

# Increasing trends in self-reported use of nitrous oxide among WA EDRS samples

**Authors: Jodie Grigg and Simon Lenton**  
**National Drug Research Institute**  
**Faculty of Health Sciences, Curtin University**

## Key findings:

- In 2019, 61% of WA participants reported recent use of nitrous oxide; the highest proportion observed since data collection commenced.
- Nitrous oxide was used on a median of 10 occasions in the preceding six months (increasing significantly from 2018) and one in four consumers reported weekly use.
- The median amount used in a 'typical' session was 10 bulbs, while the maximum median used in a session was 25 bulbs.
- Increasing trends in the use of this inhalant raise concern about the risk of associated harms, particularly neurological damage associated with vitamin B12 depletion.
- These findings suggest there may be a need for a targeted education/harm reduction campaign. There may also be a need to review existing regulation to reduce risks associated with 24/7 delivery services/promotions.

## Background

There have been some indications that recreational use of nitrous oxide (also known as 'nangs', 'whippets', laughing gas, balloons, NOS and N2O) and associated harms may be increasing in Australia and elsewhere (e.g. 1-6). Whilst having a very long history of recreational use (7) and a reputation of being relatively harmless, a growing number of case reports/series are documenting significant adverse effects associated with prolonged or frequent recreational use (4, 5, 8-12). The seemingly increasing number of nitrous-related presentations to hospital emergency departments (EDs) in New South Wales (NSW) (1) and Melbourne (5) have led to concerns about a potentially emerging public health problem in Australia (1, 5). Most health sequelae associated with nitrous oxide use are a consequence of vitamin B12 depletion, and are neurological or haematological in nature (e.g. combined degeneration of the spinal cord, myelopathy and demyelinating polyneuropathy) (13). Without early intervention, B12 depletion has the potential to cause irreversible neurological damage (8, 10, 14). Deaths involving nitrous oxide are very rare, but can occur from hypoxia (often related to loss of consciousness while using gas masks or placing plastic bags over the head) (e.g. 15) or misadventure (e.g. falls, injuries) (16).

Adding to the concern about use of this inhalant, the Global Drug Survey recently reported that among over 17,000 participants who reported recent nitrous oxide use, 3% reported “persistent numbness/tingling (paraesthesia)” (17) – symptoms potentially indicative of vitamin B12 depletion.

Given preliminary indications that use and harms associated with nitrous oxide may be increasing, there is a need for a greater understanding of the prevalence and correlates of use to help inform harm reduction initiatives. This bulletin examines trends in the use of nitrous oxide among samples of people who regularly use ecstasy and other illicit stimulants surveyed as part of the Western Australia (WA) Ecstasy and Related Drugs Reporting System (EDRS) between 2003-2019. It also investigates correlates of self-reported recent (past six month) use of nitrous oxide among the 2019 national EDRS sample.

## Method

This bulletin draws on WA and national data from the 2003-2019 EDRS. The EDRS has been conducted annually in all Australian jurisdictions since 2003. The structured interviews, which were conducted face-to-face, asked participants about a range of topics, including their demographic characteristics, drug consumption, perceptions of the illicit drug market, health, crime, and risk and harm reduction behaviours. The eligibility criteria were: (1) aged at least 17 years old (16 in WA) (changed to 18 years for all jurisdictions in 2020); (2) have used ecstasy/MDMA on at least six occasions in the preceding six months (expanded to other illicit stimulant drugs from 2012); and (3) have been a resident of the capital city in which the interview took place for the preceding 12 months. Full details for the background and methods are available for [download here](#).

