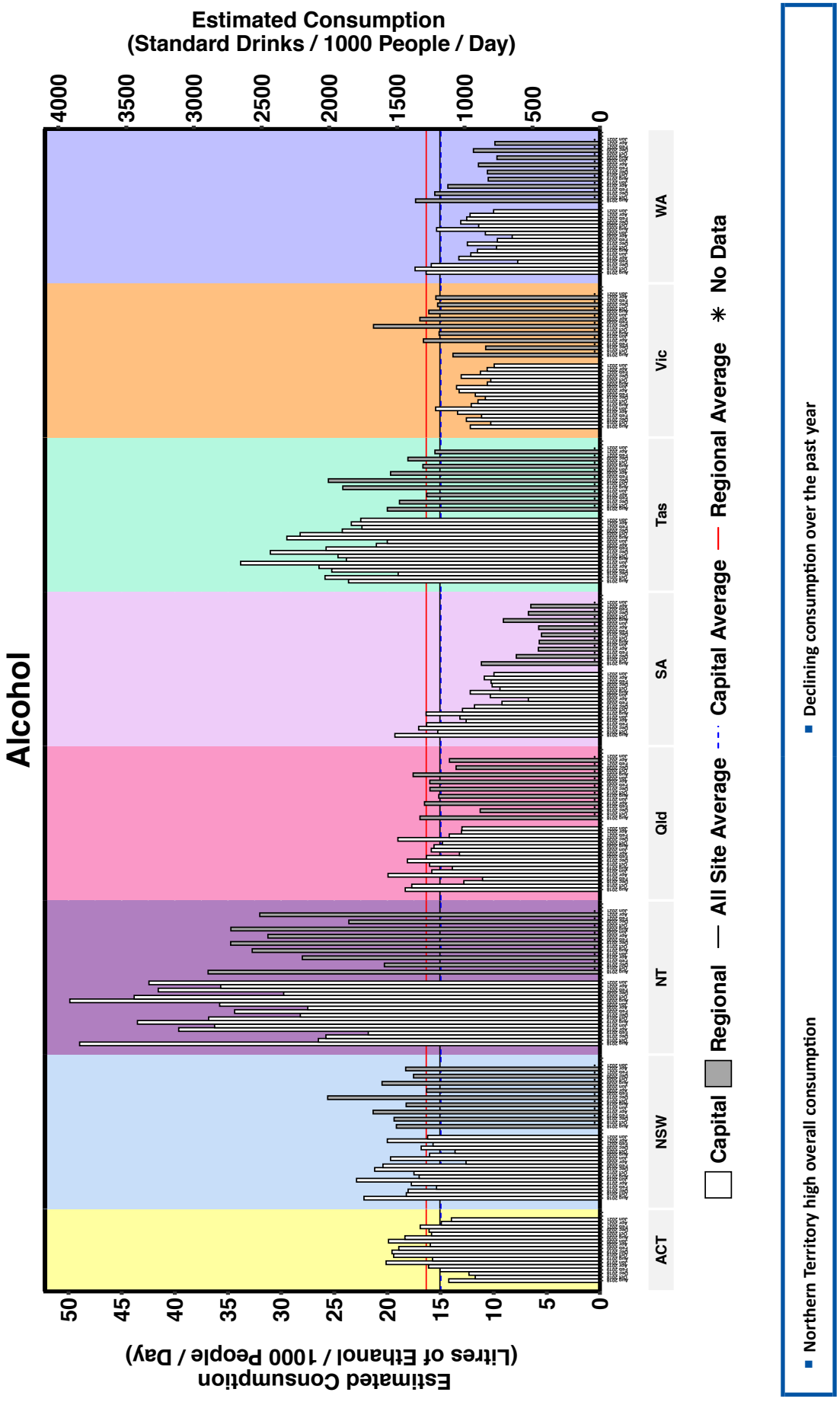


Figure 28: Estimated average consumption of alcohol by state/territory, August 2018 to June 2021. A standard drink is 10.0 g, or 12.6 mL.

4.2.2 STIMULANTS

The impact of the COVID-19 restrictions on methylamphetamine use is very evident across almost all jurisdictions, with a substantial decrease in consumption visible in mid-2020 (Figure 29). Pre-pandemic upward trends in states such as New South Wales and Tasmania were interrupted in mid-2020. In some parts of the country, use of the drug recovered for a short period, before average capital city consumption declined nationally in June 2021. Regional methylamphetamine consumption increased in all jurisdictions in April 2021, particularly in South Australia and Western Australia. Capital city South Australia had the highest consumption levels of capital city sites in June 2021.

Several sites have data available from before the start of the NWDMP showing long-term changes in use of methylamphetamine (Figure 30 and Figure 31). Levels of use of the substance increased considerably in Queensland and South Australia, but this was not evident in the long-term data for Victoria and Western Australia.

Cocaine consumption had been steadily increasing in most capital cities and many regional parts of Australia prior to the start of the COVID-19 pandemic (Figure 32). The April 2020 collection which followed shortly after the initial social restrictions were implemented, showed an immediate reduction in cocaine use in most capital cities. Regional areas in Queensland and New South Wales did not reflect the pre COVID-19 national capital city trend, with cocaine use declining sharply in regional Queensland and New South Wales in April 2021. In most jurisdictions, in both capital city and regional sites, cocaine consumption reduced across the country in April 2021. New South Wales remains the state with the highest levels of use.

MDMA use nationally is at one of the lowest levels since the start of the Program. The current reporting period shows that use of the drug remains low in virtually every state and territory, with the exception of the Northern Territory capital city catchment (Figure 33). The Northern Territory and Tasmania capital cities have historically high MDMA use. The impact of COVID-19 has made this distinction less apparent.

MDA use, corrected for the proportion derived from MDMA (Khan & Nicell 2011), is at one of the lowest levels recorded since the Program commenced in both regional and capital city locations (Figure 34). The Australian Capital Territory is one of the few areas where MDA use has been essentially steady, albeit at a low level. This is a market that is characterised by relatively low levels of use, with occasional spikes in consumption.

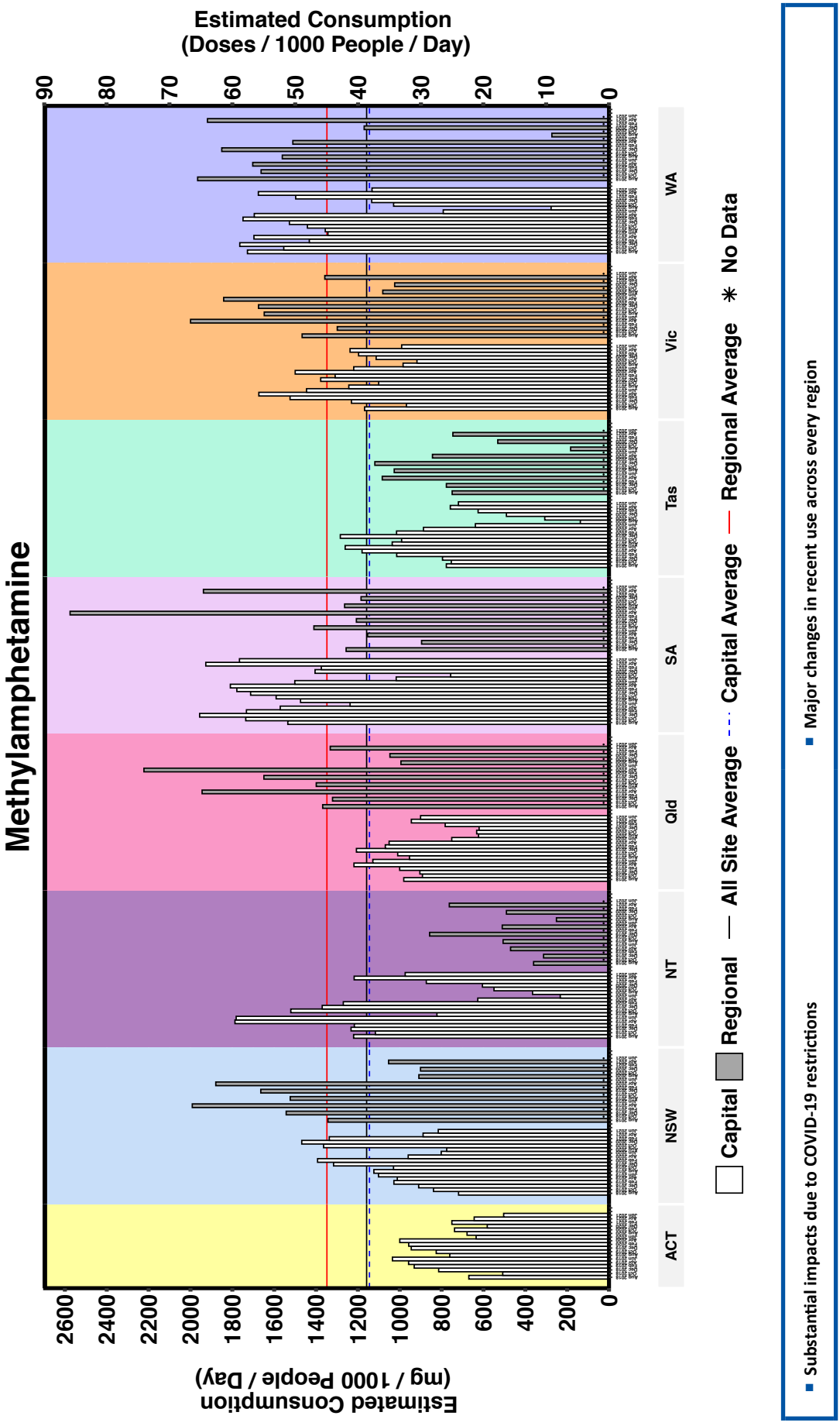


Figure 29: Estimated average consumption of methylamphetamine by state/territory, August 2018 to June 2021.

Figure 30: Change in methylamphetamine consumption for sites in Queensland and South Australia with historical data.

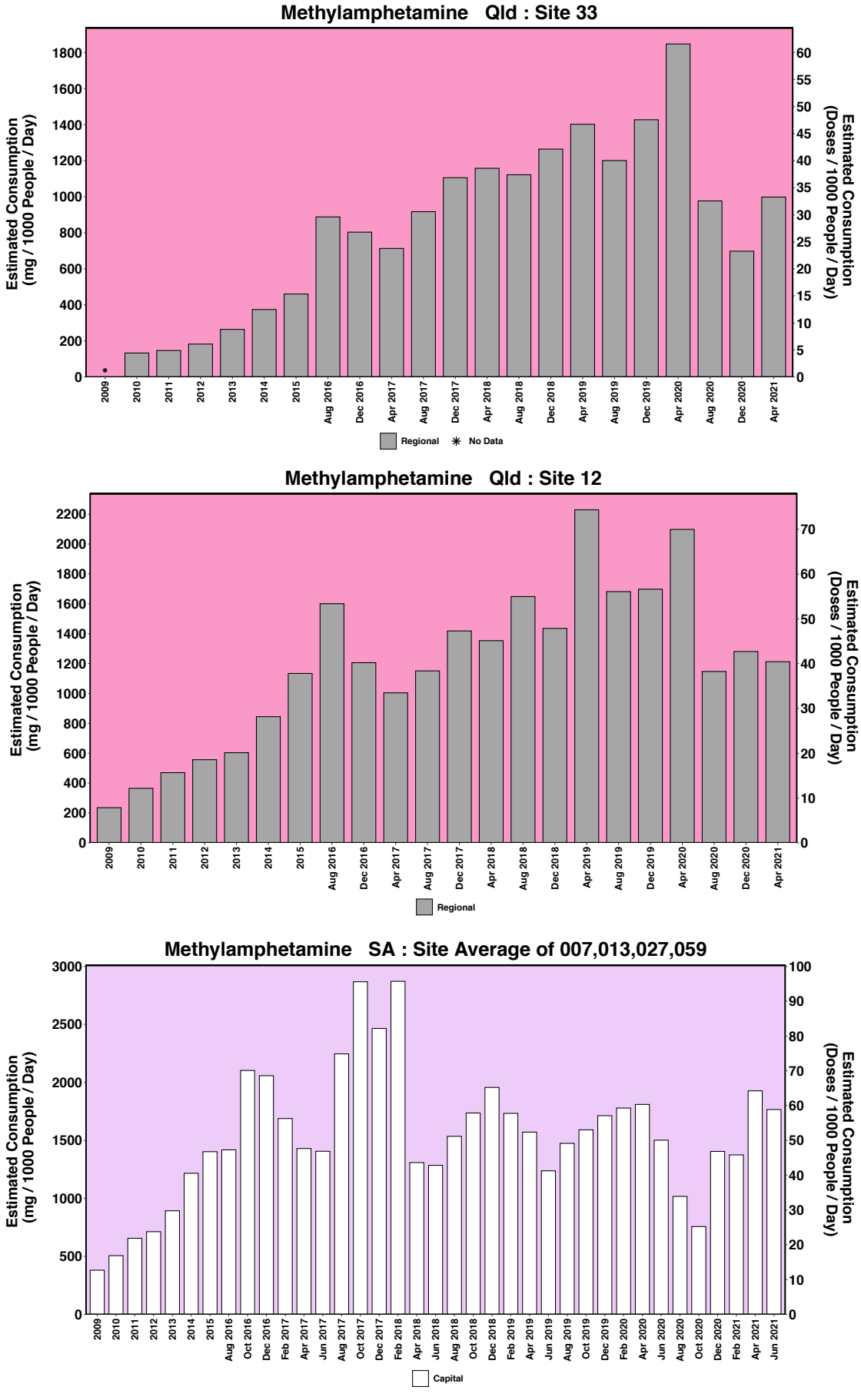
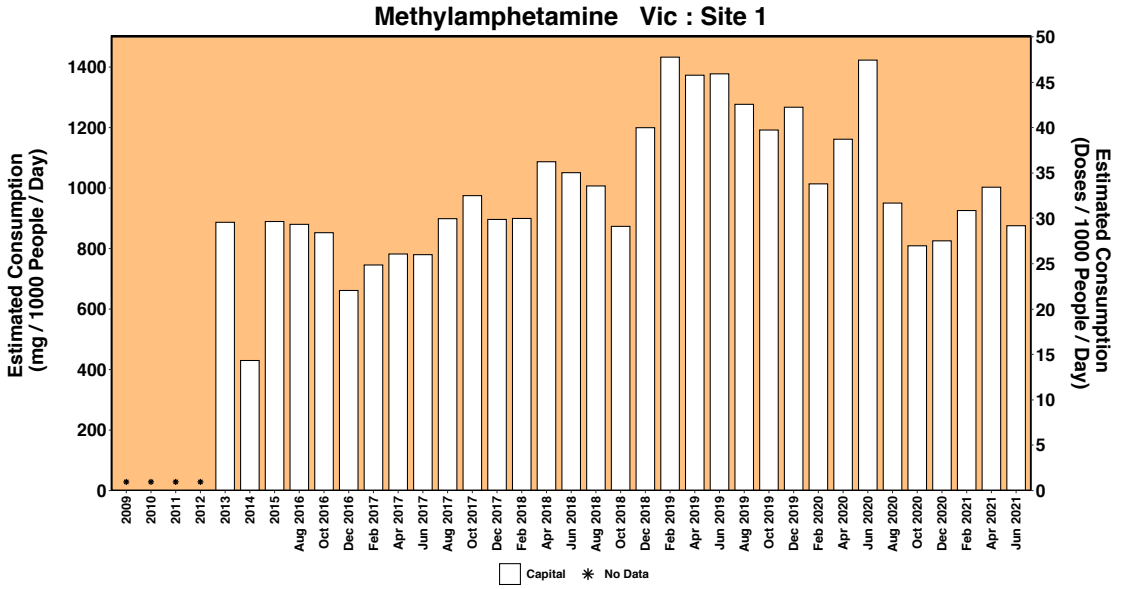
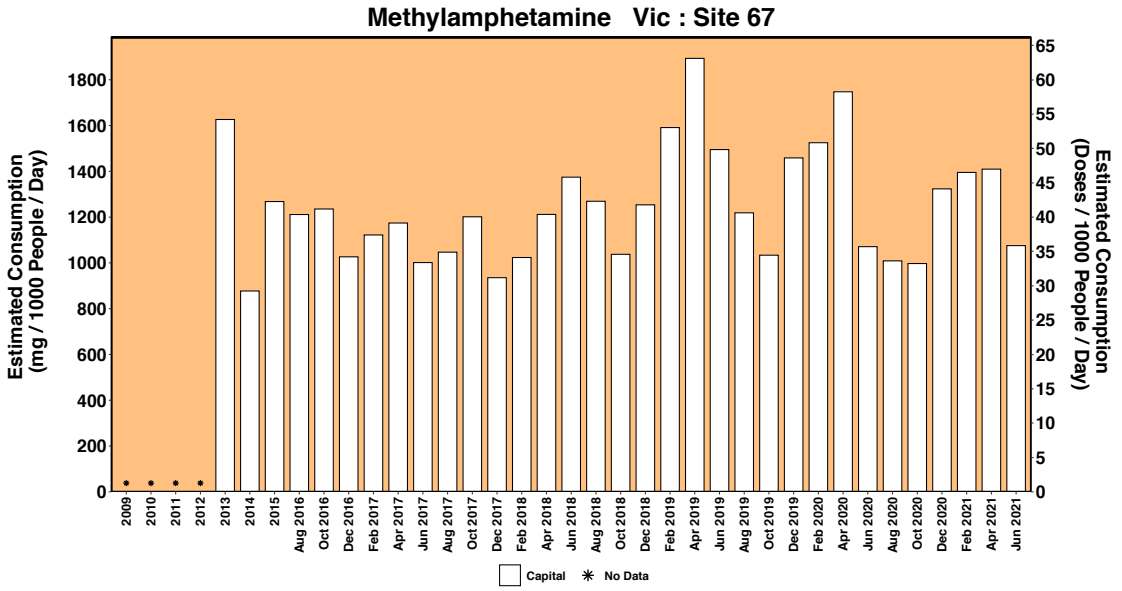
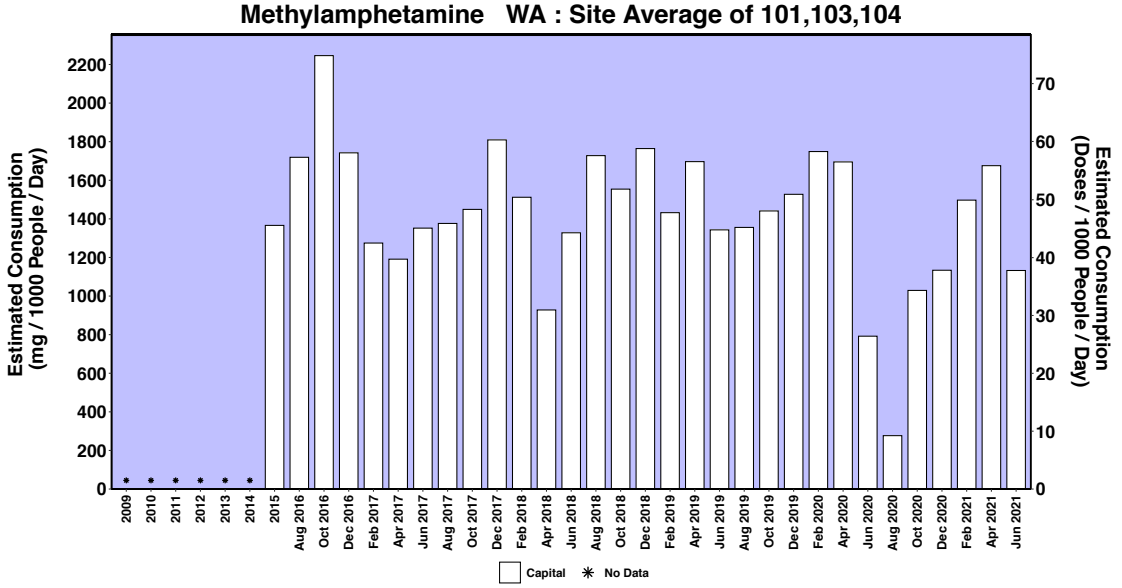


Figure 31: Change in methylamphetamine consumption for sites in Victoria and Western Australia with historical data. Both Victorian sites were the average of one week per year in 2013, 2014 and 2015.