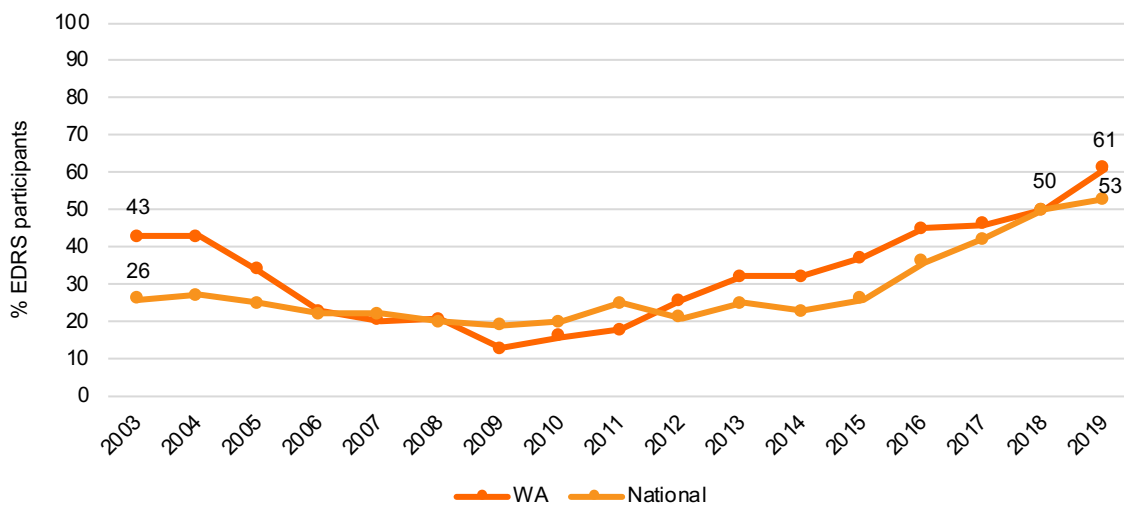
This bulletin examines data collected on self-reported use of nitrous oxide. Descriptive statistics were run to determine the percentage of respondents reporting recent use across data collection years, the frequency of use among recent consumers, and the quantity of nitrous oxide being used in single sessions (in bulbs) (Figures 1-6). To examine correlates, bivariable analyses were first run to investigate associations between key demographic/drug use characteristics and the outcome variable (self-reported recent use of nitrous oxide) among the 2019 national sample (Table 1). The national sample was used to increase the number of cases available for analysis. Candidate variables for the multivariable analyses in Table 2 included demographic or drug use variables with significant bivariable tests in Table 1. Bivariable and multivariable logistic regressions determined unique correlates of self-reported recent nitrous oxide use (Table 2). Chi-Square Tests of Independence were performed to investigate multicollinearity between categorical variables (e.g. studying and tertiary qualifications).

## Results

### Recent (past six month) use

The proportion of WA EDRS participants who self-reported recent use of nitrous oxide has steadily increased in the past decade. As shown in Figure 1, this upward trend is also observed in the national data.

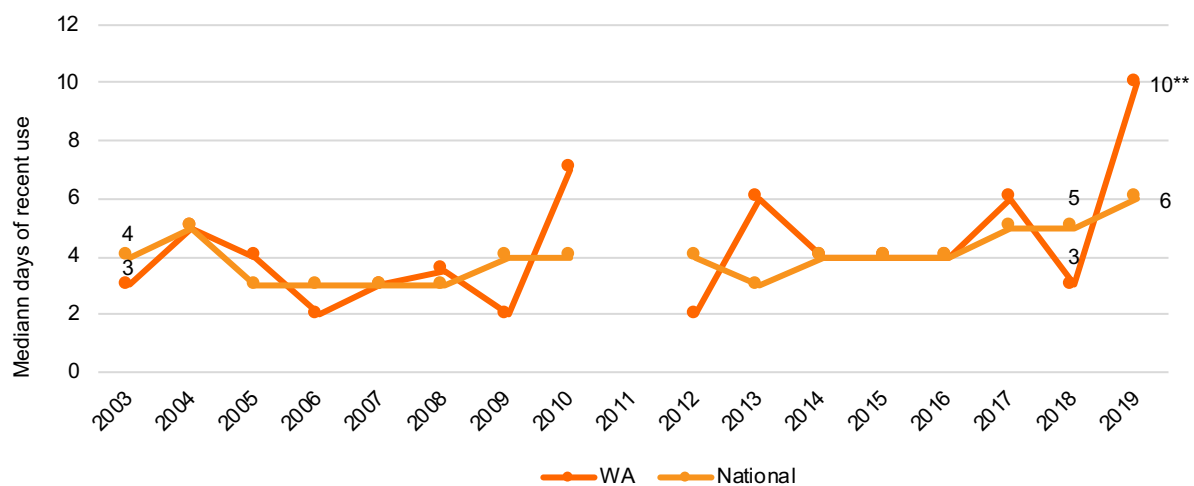
**Figure 1: Recent use of nitrous oxide among EDRS participants, 2003-2019**



### Median days of recent (past six month) use

In 2019, among recent WA consumers (n=61), nitrous oxide was used on a median of 10 occasions in the preceding six month period (IQR=3-24, range=1-80); a significant increase from three occasions in 2018 (IQR=1-10, range=1-50,  $p=0.001$ ) As evident in Figure 2, 2019 marks the highest frequency of use recorded since data collection commenced.