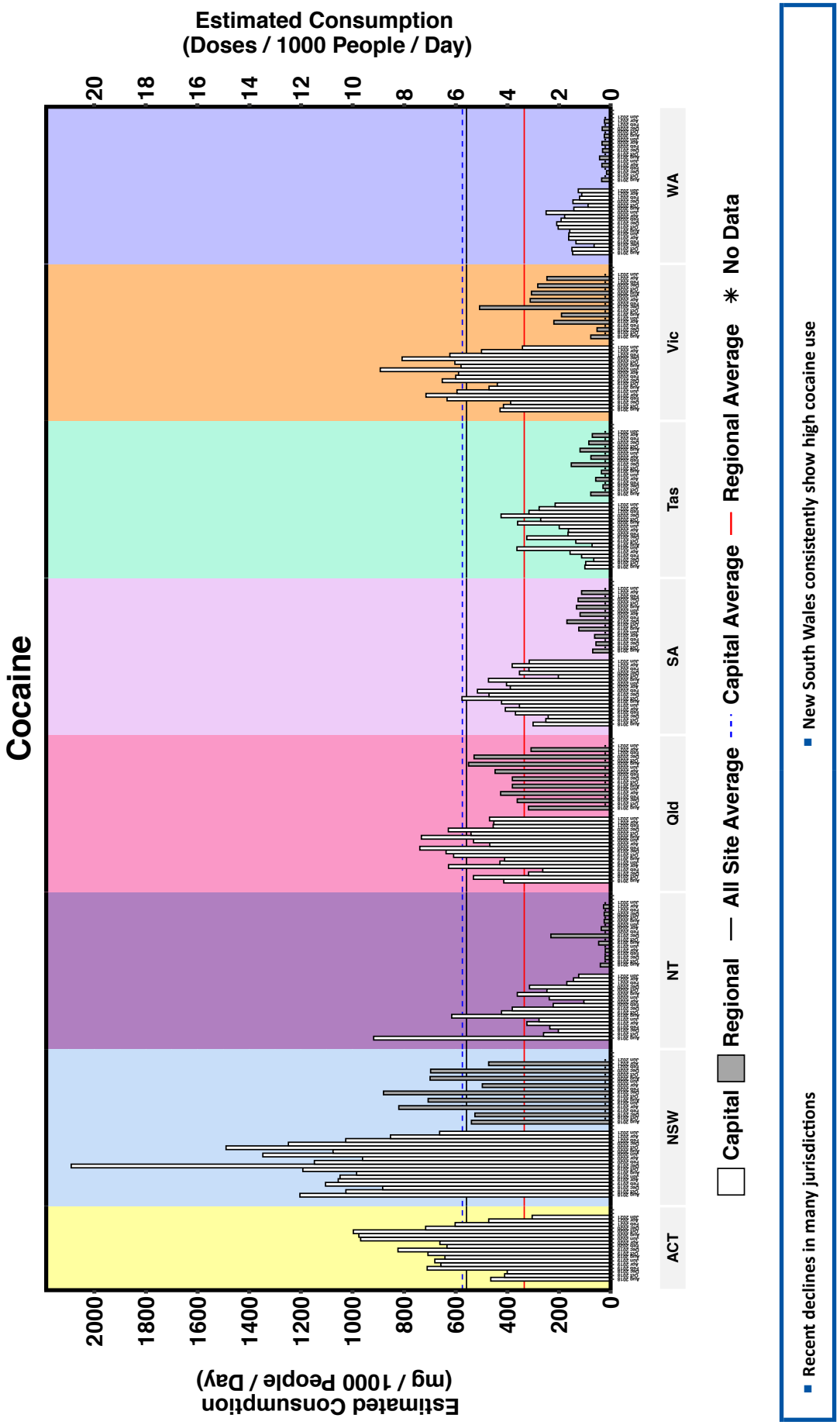


Figure 32: Estimated average consumption of cocaine by state/territory, August 2018 to June 2021.

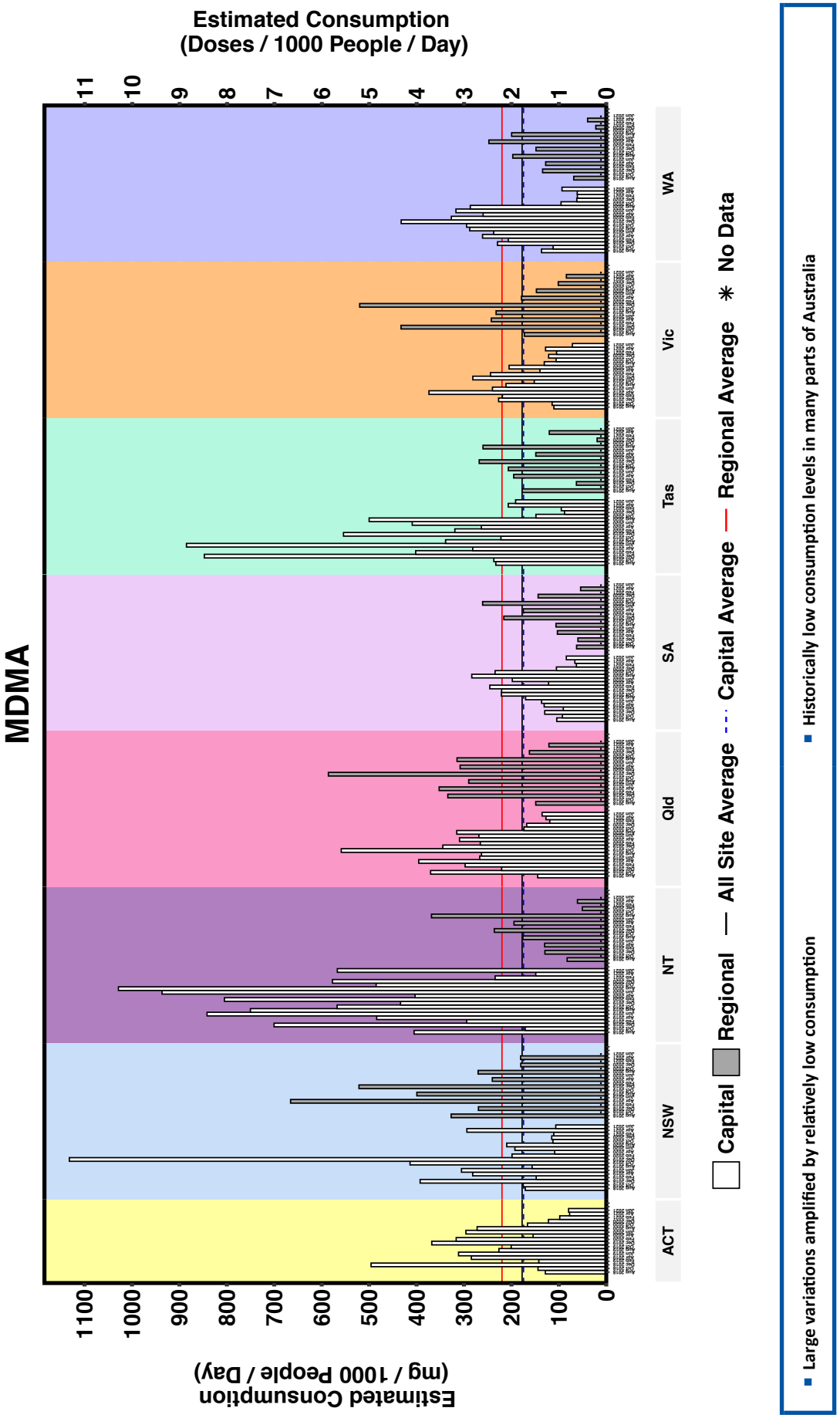


Figure 33: Estimated average consumption of MDMA by state/territory, August 2018 to June 2021.

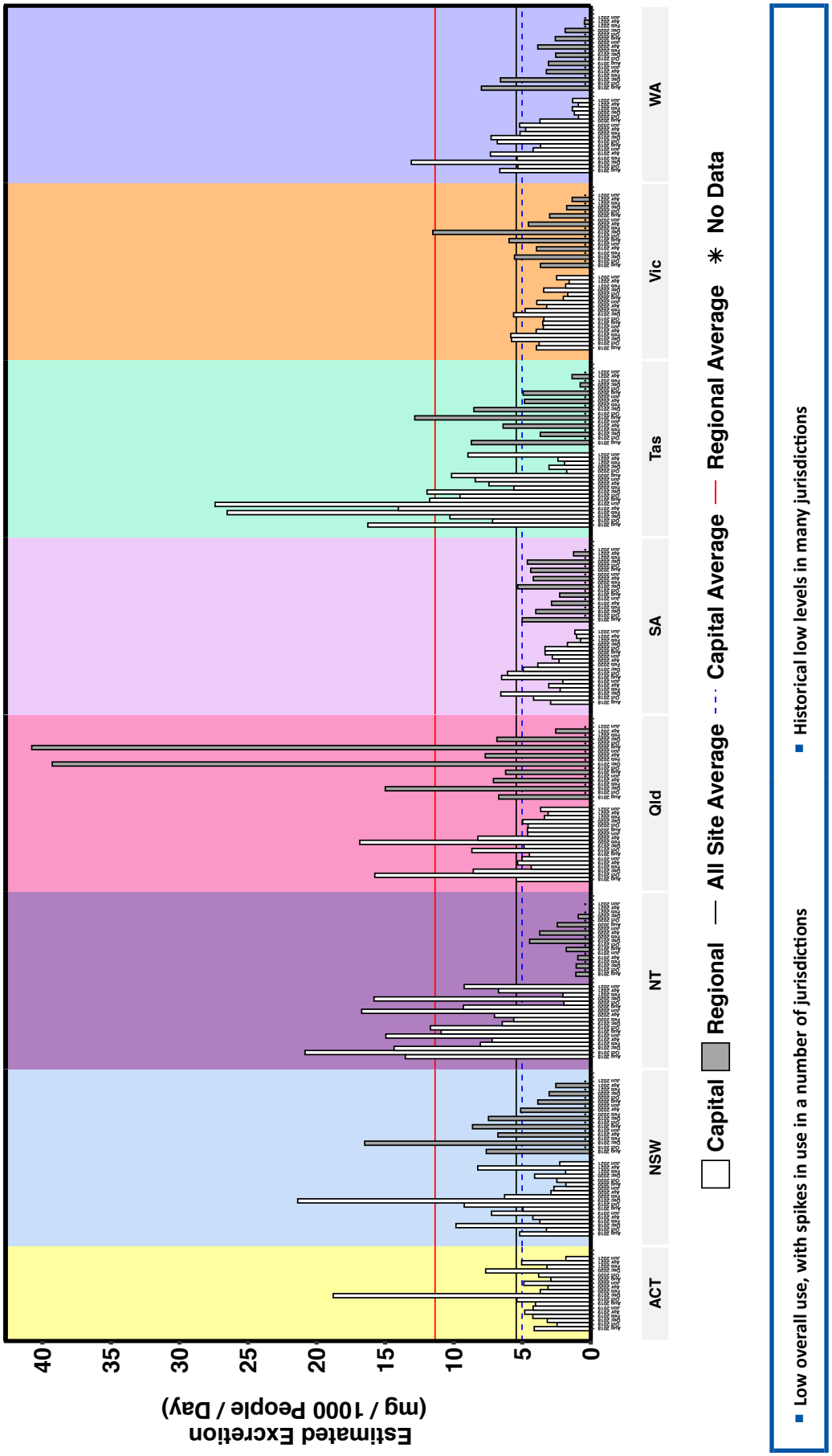


Figure 34: Estimated average excretion of MDA by state/territory, August 2018 to June 2021.

4.2.3 OPIOIDS

With the exception of the Australian Capital Territory and Queensland, capital city consumption of oxycodone in April and June 2021 was beneath the cumulative national average. This was also the case for regional areas of all jurisdictions (Figure 35). Consumption rates in the regional catchments remain higher than the capital cities, except in the case of Tasmania, but in most jurisdictions the gap is narrowing. Capital city Tasmania, the Australian Capital Territory and regional parts of Queensland and Victoria tend to be the highest consumers of oxycodone on a population basis.

There is a mixed picture in relation to fentanyl consumption, although the trend in almost all jurisdictions is towards consumption which is beneath the cumulative national average (Figure 36). Only the Tasmanian capital city exceeded the cumulative national average in April 2021 and regional consumption in April 2021 fell way below the national cumulative average. In April 2021, regional use of fentanyl tended to be higher than in the capital cities, although in a number of jurisdictions the gap in consumption is narrowing.

In contrast to the pharmaceutical opioids, heroin use in Australia occurs largely in the capital cities (Figure 37). Capital city Victoria has consistently been the centre of heroin use in the nation, but over the past year New South Wales has reached similar proportions. Consumption of the drug appeared to peak in mid-2020 in many jurisdictions. Most capital cities recorded their highest levels in August 2020, with use declining for the most part since. Tasmania, the Northern Territory and regional parts of Queensland and South Australia have recorded the lowest levels of use. Heroin consumption has been measured in capital city South Australia since 2013 (Figure 38). A gradual, long-term decline was evident from 2013 to early 2019, followed by a rapid increase over the course of that year. However, since the start of the pandemic in Australia, heroin use has fluctuated in the capital city sites.

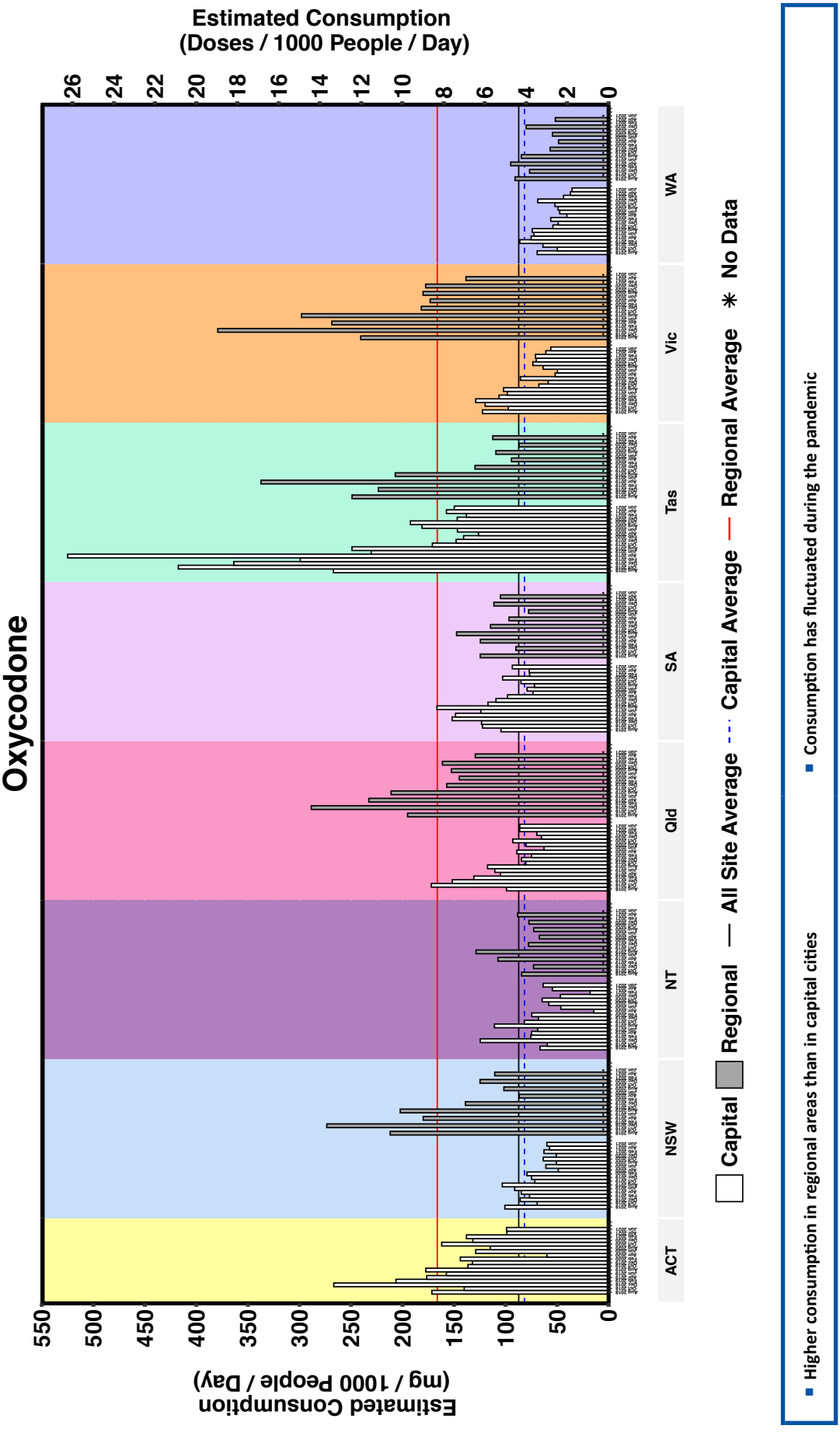


Figure 35: Estimated average consumption of oxycodone by state/territory, August 2018 to June 2021.