**Figure 2: Frequency of use in the six months preceding interview, 2003-2019**

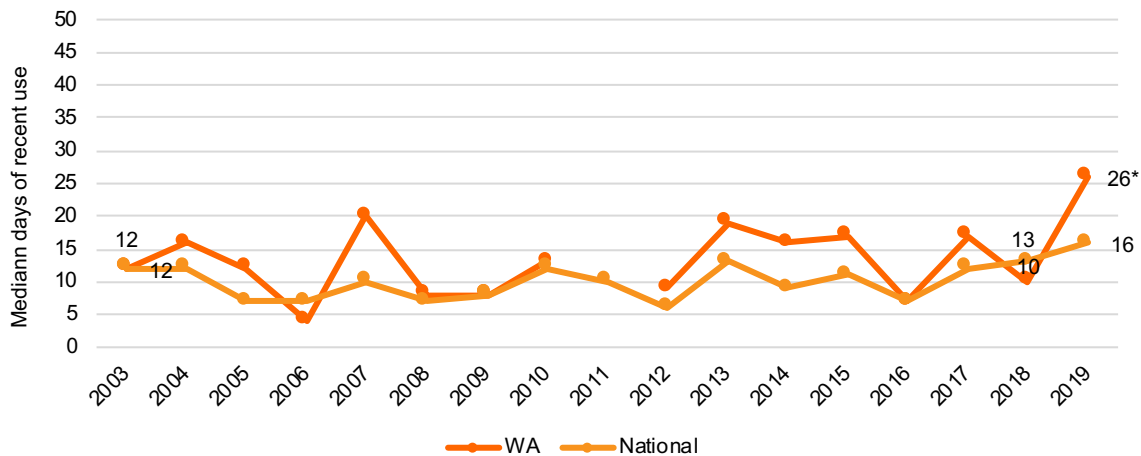


Note. Due to a small sample size in 2011 and low numbers reporting recent nitrous oxide use (n≤5), data for this year has been suppressed. Y axis reduced to 12 days to improve visibility of trends. \*\* $p<.010$  for 2018 vs 2019.

## High frequency use (at least weekly)

In 2019, a quarter of recent WA consumers reported at least weekly use in the preceding six month period; a significant increase from 10% in 2018 ( $p=0.030$ ) and the highest proportion on record for the WA EDRS. The percentage reporting weekly use in WA also exceeded the national percentage in 2019 (Figure 3).

**Figure 3: The percentage of nitrous oxide consumers reporting weekly or more frequent nitrous oxide use, 2003-2019**

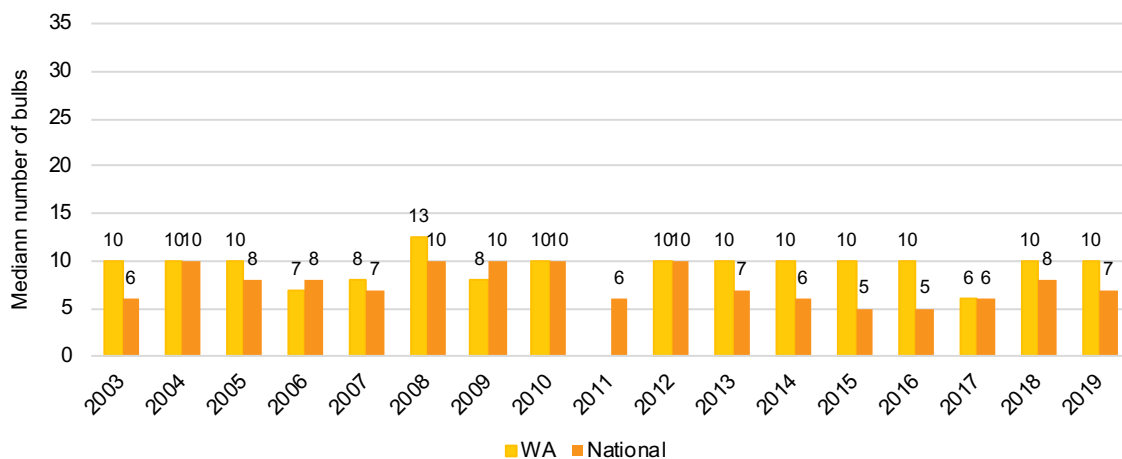


Note. Due to a small sample size in 2011 (associated with a global ecstasy shortage) and low numbers reporting recent nitrous oxide use ( $n \leq 5$ ), data for this year has been suppressed. Y axis reduced to 50 days to improve visibility of trends. \* $p < .050$  for 2018 vs 2019.

## Typical quantity per session

In 2019, the median amount used in a 'typical' session among WA consumers was 10 bulbs (IQR=5-25, range=1-100), consistent with previous data collection years (e.g. 2018 median=10, IQR=4-50, range=1-300). The median quantity observed in WA was significantly higher than the national median in 2019 ( $p=0.001$ ) (Figure 4).

**Figure 4: Average number of bulbs used in a 'typical' session in the six months preceding interview, 2003-2019**

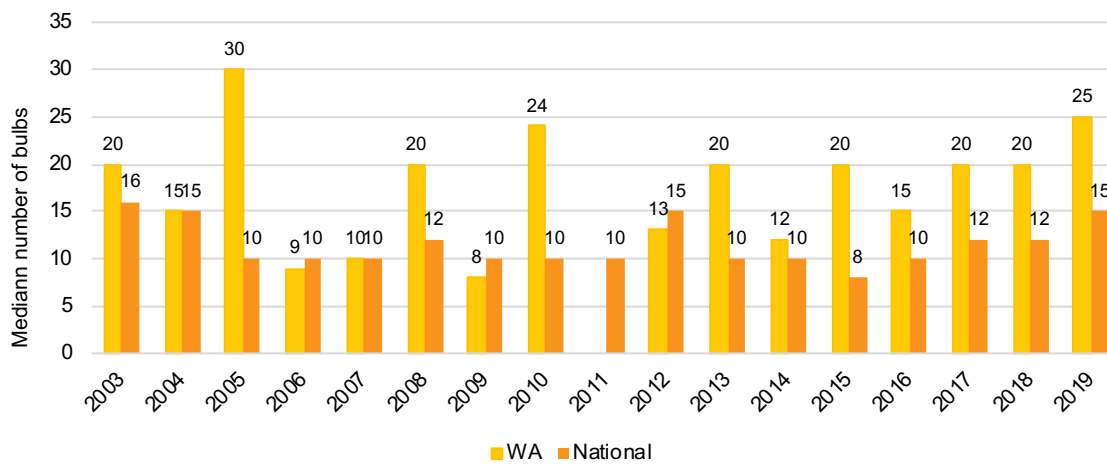


Note. Due to a small WA sample size in 2011 (associated with a global ecstasy shortage) and low numbers reporting recent nitrous oxide use ( $n \leq 5$ ), data for this year has been suppressed. Y axis reduced to 50 bulbs to improve visibility of trends.

## Maximum quantity per session

In 2019, the median ‘maximum’ amount used in a session among WA consumers was 25 bulbs (IQR=11-50, range=1-300); a non-significant increase from 20 bulbs in 2018 (IQR=4-50, range=1-500;  $p=0.185$ .) The maximum amount used in WA has been higher than the national median for the past seven reporting years (Figure 5).

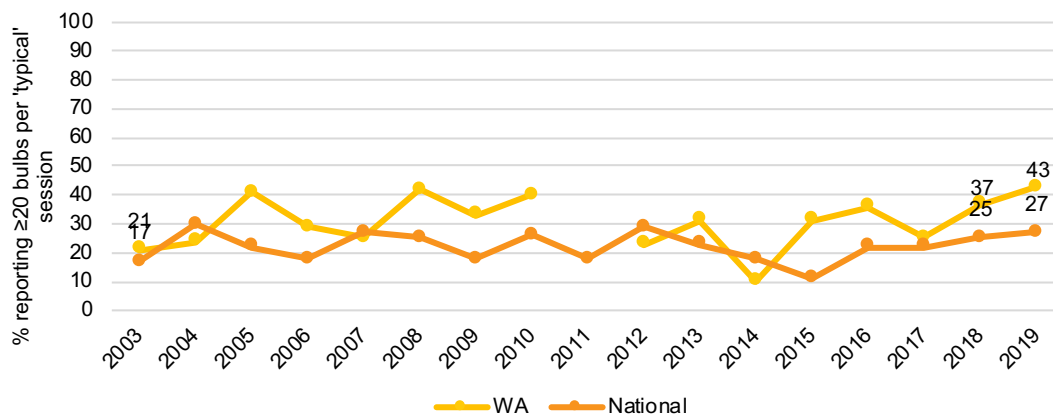
**Figure 5: Maximum number of bulbs used in a session in the six months preceding interview, 2003-2019**



Note. Due to a small WA sample size in 2011 (associated with a global ecstasy shortage) and low numbers reporting recent nitrous oxide use ( $n \leq 5$ ), data for this year has been suppressed. Y axis reduced to 50 bulbs to improve visibility of trends.