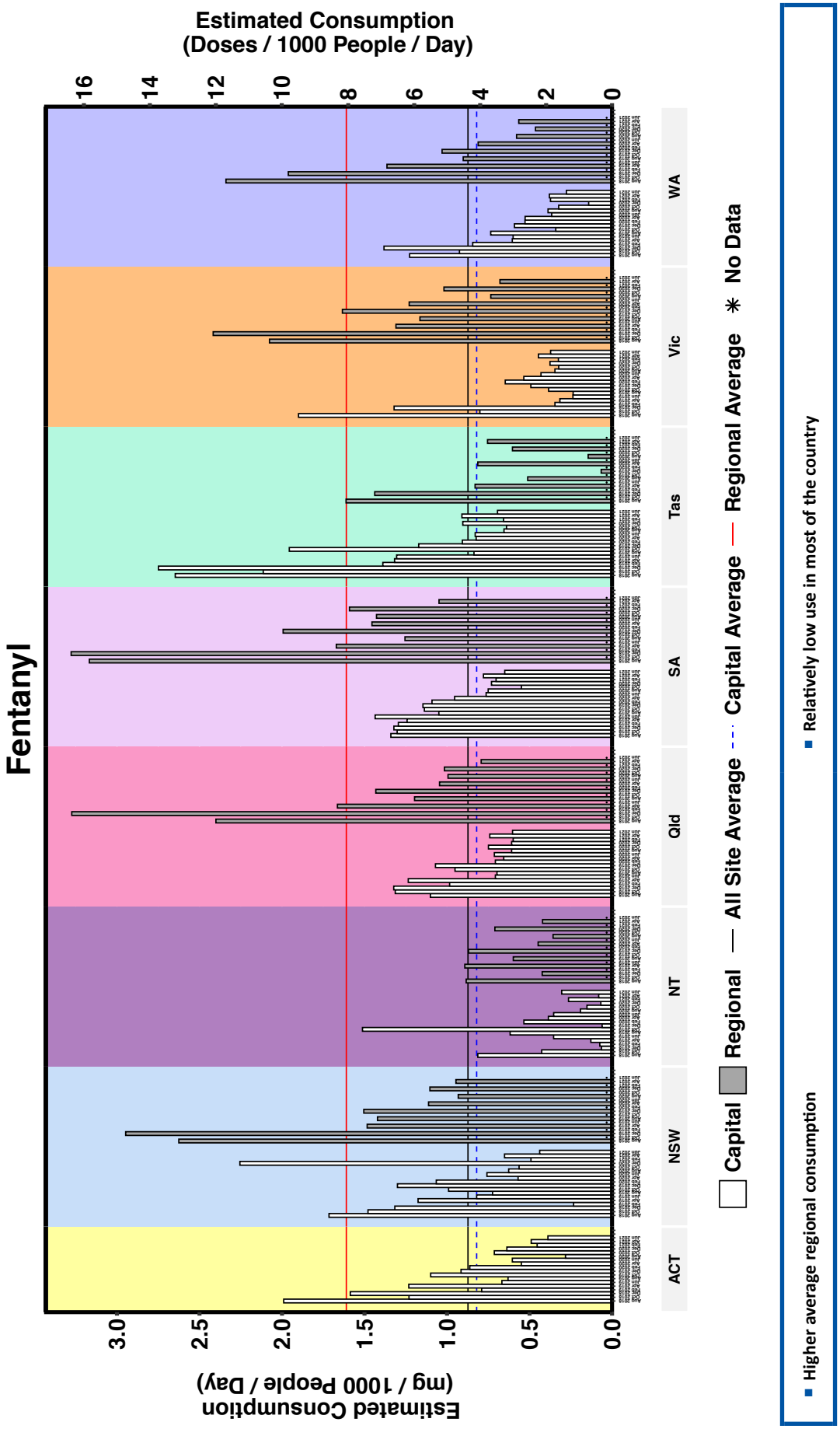


Figure 36: Estimated average consumption of fentanyl by state/territory, August 2018 to June 2021.

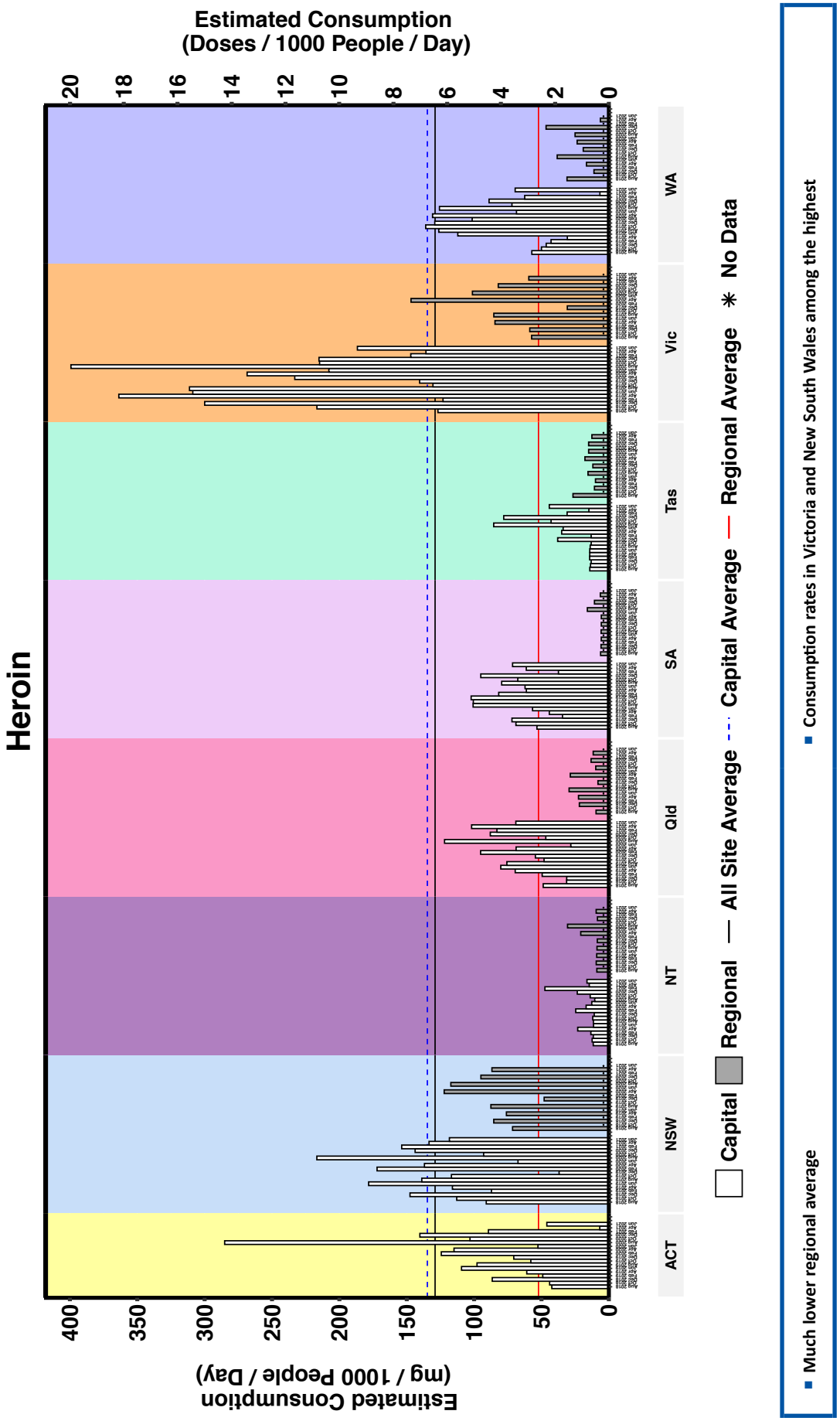
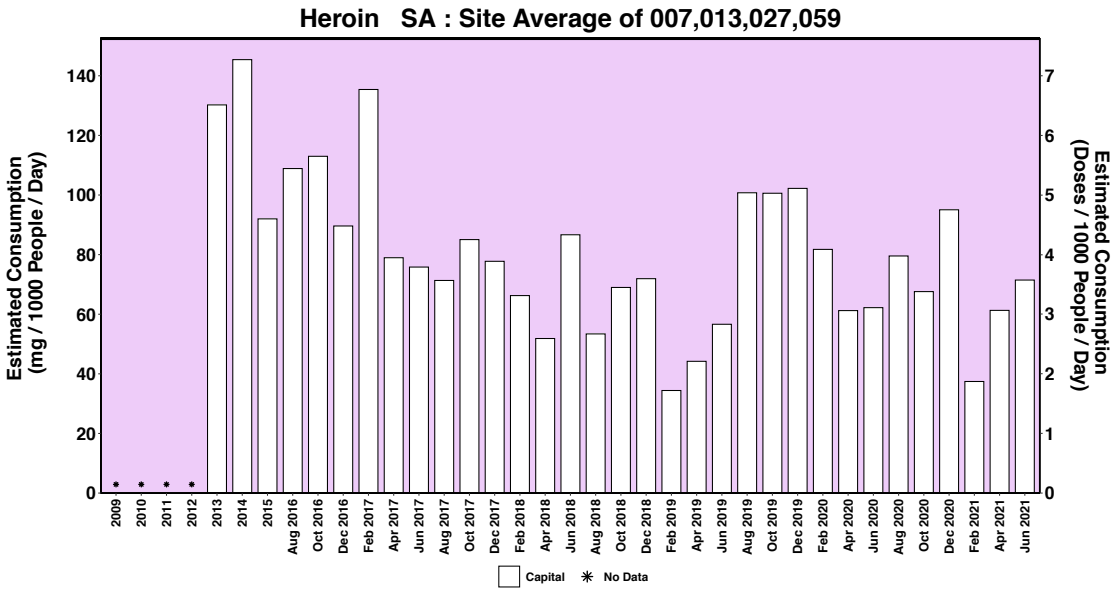


Figure 37: Estimated average consumption of heroin by state/territory, August 2018 to June 2021.

Figure 38: Change in heroin consumption for South Australia.



4.2.4 CANNABIS

Cannabis was first included in the Program in August 2018. Longer term trends show that cannabis use in the Australian Capital Territory and New South Wales has been steadily increasing (Figure 39). Elsewhere, consumption has been largely stable or showed short-term fluctuations. Capital city and regional consumption appears to have peaked in the latter half of 2020, but for the most part has decreased since. Regional consumption has been substantially higher than capital city levels, with the highest consumption spread over several states and territories, in particular the Northern Territory, Tasmania and regional South Australia. Use in capital city New South Wales, Victoria and Queensland was lower. In April 2021, consumption in these capital cities was less than half that in the regional areas of the respective jurisdictions.

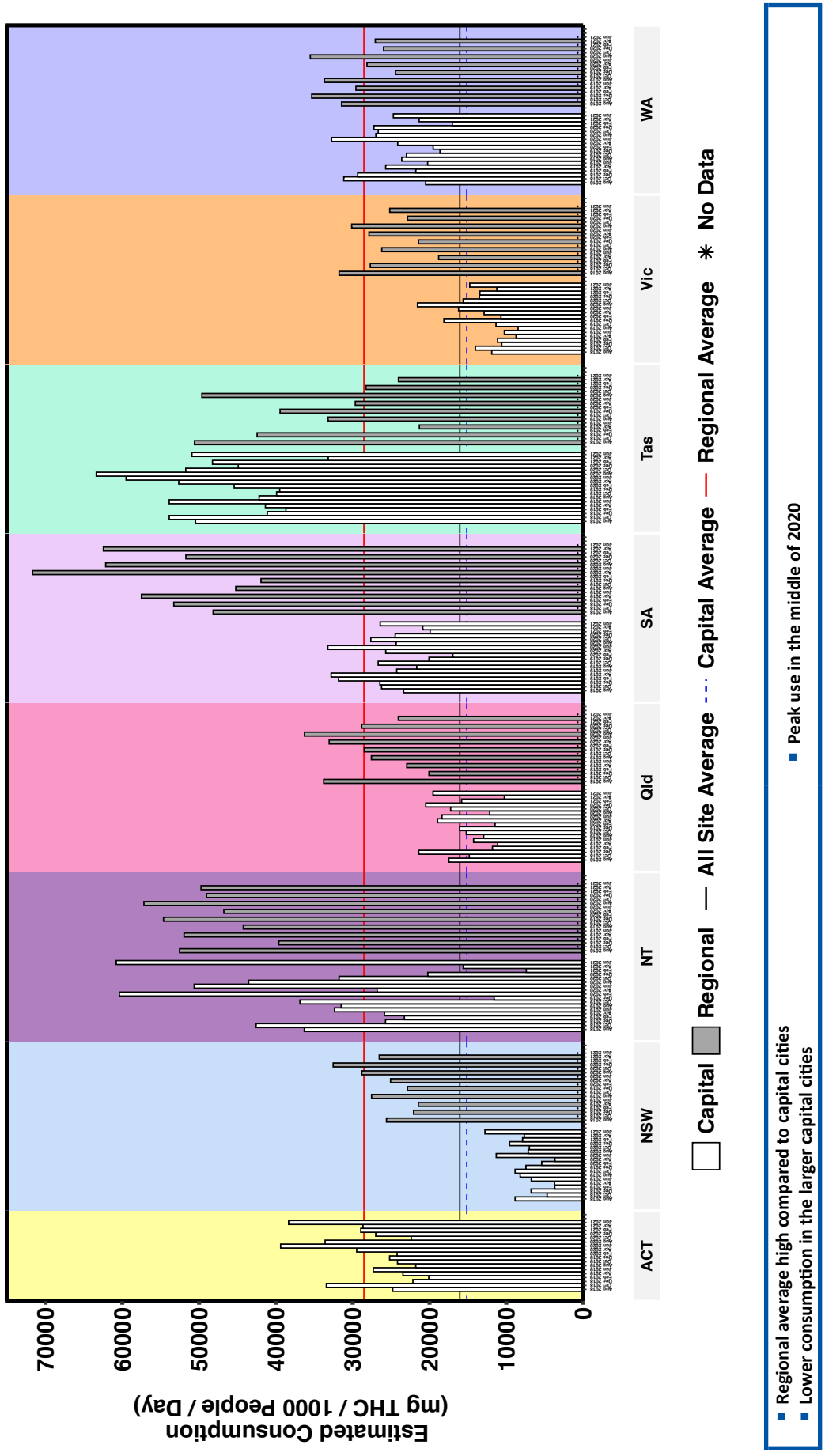
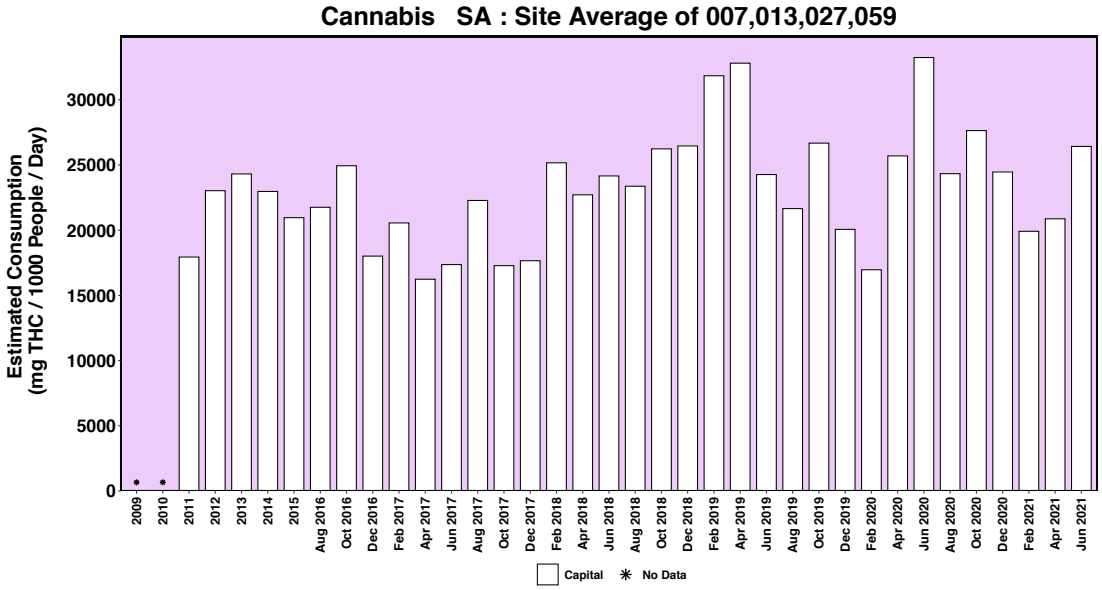


Figure 39: Estimated average consumption of cannabis by state/territory, August 2018 to June 2021.

Consumption of cannabis has previously been measured in capital city South Australia since 2011. An upward trend emerged up to early 2019, followed by a short-term decline to February 2020 (Figure 40). Cannabis use in the capital of the state increased after the outbreak of the COVID-19 pandemic, but has fluctuated since that time.

Figure 40: Change in cannabis consumption in capital city South Australia. Cannabis is detected via the THC metabolite, THC-COOH.



4.2.5 KETAMINE

Ketamine has only been included in the Program since December 2020. Therefore, only four collections have been conducted in capital cities and two in regional Australia. Early findings suggest that use in the capital cities exceeds that in regional areas (Figure 41). The Northern Territory capital city catchment shows large variability between collection periods.

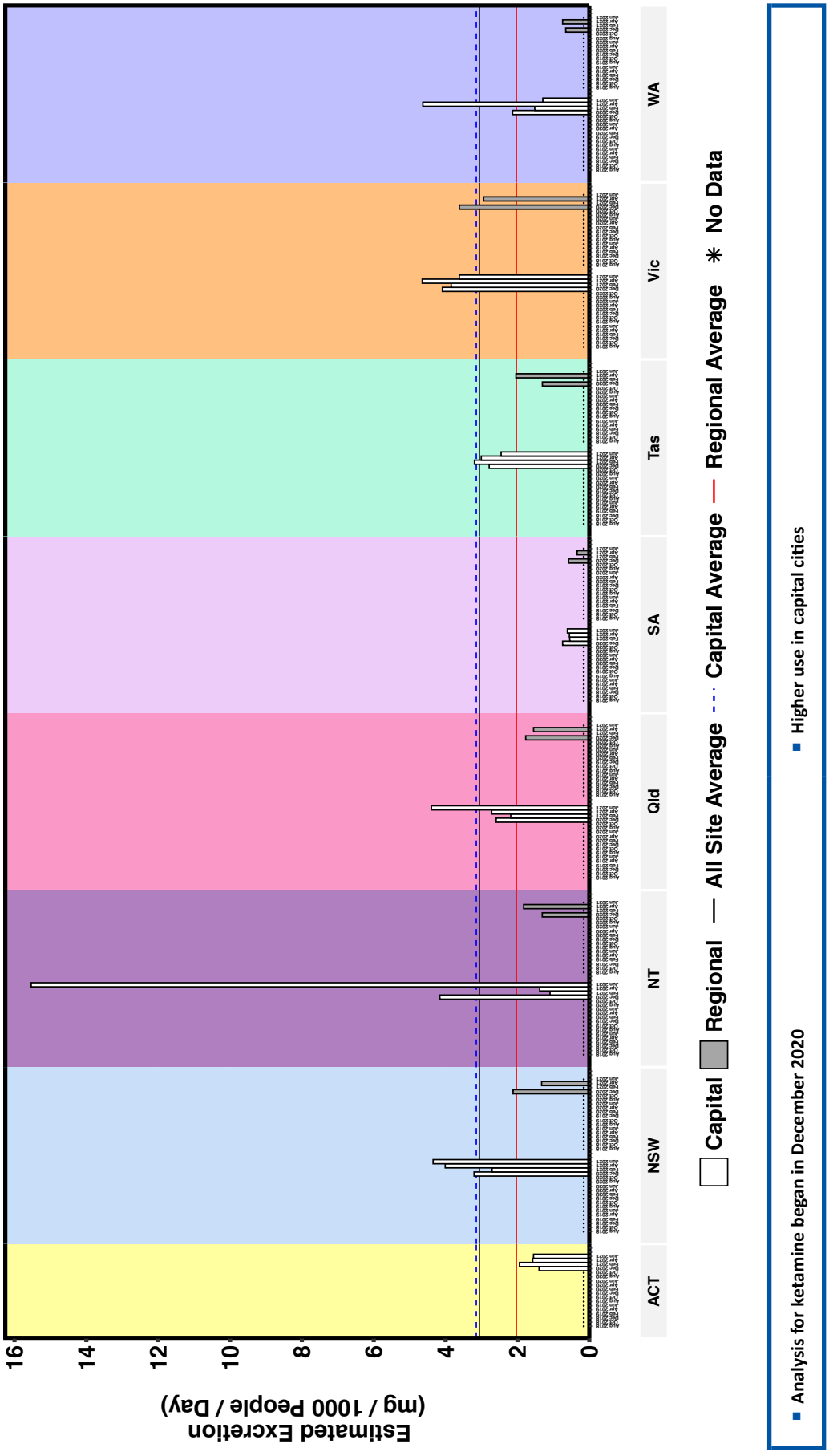


Figure 41: Estimated average consumption of ketamine by state/territory, August 2018 to June 2021.

4.3 NATIONAL CAPITAL CITY AND REGIONAL AVERAGES

In order to show the national trends in the use of individual substances, all capital city and regional sites were combined and displayed as separate graphs for the total sampling period (Figure 42 to Figure 47). Fewer sites were sampled in October 2016.

In terms of legal substances with abuse potential, nicotine consumption has remained relatively unchanged from the start of the Program, with only small fluctuations evident, and alcohol consumption has reduced (Figure 42). Nicotine use reached a high point in December 2019, but levels have slowly declined since then. Results from this reporting period again show a marginal decline in capital city and regional nicotine consumption. In the case of alcohol, the highest level of regional consumption during the life of the Program occurred in December 2019, before a relatively steady decline to April 2021. During the same period, capital city consumption has fluctuated, but largely remained unchanged to April 2021.

Overall methylamphetamine consumption rates in regional Australia increased more than in the capital cities from early 2017 to April 2020 (Figure 43). Between April and August 2020 there was a substantial decline in capital city and (particularly) regional consumption of methylamphetamine, but since August 2020 there has been a gradual increase in consumption in both capital city and regional locations. It is noteworthy that the gap between capital city and regional use has diminished since April 2020, with regional consumption even briefly dropping below capital city consumption in December 2020 for the first time since April 2017.

MDMA consumption rates declined overall over the first year of the Program, followed by a gradual increase until April 2019, a short lived reduction in consumption until August of that year and a substantial increase in consumption in December 2019 (Figure 43). Since that time there has been a tangible decline in consumption in capital city and regional areas, to the extent that by June 2021 capital city consumption was almost at the lowest level recorded by the Program. Regional consumption in April 2021 was also close to the lowest levels recorded by the Program.

Long-term trends in cocaine and MDA consumption clearly showed the discrepancy between capital city and regional use of these illicit substances (Figure 44). Cocaine consumption in the capital cities far exceeded that in regional Australia. Overall cocaine consumption in the capital cities has been trending upwards over the lifespan of the Program, reaching a peak in mid-2020, although since December 2020 there has been a consistent decline in capital city cocaine consumption. There has also been a decline in cocaine consumption in regional locations since December 2020.

For the first time in April 2021, capital city MDA consumption exceeded regional consumption. Regional consumption of MDA is variable and is mainly driven by a small number of sites in Queensland. MDA consumption has been consistently low at capital city sites for the life of the Program.

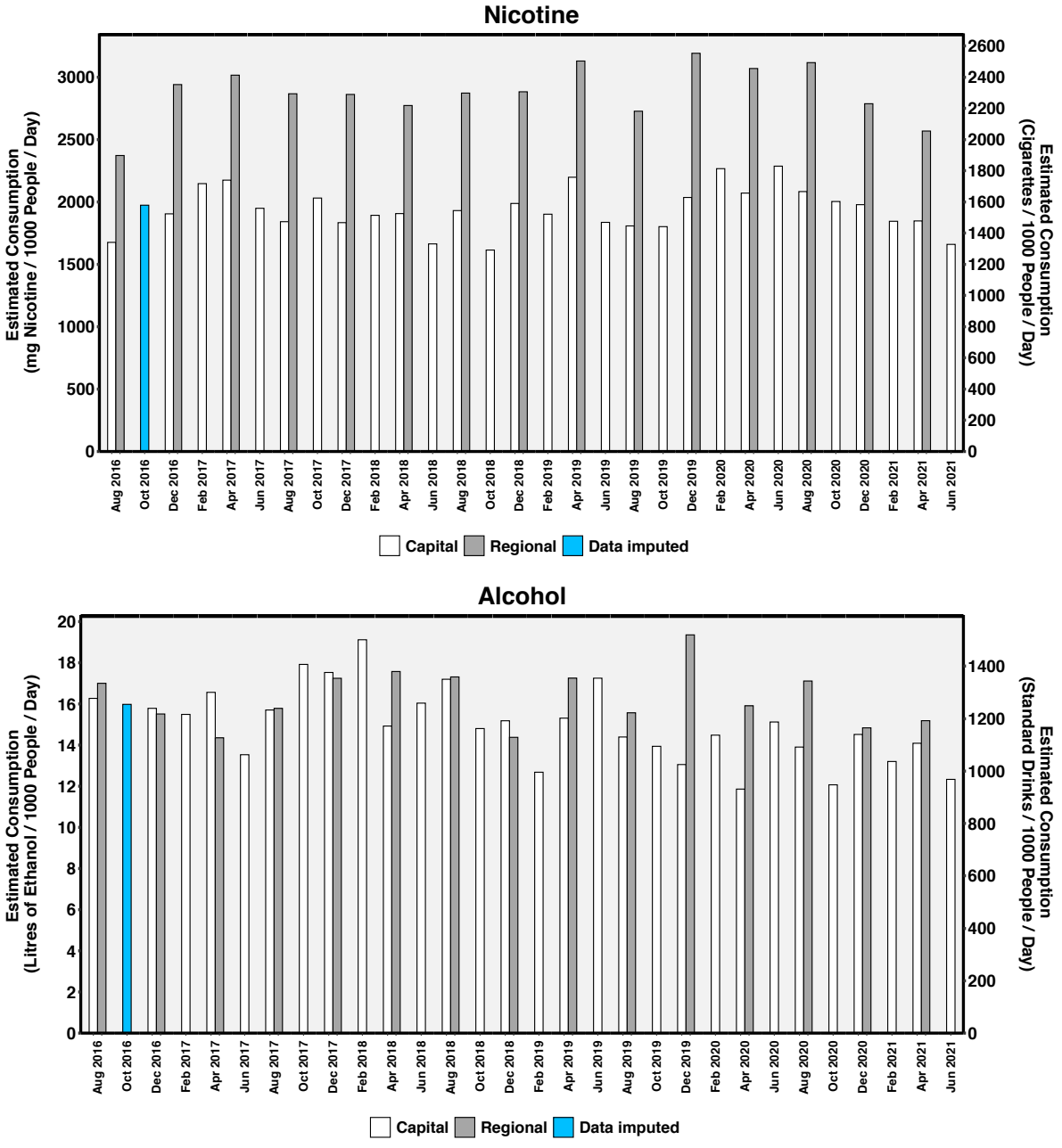
Up until December 2020, there was a distinct difference between capital cities and regional Australia for the two pharmaceutical opioids monitored by the Program (Figure 45). This continues to hold true for oxycodone, however for fentanyl the difference is now less pronounced.. Oxycodone consumption increased steadily after early 2017 and reached a peak in December 2018, but has declined since then. This has been more apparent in the case of regional centres. There was a steady but not uniform increase in capital city and regional consumption of fentanyl to December 2018. Since then, consumption in both capital city and regional locations has declined considerably and is now at the lowest levels recorded by the Program.

The remaining substances, heroin, ketamine and cannabis, had mixed trends in consumption (Figure 46 and Figure 47, respectively). Heroin reached its highest recorded levels in capital cities in August 2020, before declining considerably. Consumption of the drug in regional areas remains at a relatively low level and has continued to decline since April 2020.

Ketamine was included for the first time in the previous reporting period (December 2020 and February 2021). Early signs are that use of ketamine tends to be higher in the capital cities. There have only been minor fluctuations in capital city consumption to date.

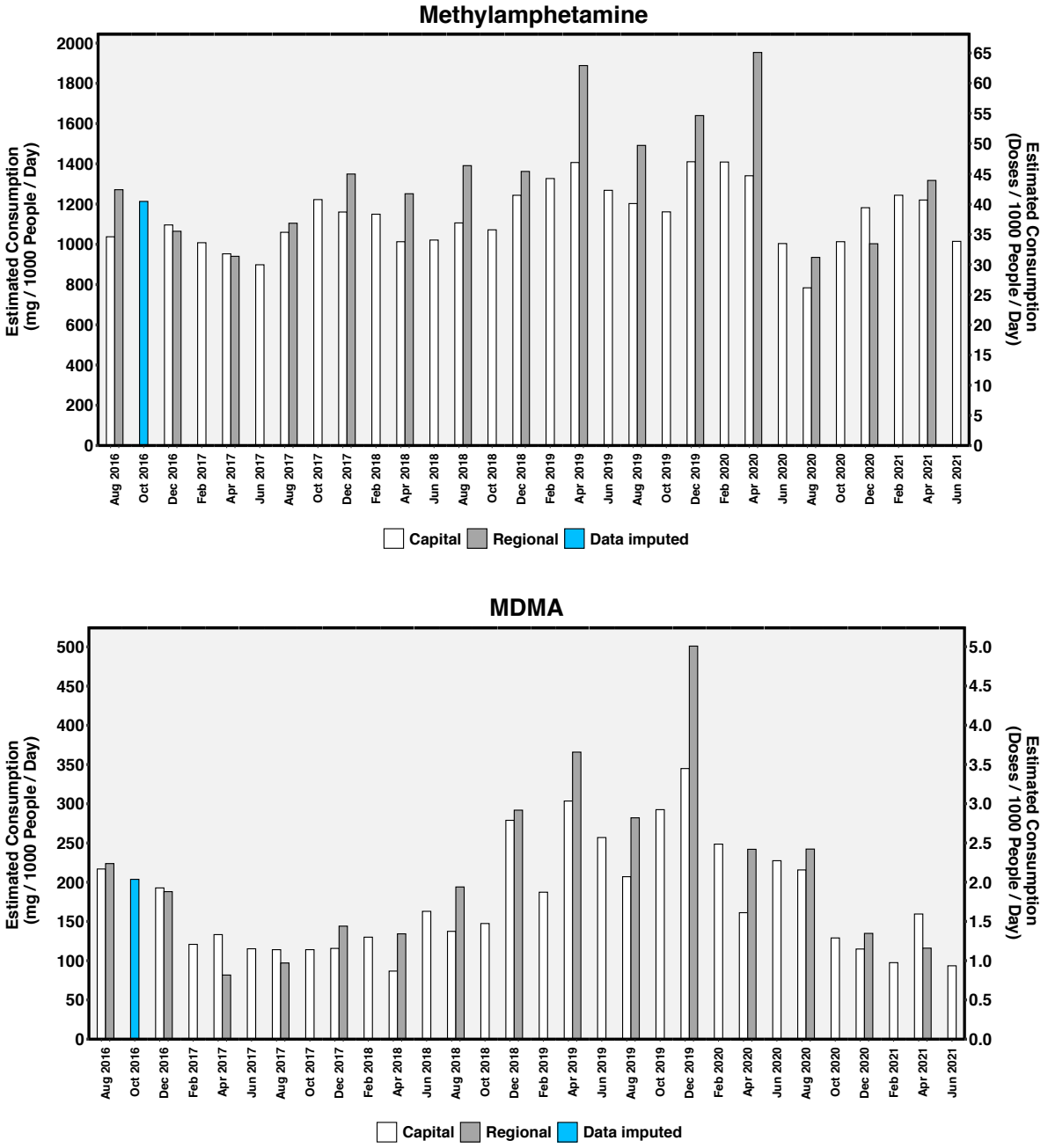
Cannabis consumption at capital city sites has fluctuated within a relatively narrow range since monitoring commenced in August 2018 and current consumption is only slightly higher than that recorded early in the Program (Figure 47). Cannabis use reached its highest levels in regional Australia in August 2020, since when it has declined.

Figure 42: The population-weighted average of all sites for nicotine and alcohol.



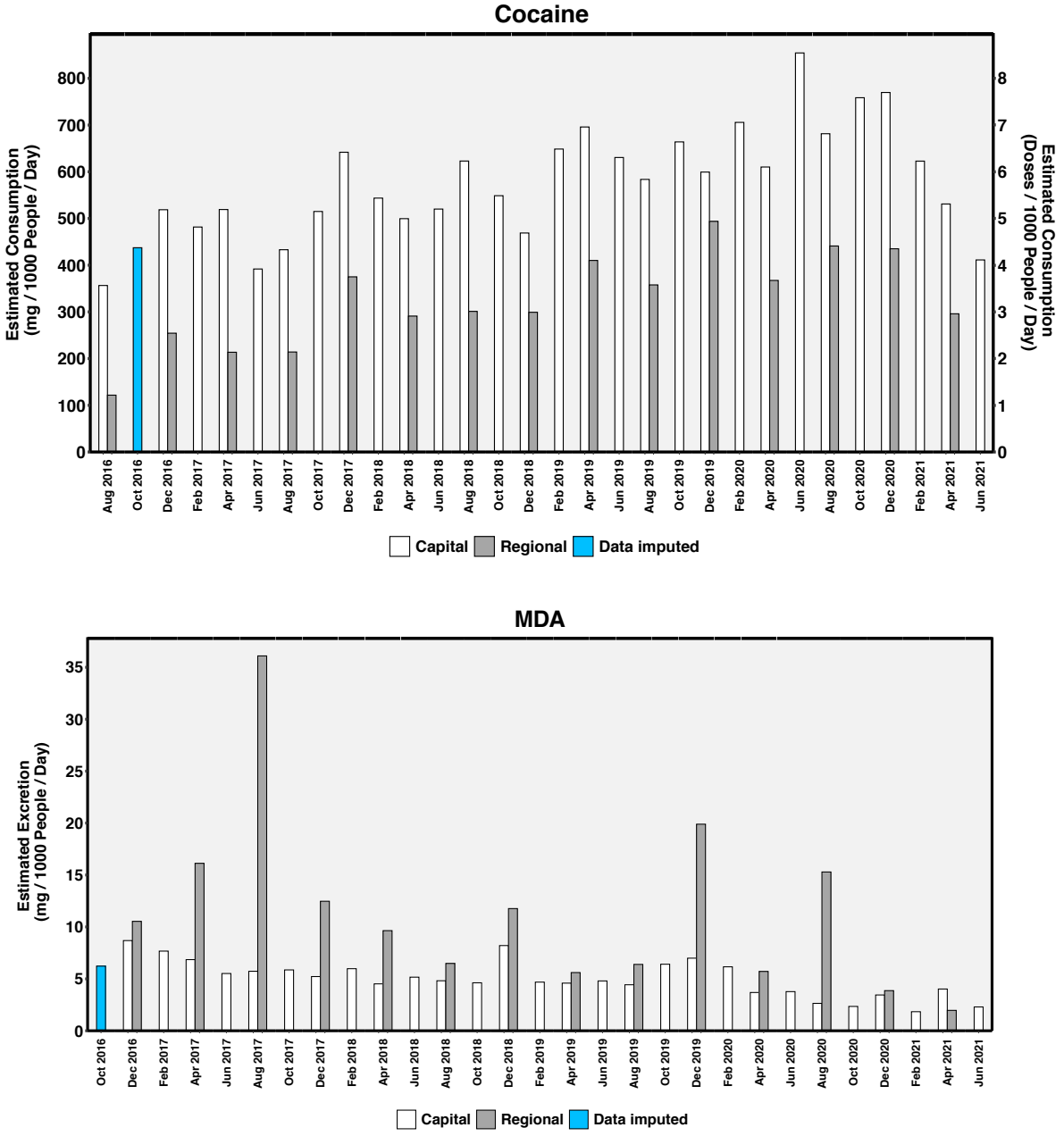
Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

Figure 43: The population-weighted average of all sites for methylamphetamine and MDMA.



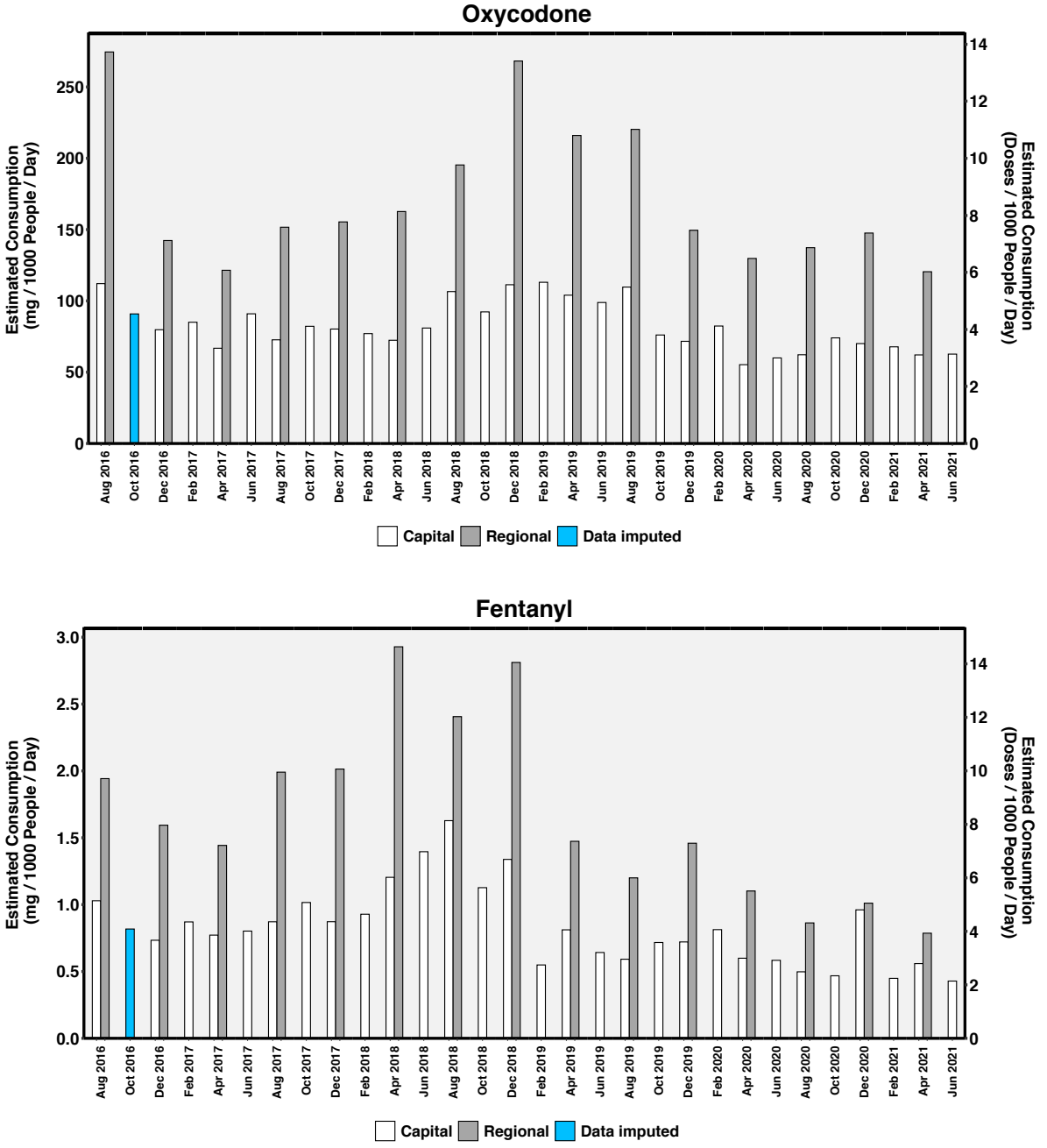
Regional areas are only sampled every second collection period. As Queensland and New South Wales capital city sites were not sampled in October 2016, their average consumption in August and December 2016 was used to provide the overall October estimate.

Figure 44: The population-weighted average of all sites for cocaine and MDA.



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

Figure 45: The population-weighted average of all sites for oxycodone and fentanyl.



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

Figure 46: The population-weighted average of all sites for heroin and ketamine.

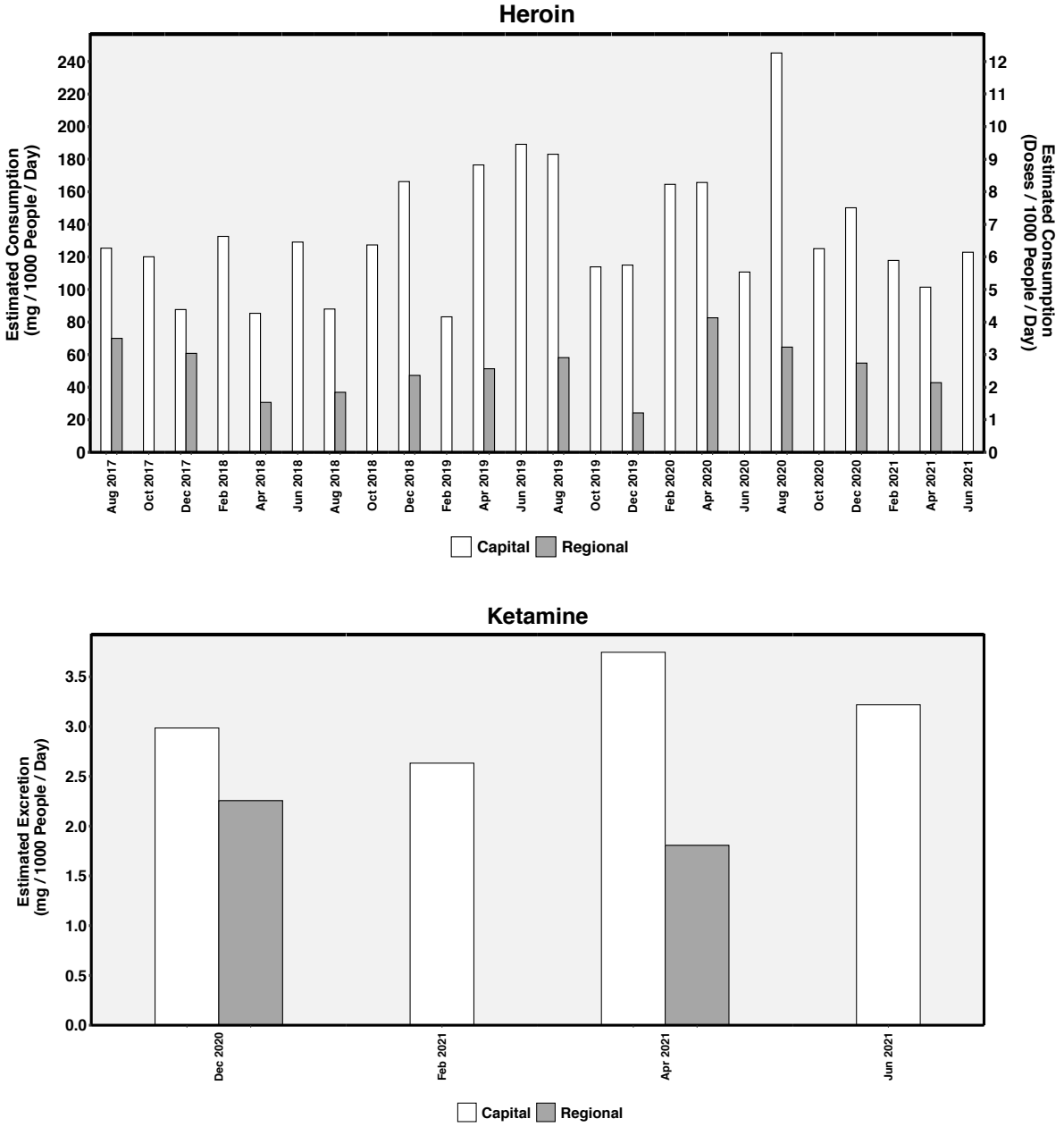
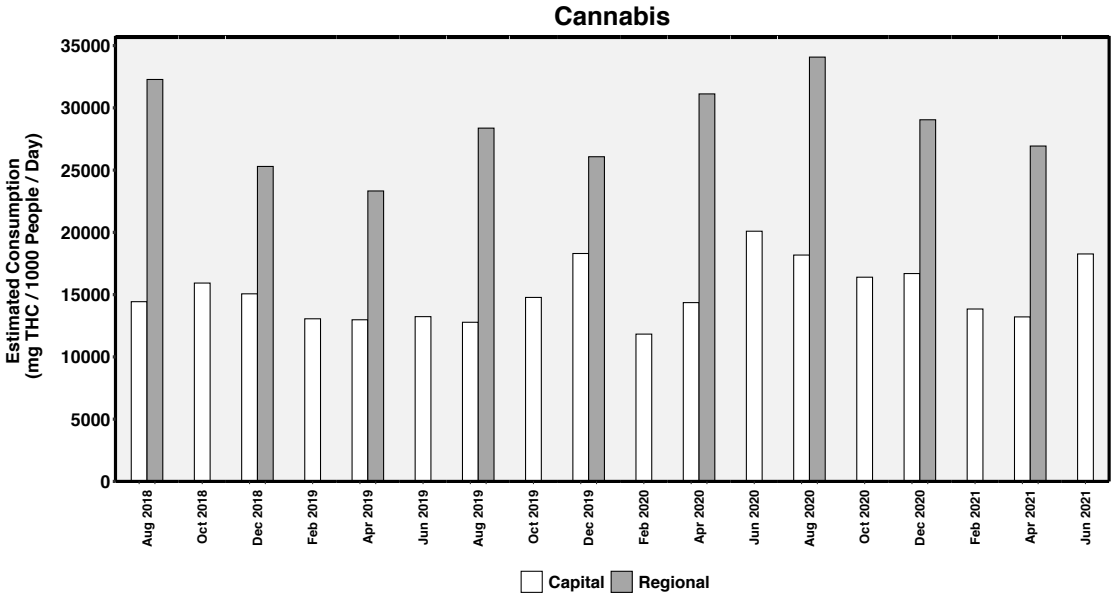


Figure 47: The population-weighted average of all sites for cannabis.



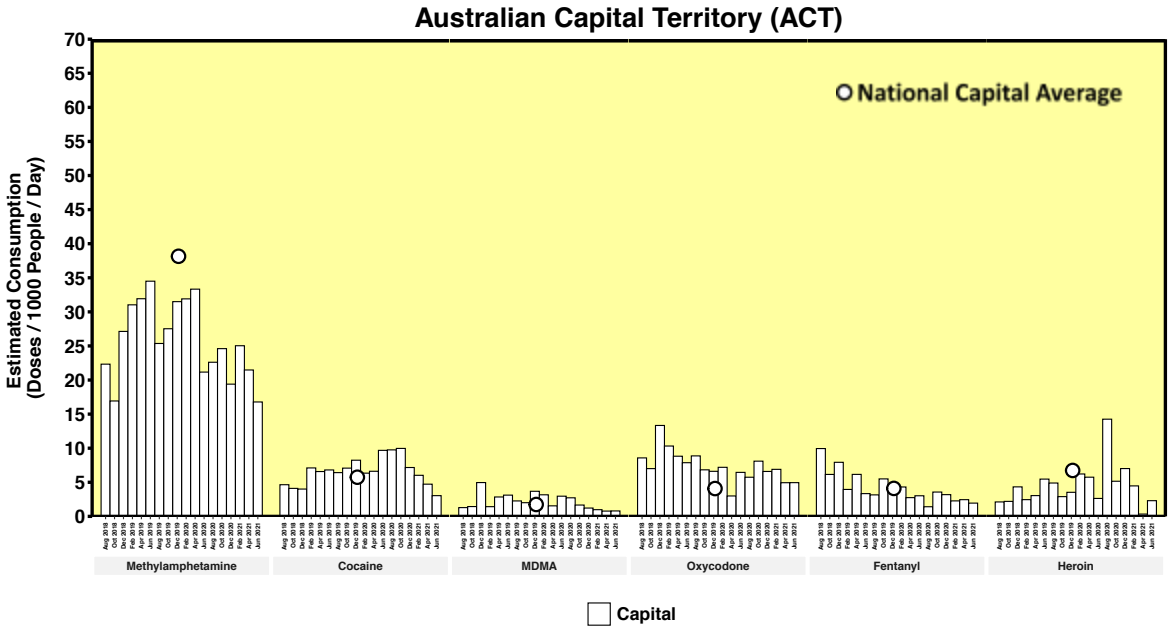
4.4 DRUG PROFILE FOR EACH STATE AND TERRITORY

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

When the amount of drug measured in wastewater was normalised for population size and average dose consumed (excretion factors listed in Appendix 1), alcohol and nicotine remained consistently the highest consumed drugs in all states and territories. For example, the national average consumption of nicotine and alcohol per 1,000 people per day in April 2021 was approximately 1,600 cigarettes (Figure 5) and 1,200 standard drinks (Figure 6), whereas for methylamphetamine, the national average consumption was approximately 40 doses per 1,000 people per day (Figure 9).

Aside from nicotine and alcohol, of the illicit stimulants with dose information available, methylamphetamine use remained highest of the drugs included in the report (Figure 48 to Figure 51). This was the case across all regions of Australia, with the scale of use of methylamphetamine consistently high for both capital cities and regional sites. Even with the dramatic reduction in methylamphetamine use in some states due to the pandemic, e.g. Western Australia where use declined to historical lows in August 2020, the drug was still present at higher levels than any other illicit substance included in the graphs (Figure 51). During the early stage of the Program, regional methylamphetamine use in New South Wales far exceeded use in the capital city. More recently, the relative scales of use are more similar, and in December 2020 capital city consumption exceeded regional consumption in New South Wales. In terms of the profiles of other drugs monitored by the NWDMP (cocaine, MDMA, oxycodone and fentanyl), the patterns were less consistent. The proportional increase in cocaine in the Australian Capital Territory up to October 2020 was conspicuous, but levels have declined since then. In most states, a decline in pharmaceutical opioid use is apparent, especially in regional areas (Figures 48 to 51).

Figure 48: Profile of average drug consumption by state or territory, August 2018 to June 2021 for capital sites and to April 2021 for regional sites. Consumption is shown as the number of doses per 1,000 people per day to allow comparison of drugs of different types within the same region (state or territory). The circles represent the cumulative national average of all time points for respective drugs.



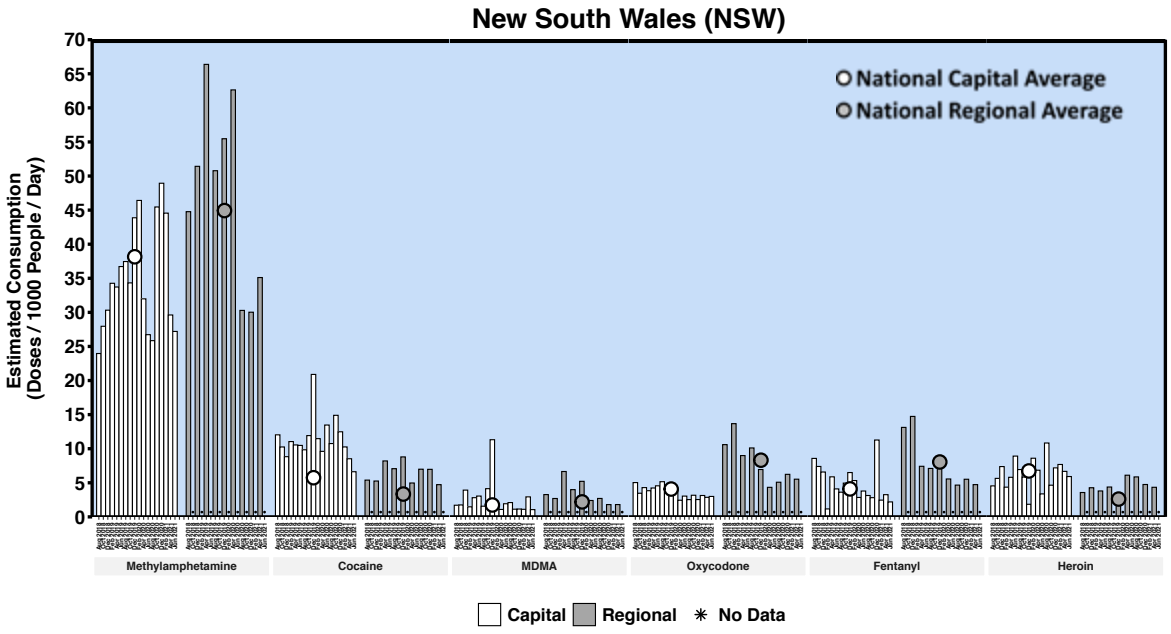


Figure 49: Profile of average drug consumption by state or territory, August 2018 to June 2021 for capital sites and to April 2021 for regional sites.

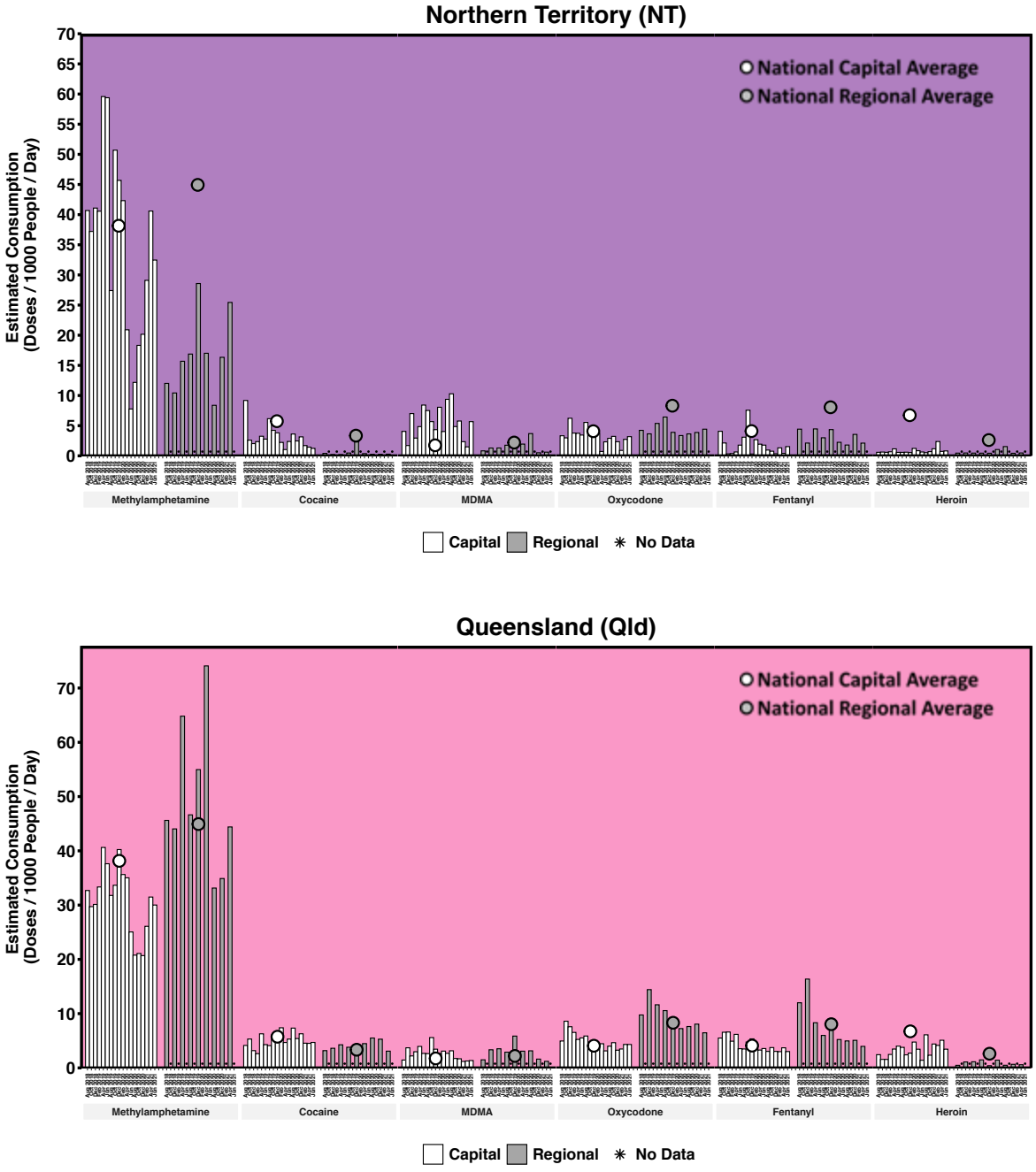
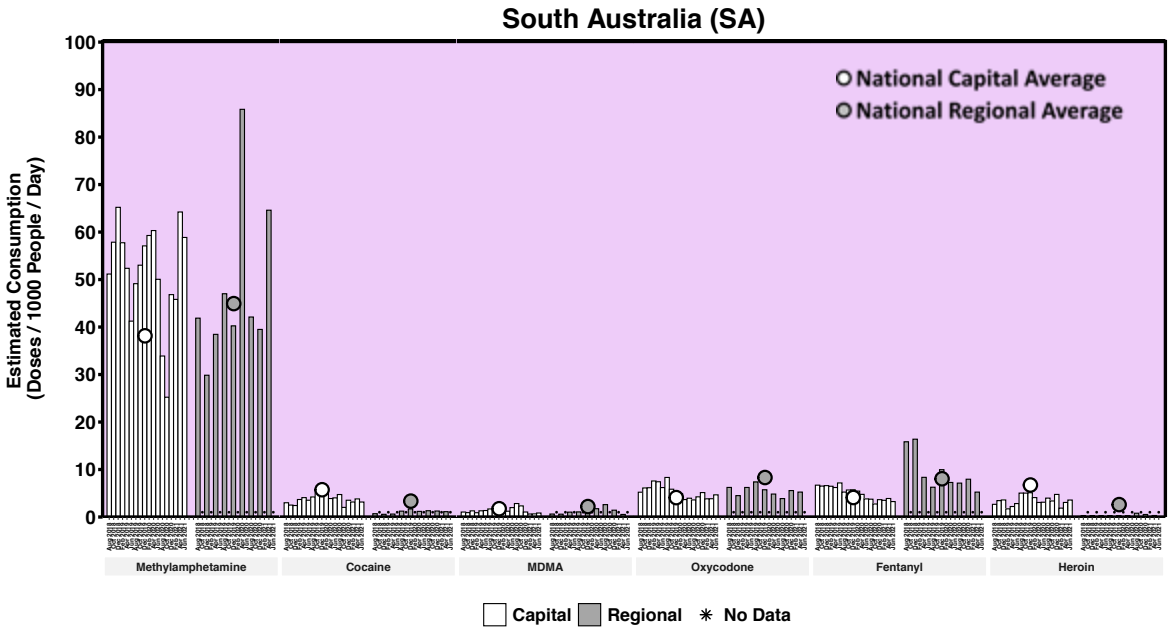


Figure 50: Profile of average drug consumption by state or territory, August 2018 to June 2021 for capital sites and to April 2021 for regional sites. Note: the y axis for South Australia is higher than the other jurisdictions.



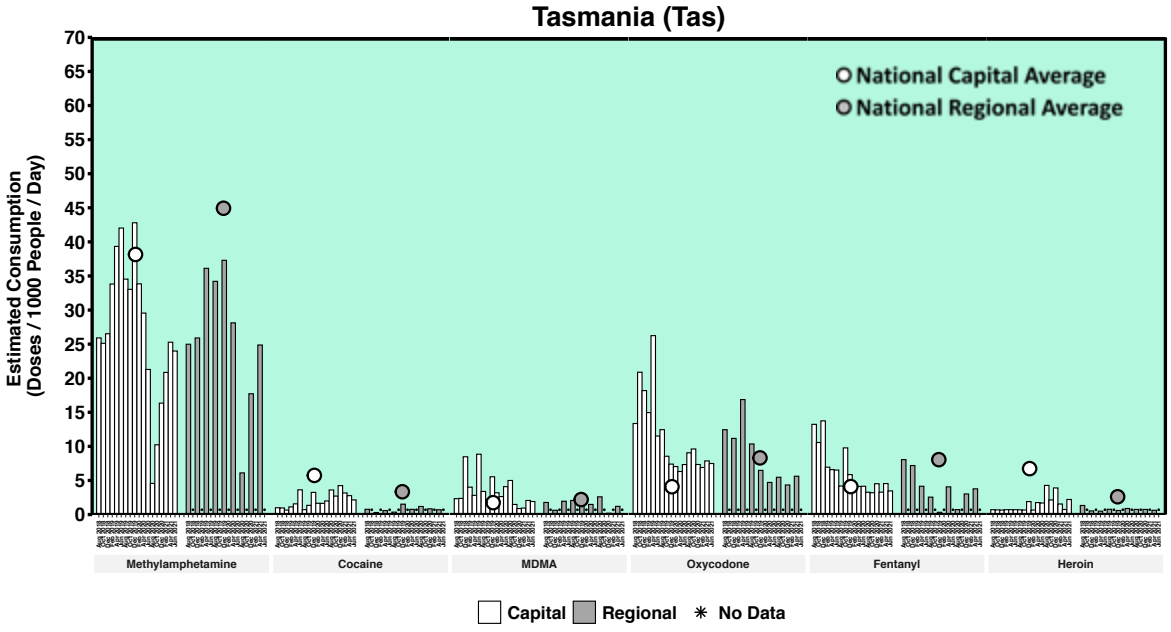
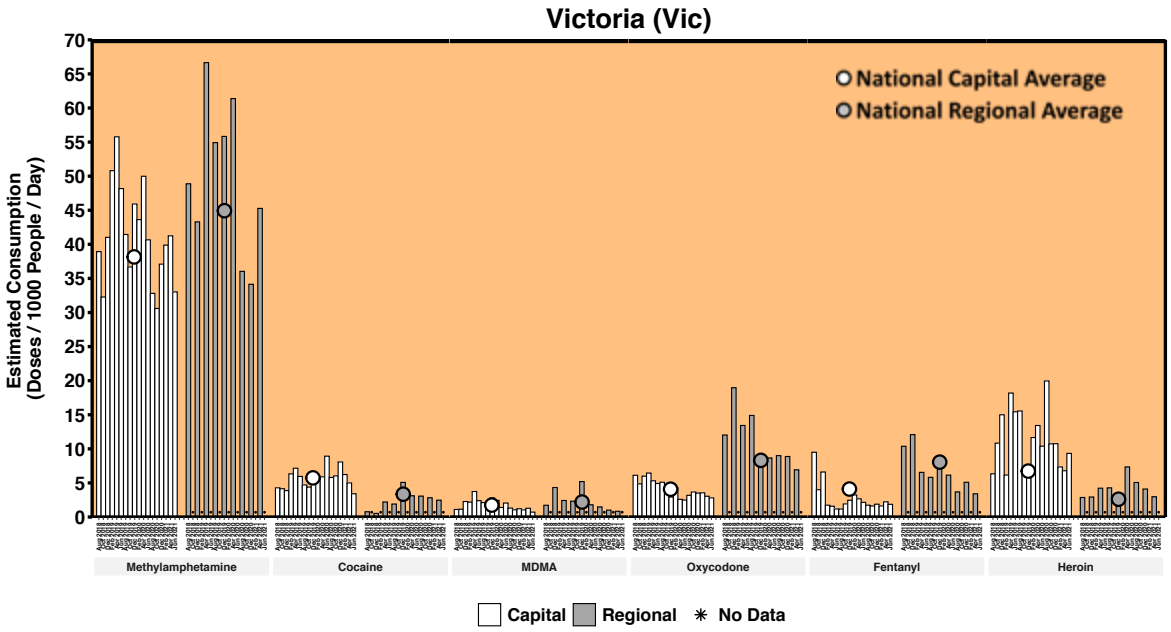
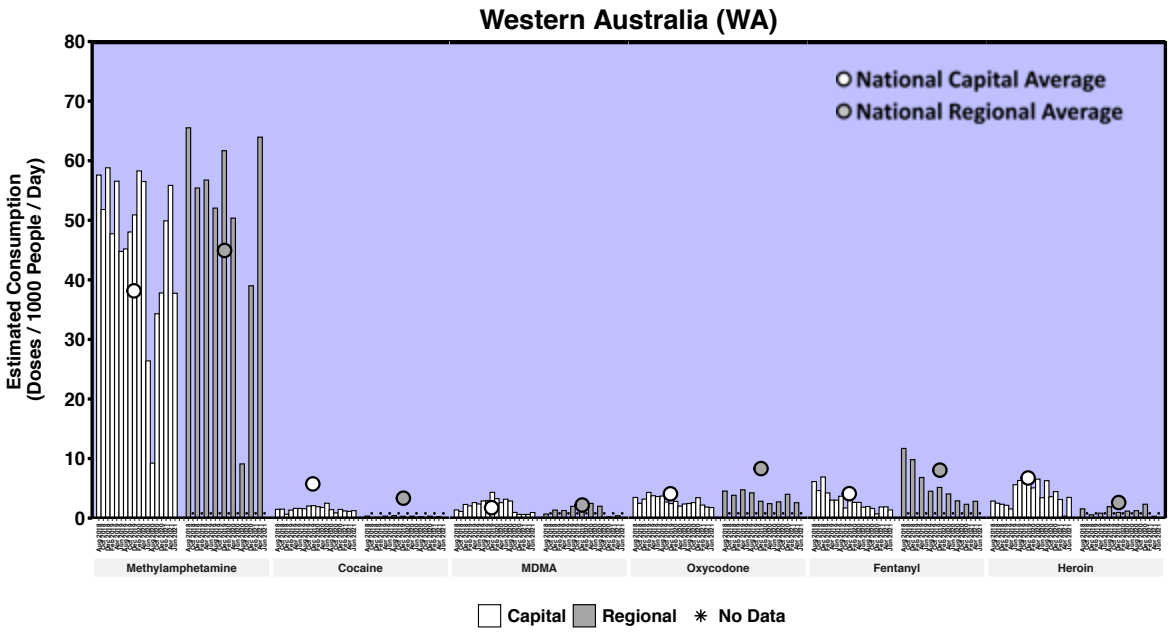


Figure 51: Profile of average drug consumption by state or territory, August 2018 to June 2021 for capital sites and to April 2021 for regional sites. Note: the y axis for Western Australia is higher than the other jurisdictions.





5: COMPARISONS WITH INTERNATIONAL DATA

5.1: BACKGROUND

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

European data from this inter-laboratory testing regime were obtained from the SCORE network, as reported on the EMCDDA website[6] and estimated from the SCORE results figures[7] for non-European sites. The most recent data available were collected between March and May 2020 from participating laboratories, specifically from 138 sites in 28 countries across Europe, and 4 countries outside Europe. The collection period coincided with the first spread of COVID-19 and associated lockdowns or restrictions on social interaction and movement. It is possible that the levels of drug use may have been affected by the pandemic, so some caution is required when comparing results with the current period covered by this Report 14. SCORE reports their results as the amount of drug excreted in mg per day per 1,000 people, whereas the NWDMP converts these measures to consumption (either as mg consumed/day/1,000 people or doses consumed/day/1,000 people). To compare the same units, the SCORE data were converted to the NWDMP consumption estimates by applying the same excretion factors and doses used in the NWDMP. The data for each site was aggregated by population-weighting each site to formulate the country average, using the same methodology as the NWDMP.

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

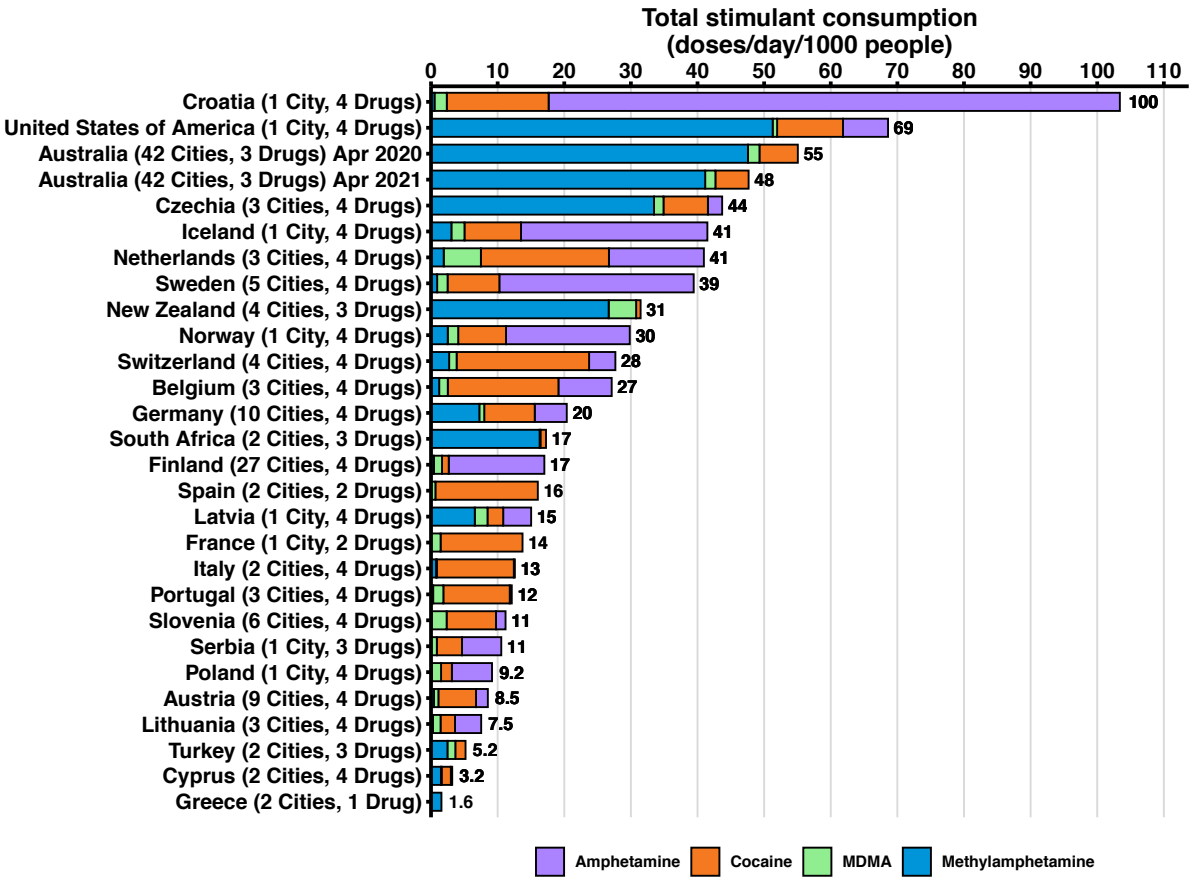
6 See Wastewater analysis and drugs — a European multi-city study, available from <https://www.emcdda.europa.eupublications/html/pods/waste-water-analysis_en>.
7 See SCORE monitoring 2020, available from <https://score-cost.eu/wp-content/uploads/sites/118/2021/05/SCORE_2020_publish_v4d.pdf>.

5.2: RESULTS

Due to the large difference in consumption between the stimulant drugs, it may be useful to compare total stimulant use between locations to account for these differences. In Figure 52, cocaine, MDMA (ecstasy), methylamphetamine and amphetamine were expressed as the number of doses/day/1,000 people and summed to evaluate the total use of these four common stimulants. In the case of amphetamine, all data were adjusted for the expected percentage of the drug which is derived from methylamphetamine metabolism. It should also be noted that not all sites measured for or detected all drugs, which may also limit the comparisons between some locations. In some countries, including Australia, amphetamine (such as dextroamphetamine or dexamfetamine) can also be prescribed for the treatment of ADHD and cannot be separated using the methodology which has been used to acquire these drug concentrations.

Two sets of values were determined for Australia to reflect the current reporting period as well as the period coinciding with the 2020 SCORE release. Australia ranked third highest in terms of combined stimulant use when compared to the SCORE dataset at 48 and 55 doses per day per 1,000 people for April 2021 and April 2020 respectively (Figure 52). The Australian data were driven chiefly by methylamphetamine consumption and were third in total doses per day per 1,000 people after Croatia (100) and the United States of America (USA; 69), and just higher than Czechia (formerly the Czech Republic, 44), Iceland (41), the Netherlands (41) and Sweden (41). It is apparent that the Australian, USA and Czechian rankings are a consequence of a high proportion of methylamphetamine use, whereas Iceland, the Netherlands and Sweden were proportionally higher in cocaine and/or amphetamine use. For the Australian data, total use of stimulants was higher in April 2020 than in April 2021, but the proportion of each stimulant was similar.

Figure 52: The total amount of stimulants consumed (as the population-weighted average doses per 1,000 people per day) for each country in the SCORE dataset. Note the data labels are rounded to 2 significant figures.

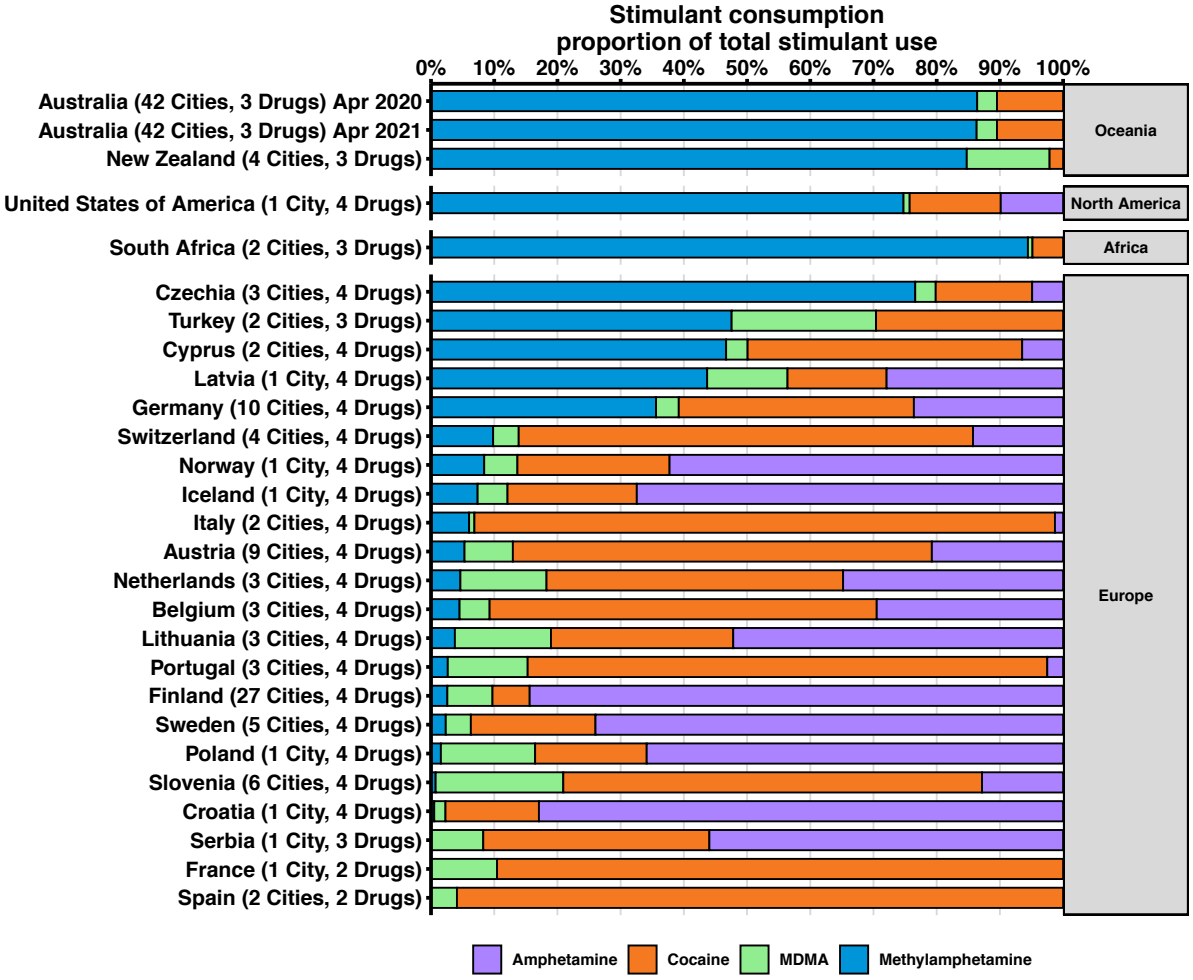


Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE European data were from March 2020. Australian data is from April 2020 and April 2021.

The proportion that each of the four stimulants contributes to the total number of doses can be visualised in a different way to reveal which of the drugs contribute most to the stimulant use within each country. Figure 53 shows the same data as Figure 52 but with each drug scaled as a percentage of the total used within each country. This representation of the data (scaled to the same value of 100 per cent) reveals the contribution of each drug to the total use, or drug profile, which can be compared between locations.

The profile of stimulant use in Australia is heavily influenced by methylamphetamine, at more than 85 per cent of the total stimulants used. This is similar in some Western European countries like Czechia at just under 80 per cent, New Zealand (>80 per cent), the USA (>70 per cent) and South Africa (>90 per cent). Some other participating countries had higher proportions of methylamphetamine than other illicit stimulants, including Germany, Latvia, Cyprus and Turkey, with proportions of methylamphetamine around 35 per cent to 45 per cent of the total stimulant use. In contrast, countries such as Croatia, Sweden, Finland, Iceland, and Poland had proportionally higher amphetamine use of between 60 per cent to 90 per cent of the total stimulant load, while others including Switzerland, Italy, Slovenia, and Portugal had much higher proportions of cocaine consumption (between 60 per cent and 90 per cent of total stimulant use).

Figure 53: National population weighted average consumption for cities reported in the SCORE European study for methylamphetamine, MDMA, cocaine and amphetamine, represented as the proportion of the total stimulant consumption in each country. Note that some countries did not analyse for or detect some substances.



The high methylamphetamine consumption estimates in Australia were evident when comparing the drug individually with sites in the SCORE study (Figure 54). Methylamphetamine levels in Australia were the second highest compared to other countries participating in the study, behind the site in the USA (48 doses/day/1,000 people in Australia in April 2020 vs 51 doses/day/1,000 people in the USA). Some countries in the world with reasonably high methylamphetamine use according to police actions or research papers, such as in Asia and other parts of the Americas, are not published with the SCORE study data and are not represented here. Amphetamine data is shown for the other countries in Figure 55.

Figure 54: National population weighted average consumption of methylamphetamine in Europe and Australia.

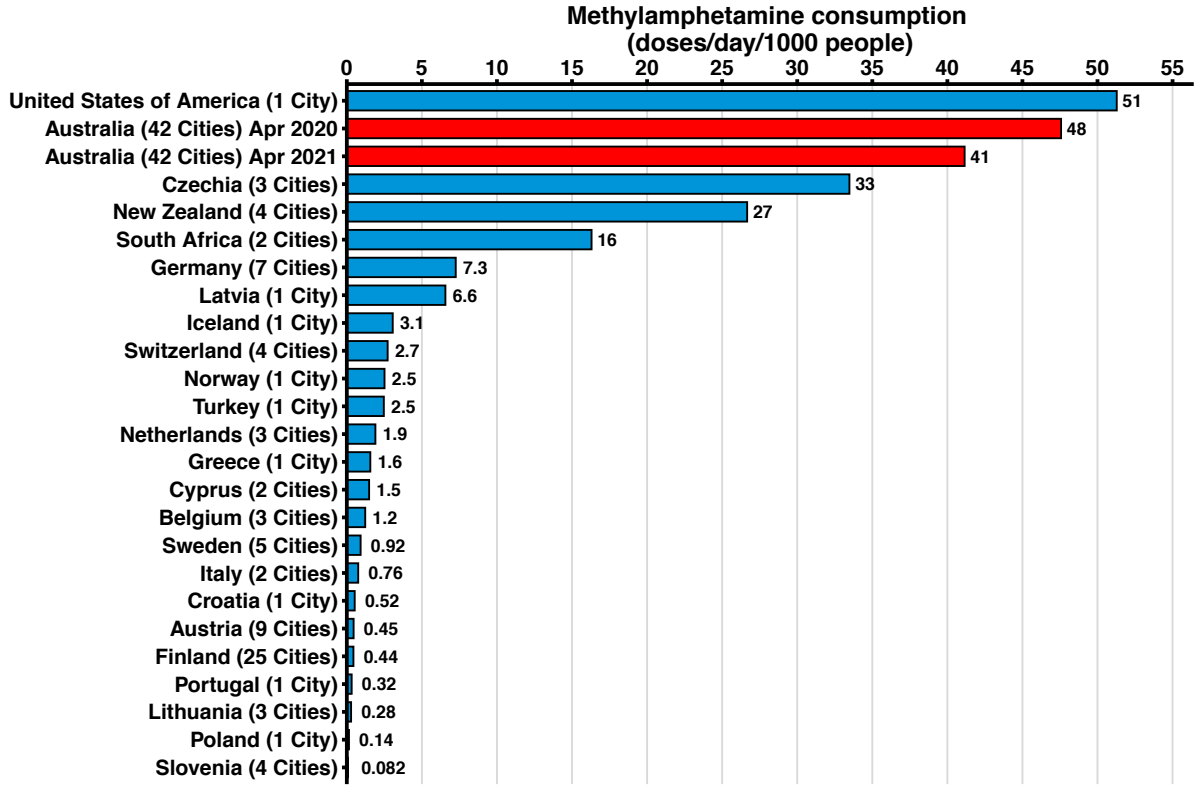
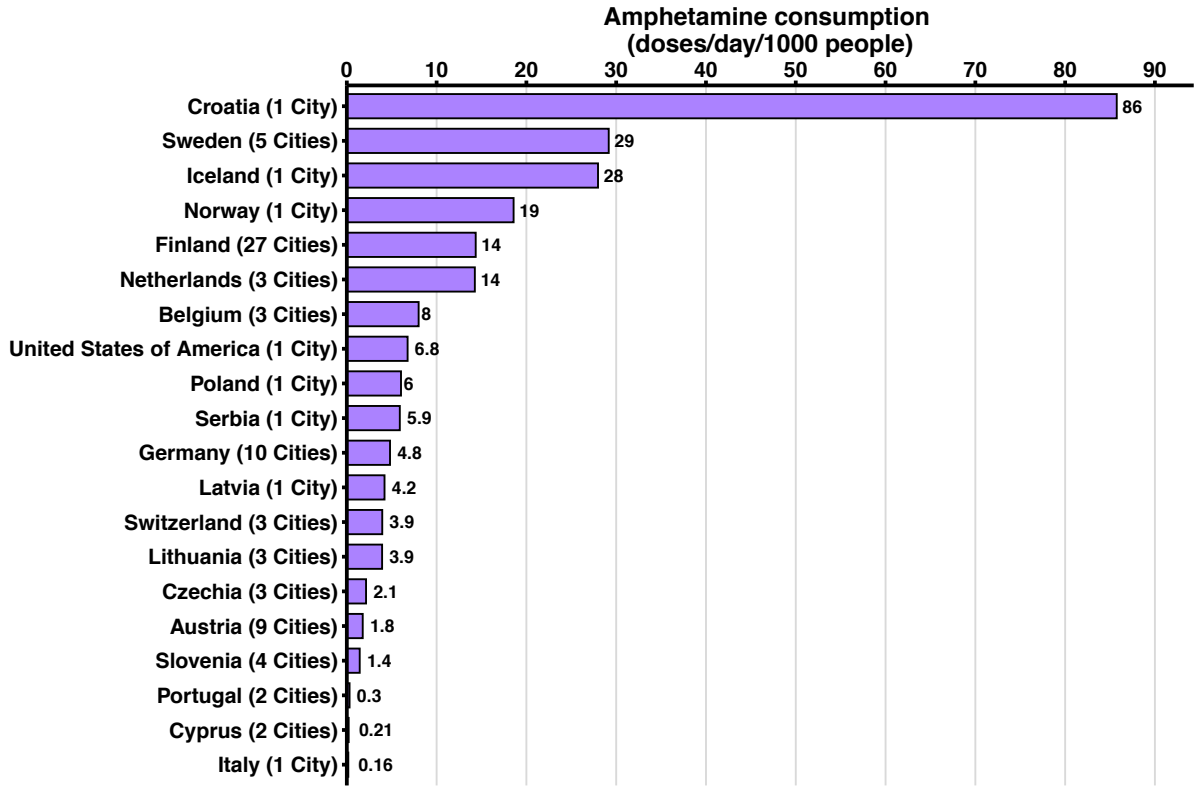


Figure 55: National population weighted average consumption of amphetamine in Europe.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a specific country. All SCORE data were from March-May 2020. Australian data is from April 2020 and April 2021.

Compared to drug usage patterns in the SCORE dataset, Australian cocaine consumption was towards the lower end (5-5.8 doses/day/1,000 people, Figure 56), around one third to one quarter of the highest consumption observed in Switzerland and the Netherlands (19-20 doses/day/1,000 people). Australian MDMA use ranked towards the higher end of consumption levels in the European sites (1.5-1.7 doses per day per 1,000 people, Figure 57) yet was still around three times lower than consumption levels observed in the Netherlands (5.6 doses/day/1,000 people) and substantially lower than New Zealand (4.1 doses/day/1,000 people).

Figure 56: National population weighted average consumption of cocaine in Europe and Australia.

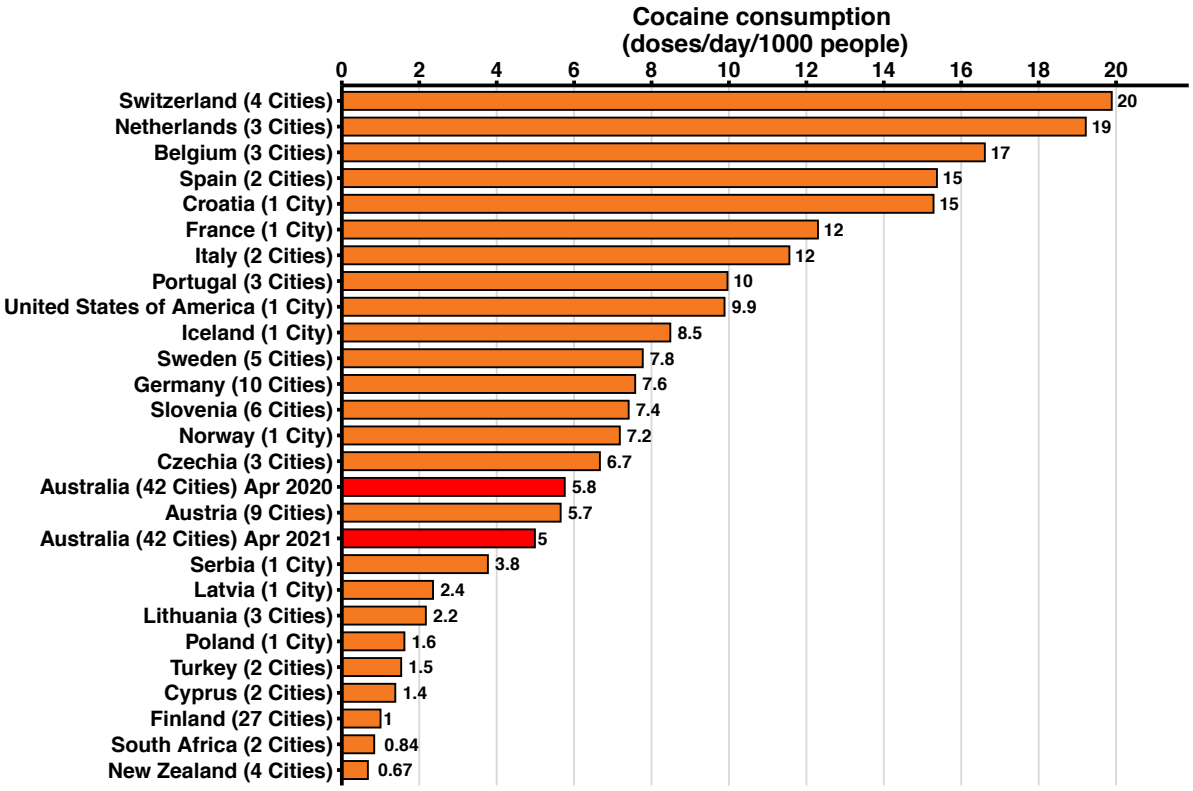
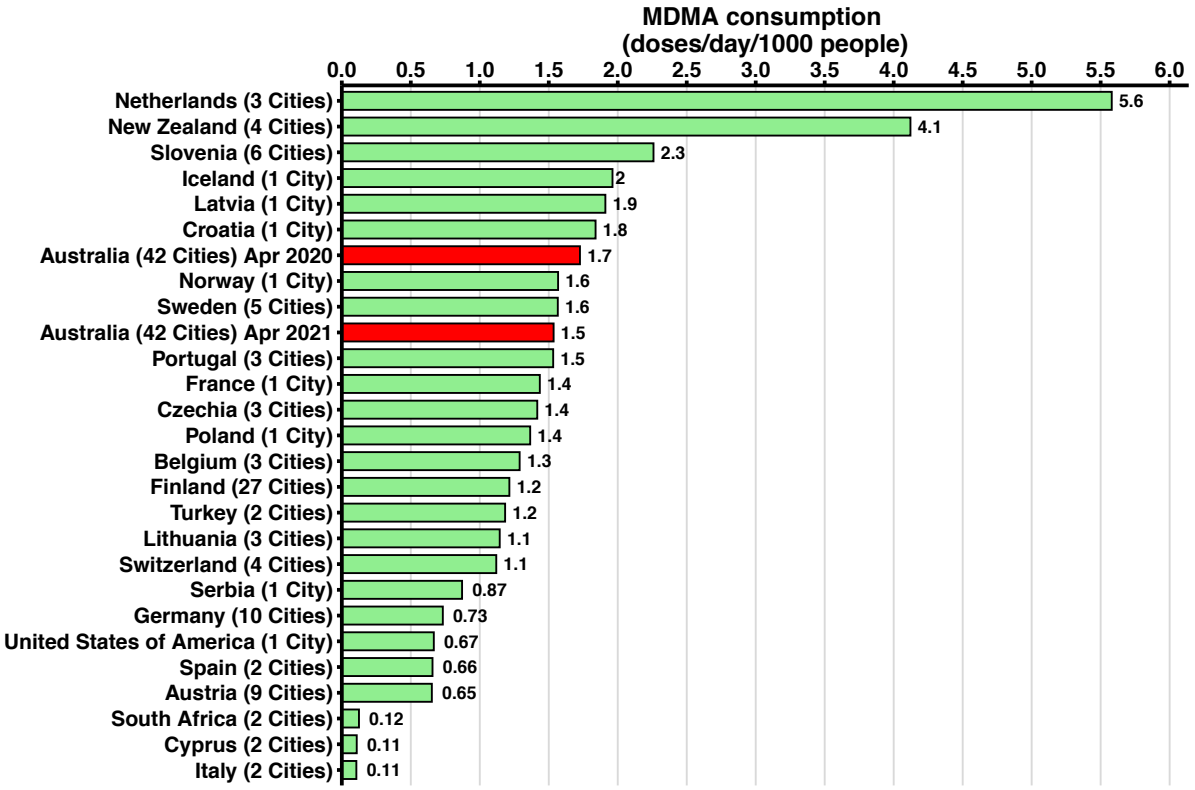


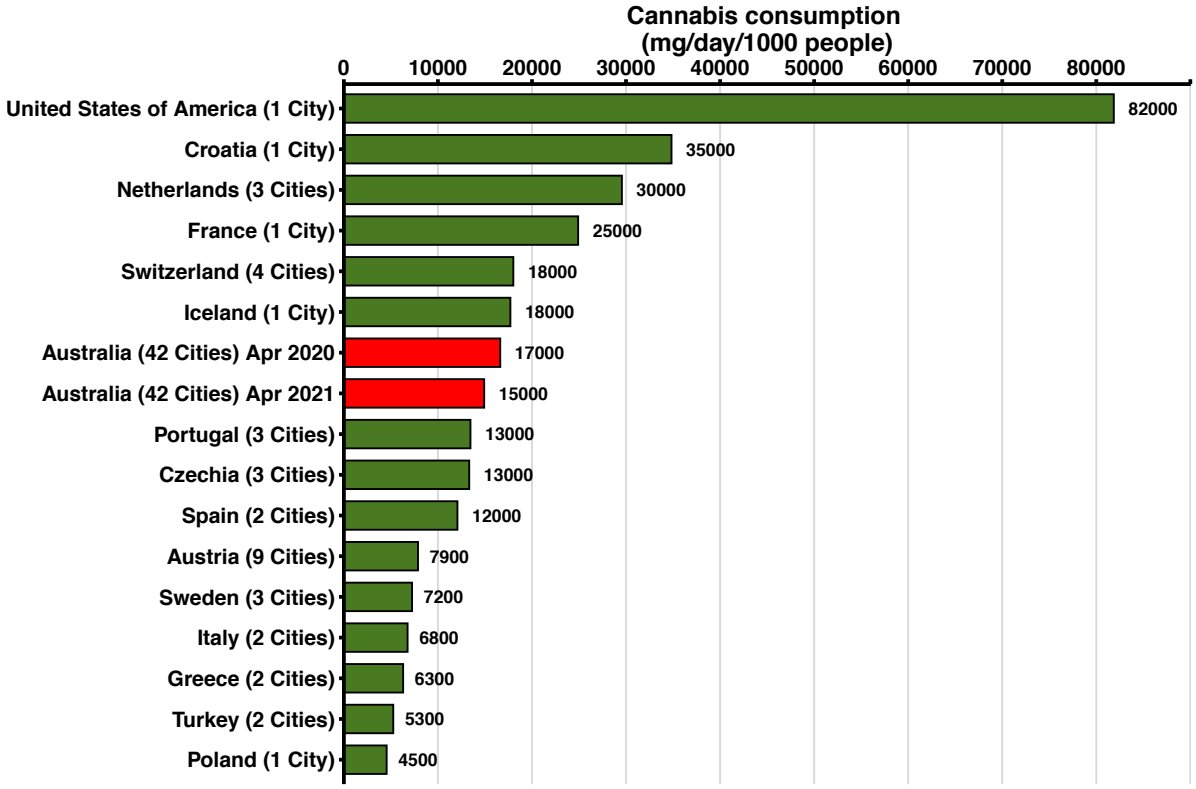
Figure 57: National population weighted average consumption of MDMA in Europe and Australia.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a given country. All SCORE data were from March-May 2020. Australian data is from April 2020 and April 2021.

For the first time in the NWDMP report, Australian data is compared with cannabis consumption assessed in 15 countries across Europe and USA as part of the 2020 SCORE inter-lab sampling campaign. The participating site in the USA had the highest levels at approximately 82,000 mg THC consumed/day/1,000 people, which could be related to the legal status of the drug in many states of the USA. Caution should be taken when comparing international data with the USA data as the legal status of cannabis varies between states and the participating city may not be representative of the country as a whole. Croatia, the Netherlands, and France sites were also among the highest consumers of cannabis, with 25,000 to 35,000 mg THC consumed/day/1,000 people each day. Australian per-capita consumption of cannabis ranked among the mid-level consumption in comparison to the USA and European sites, at around 15,000 to 17,000 mg THC consumed/day/1,000 people. Countries with lower consumption were Greece, Turkey, and Poland, with between 4,500 and 6,300 mg THC consumed/day/1,000 people.

Figure 58: National population weighted average consumption of cannabis in SCORE and Australian datasets.



Note: the international estimates are based on data of a few sites per country only and therefore may not represent the national per capita consumption for a given drug in a given country. All SCORE data were from March-May 2020. Australian data is from April 2020 and April 2021.

6: ACKNOWLEDGEMENTS

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

The University of South Australia would like to thank our funding partners, the Drug and Alcohol Services South Australia (DASSA), for their permission to use historical and current data from South Australia. The University of Queensland thanks Geoff Eaglesham for his contributions to the analytical work for this study and Rachel Mackie and PhD students at QAEHS for their assistance with sample collection and processing.

We also thank the members of the Emerging Environmental Health Risks research group at QAEHS (incorporating the former Entox) for assistance with preparing and shipping sampling bottles to the various plants, and those members, past and present, who helped establish this field at the university.

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

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

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8: APPENDICES

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

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

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

APPENDIX 2: SAMPLING DETAILS OF EACH SITE FOR APRIL AND JUNE 2021.

Site Code	Capital or Regional	April 2021	June 2021	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: 021	Capital	–	–	30,000 to 150,000
NSW: 071	Capital	–	–	> 150,000
NSW: 016	Regional	7	–	30,000 to 150,000
NSW: 025	Regional	7	–	30,000 to 150,000
NSW: 040	Regional	–	–	< 30,000
NSW: 051	Regional	–	–	< 30,000
NSW: 068	Regional	7	–	> 150,000
NSW: 081	Regional	7	–	< 30,000
NSW: 115	Regional	7	–	30,000 to 150,000
NSW: 163	Regional	7	–	< 30,000
NSW: 164	Regional	7	–	< 30,000
NSW: 165	Regional	7	–	< 30,000
NT: 010	Capital	7	7	30,000 to 150,000
NT: 078	Regional	7	–	< 30,000
Qld: 002	Capital	7	7	> 150,000
Qld: 005	Capital	7	7	> 150,000
Qld: 011	Capital	7	6	> 150,000
Qld: 012	Regional	7	–	> 150,000
Qld: 020	Regional	–	–	< 30,000
Qld: 024	Regional	7	–	30,000 to 150,000
Qld: 028	Regional	7	–	30,000 to 150,000
Qld: 029	Regional	7	–	30,000 to 150,000
Qld: 033	Regional	7	–	30,000 to 150,000
Qld: 039	Regional	–	–	< 30,000
Qld: 042	Regional	7	–	30,000 to 150,000
Qld: 053	Regional	7	–	< 30,000
Qld: 077	Regional	7	–	< 30,000
Qld: 092	Regional	–	–	< 30,000
SA: 007	Capital	7	7	> 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: 022	Regional	7	–	< 30,000
SA: 063	Regional	7	–	< 30,000
SA: 076	Regional	7	–	< 30,000
SA: 119	Regional	7	–	< 30,000

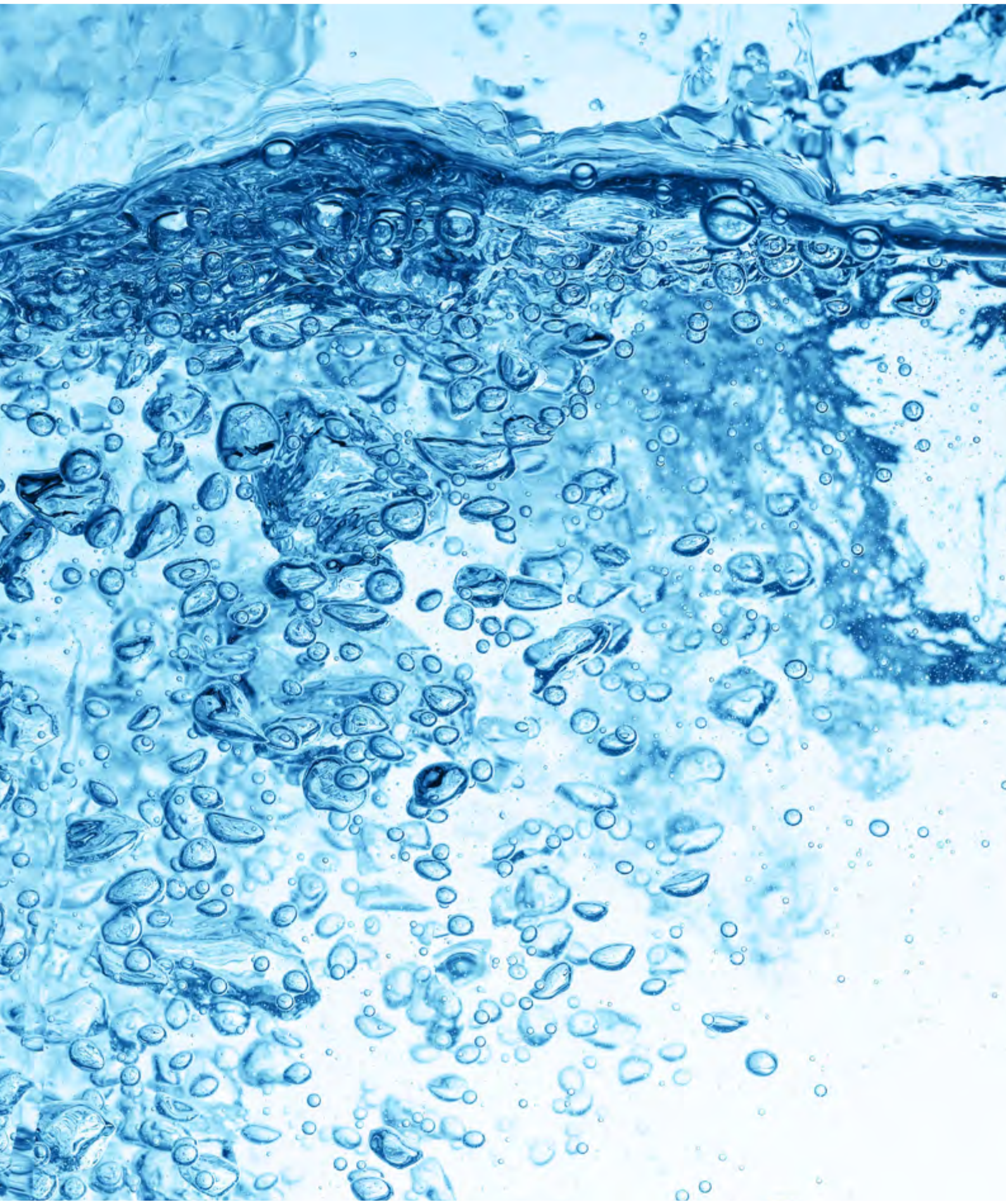
APPENDIX 2 (CONTINUED)

Site Code	Capital or Regional	April 2021	June 2021	Population
Tas: 004	Capital	5	5	< 30,000
Tas: 019	Capital	5	5	< 30,000
Tas: 041	Capital	5	5	< 30,000
Tas: 018	Regional	5	–	< 30,000
Tas: 038	Regional	–	–	< 30,000
Tas: 048	Regional	5	–	< 30,000
Tas: 058	Regional	–	–	< 30,000
Vic: 001	Capital	7	7	> 150,000
Vic: 067	Capital	7	7	> 150,000
Vic: 037	Regional	7	–	> 150,000
Vic: 046	Regional	–	–	30,000 to 150,000
Vic: 061	Regional	7	–	30,000 to 150,000
Vic: 062	Regional	–	–	< 30,000
Vic: 066	Regional	7	–	30,000 to 150,000
Vic: 114	Regional	7	–	30,000 to 150,000
Vic: 121	Regional	7	–	< 30,000
Vic: 122	Regional	–	–	< 30,000
Vic: 123	Regional	–	–	< 30,000
Vic: 124	Regional	–	–	< 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: 118	Regional	–	–	< 30,000
WA: 120	Regional	7	–	30,000 to 150,000
WA: 129	Regional	7	–	< 30,000
Regional Sites		36	–	
Capital Sites		20	20	
Total Sites		**56**	**20**	
Regional Samples		248	–	
Capital Samples		134	133	
Total Samples		382	133	
Cumulative Samples		**6,835**	**6,968**	

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

Drug	Capital or Regional	April 2021	June 2021
Alcohol	Capital	100	100
Alcohol	Regional	100	–
Cannabis	Capital	100	100
Cannabis	Regional	99	–
Cocaine	Capital	100	96
Cocaine	Regional	80	–
Fentanyl	Capital	95	100
Fentanyl	Regional	96	–
Heroin	Capital	44	82
Heroin	Regional	17	–
Ketamine	Capital	92	94
Ketamine	Regional	70	–
MDA	Capital	66	78
MDA	Regional	58	–
MDMA	Capital	100	100
MDMA	Regional	99	–
Methylamphetamine	Capital	100	100
Methylamphetamine	Regional	100	–
Nicotine	Capital	100	100
Nicotine	Regional	100	–
Oxycodone	Capital	100	100
Oxycodone	Regional	100	–

8 Percentage detection for previous collection periods are available in Report 7, 8, 9, 10, 11, 12, Appendix 3 and Report 6, Appendix 4.



CONCLUSIONS

CONCLUSIONS

For the 14th report of the National Wastewater Drug Monitoring Program, wastewater analysis was conducted in April (capital city and regional sites) and June 2021 (capital city sites only). The Program identified variations in patterns of drug consumption, both over time and within and between jurisdictions. Consistent with previous reports, findings show that of the substances monitored with known doses, nicotine and alcohol are the most consumed drugs in Australia, while methylamphetamine remains the most consumed illicit drug.[9]

METHYLAMPHETAMINE

When comparing data for December 2020 and April 2021, the population-weighted average consumption of methylamphetamine increased in both capital city and regional sites. Average capital city methylamphetamine consumption decreased from April to June 2021. In April 2021, regional methylamphetamine consumption returned to the previously observed trend of exceeding capital city consumption. In April 2021, South Australia had the highest estimated average capital city and regional consumption of methylamphetamine.

COCAINE

When comparing data for December 2020 and April 2021, the population-weighted average consumption of cocaine decreased in both capital city and regional sites, with capital city cocaine consumption further decreasing in June 2021. Average capital city cocaine consumption continues to exceed average regional consumption. In April 2021, New South Wales had the highest estimated average capital city and regional consumption of cocaine.

3,4-METHYLENEDIOXYMETHYLAMPHETAMINE (MDMA)

When comparing data for December 2020 and April 2021, the population-weighted average consumption of MDMA increased in capital city sites and decreased in regional sites. Average capital city MDMA consumption decreased from April to June 2021. In April 2021, average capital city MDMA consumption exceeded average regional consumption for the first time since August 2017. In April 2021, New South Wales had the highest estimated average capital city and regional consumption of MDMA.

3,4-METHYLENEDIOXYAMPHETAMINE (MDA)

MDA is a metabolite of MDMA, but also an illicit drug in its own right. When comparing data for December 2020 and April 2021, MDA excretion increased in capital city sites and decreased in regional sites to the lowest level recorded by the Program. Average capital city MDA excretion decreased from April to June 2021. Average capital city MDA excretion exceeded average regional excretion for the first time. In April 2021, New South Wales had the highest estimated average capital city excretion of MDA, while Queensland had the highest estimated average regional excretion.

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

HEROIN

When comparing data for December 2020 and April 2021, the population-weighted average consumption of heroin decreased in both capital city sites and regional sites. Average capital city heroin consumption increased from April to June 2021. Average capital city heroin consumption continues to exceed average regional consumption. In April 2021, Victoria had the highest estimated average capital city consumption of heroin, while New South Wales had the highest estimated average regional consumption.

CANNABIS

The Program began measuring cannabis consumption in August 2018. When comparing data for December 2020 and April 2021, the population-weighted average consumption of cannabis decreased in both capital city and regional sites. Average capital city cannabis consumption increased from April to June 2021. Average regional cannabis consumption continues to exceed average capital city consumption. In April 2021, Tasmania had the highest estimated average capital city consumption of cannabis, while South Australia had the highest estimated average regional consumption.

KETAMINE

The Program began measuring ketamine excretion in December 2020. When comparing data for December 2020 and April 2021, the population-weighted average excretion of ketamine increased in capital city sites and decreased in regional sites. Average capital city ketamine excretion decreased from April to June 2021. Average capital city ketamine excretion exceeded regional ketamine excretion. In April 2021, Victoria had the highest estimated average capital city and regional excretion of ketamine.

OXYCODONE

When comparing data for December 2020 and April 2021, the population-weighted average consumption of oxycodone decreased in both capital city and regional sites, with regional consumption decreasing to the lowest level recorded by the Program. Average capital city oxycodone consumption remained relatively stable from April to June 2021. Average regional oxycodone consumption continues to exceed average capital city consumption. In April 2021, Tasmania had the highest estimated average capital city consumption of oxycodone, while Victoria had the highest estimated average regional consumption.

FENTANYL

When comparing data for December 2020 and April 2021, the population-weighted average consumption of fentanyl decreased in both capital city and regional sites, with capital city fentanyl consumption further decreasing in June 2021. Average regional fentanyl consumption in April and average capital city consumption in June 2021 were the lowest levels recorded by the Program. Average regional fentanyl consumption continues to exceed average capital city consumption. In April 2021, Tasmania had the highest estimated average capital city consumption of fentanyl, while South Australia had the highest estimated average regional consumption.

NICOTINE

When comparing data for December 2020 and April 2021, the population-weighted average consumption of nicotine decreased in both capital city and regional sites, with average capital city nicotine consumption further decreasing in June 2021. Average regional nicotine consumption continues to exceed average capital city consumption. In April 2021, the Northern Territory[10] had the highest estimated average capital city and regional consumption of nicotine.

ALCOHOL

When comparing data for December 2020 and April 2021, the population-weighted average consumption of alcohol decreased in capital city sites and increased in regional sites. Average capital city alcohol consumption further decreased from April to June 2021. Average regional alcohol consumption exceeded average capital city consumption. In April 2021, the Northern Territory[11] had the highest estimated average capital city and regional consumption of alcohol.

NEXT REPORT

The 15th report is scheduled for public release in February 2022.

10 As the Northern Territory only had 2 participating sites, results may not be representative of the Territory as a whole.
11 Ibid.