Figure 6 presents the percentage of recent consumers who reported using  $\geq 20$  bulbs in a ‘typical’ session (i.e. ‘heavy’ use). While there is no clear trend line, 43% of recent WA consumers reported using to this level in 2019; the highest proportion since data collection commenced.

**Figure 6: The percentage of recent consumers reporting  $\geq 20$  bulbs in a ‘typical’ session, 2003-2009**



Note. Due to a small WA sample size in 2011 and low numbers reporting recent nitrous oxide use ( $n \leq 5$ ), data for this year has been suppressed. Unlike alcohol, there are no recommended guidelines/levels of nitrous oxide use to reduce the risk of harm. Thus, the ‘heavy’ use threshold was chosen as 20 bulbs was above the typical median for most WA reporting years and could be reasonably argued to be ‘heavy’ by most standards, regardless of the frequency of use.

## Correlates of use (bivariable and multivariable analysis)

Among the 2019 national EDRS sample, 53% (n=424) reported recent use of nitrous oxide. Bivariable logistic regression analyses found respondents from NSW (as compared to QLD), younger participants, males, those who had not (yet) completed tertiary qualifications, those who were studying at university, and those with lower income were at significantly greater odds of reporting recent nitrous oxide use (Table 1).

As outlined in the methods, candidate variables for the multivariable analysis were determined by bivariable significance in Table 1. After controlling for other variables, only jurisdiction, age and gender uniquely predicted recent use of nitrous oxide, and younger age was the strongest correlate identified in the model (Table 2).

**Table 1: Demographic characteristics of the 2019 national EDRS sample according to self-reported recent use of nitrous oxide**

Demographic characteristics	Level	n	Recent use	No recent use	Bivariable		
			(53.2%) (n=424)	(46.8%) (n=373)	OR	95% CI	P-Value
Jurisdiction	NSW	100	72.0	28.0	1.974	1.094-3.563	0.024*
	ACT	100	57.0	43.0	1.018	0.581-1.784	0.951
	VIC	100	61.0	39.0	1.201	0.682-2.113	0.525
	TAS	100	34.0	66.0	0.396	0.223-0.702	0.002**
	SA	99	43.4	56.6	0.590	0.336-1.034	0.065
	WA	100	61.0	39.0	1.201	0.682-2.113	0.525
	NT	99	40.4	59.6	0.521	0.296-0.916	0.024*
	QLD	99	56.6	43.4	1.000		
Age group	16-19	244	69.7	19.9	4.923	3.352-7.229	<0.001***
	20-24	310	57.1	35.8	2.852	2.006-4.054	<0.001***
	≥25	242	31.8	44.4	1.000		
Gender	Female	311	47.3	44.7	0.674	0.505-0.898	0.007**
	Male	473	57.1	55.3	1.000		
Sexual identity	Other	159	52.2	47.8	0.951	0.672-1.347	0.778
	Hetero	638	53.4	46.6	1.000		
Speak English at home	No	25	48.0	52.0	0.807	0.363-1.790	0.597
	Yes	772	53.4	46.6	1.000		
Completed year 12 <sup>a</sup>	No	207	44.0	56.0	0.612	0.444-0.843	0.003**
	Yes	566	56.2	43.8	1.000		
Tertiary qual completed <sup>a</sup>	No	343	64.1	35.9	2.128	1.498-3.022	<0.001***
	Yes – trade	222	42.2	57.8	0.867	0.592-1.269	0.0462
	Yes – uni	208	45.7	54.3	1.000		
Studying	No	435	48.3	51.7	0.568	0.417-0.772	<0.001***
	Yes – trade	85	49.4	50.6	0.594	0.364-0.970	0.037*
	Yes – uni	275	62.2	37.8	1.000		
Unemployed <sup>a</sup>	No	565	52.7	47.3	0.985	0.717-1.354	0.928
	Yes	209	53.1	46.9	1.000		
Income per week	\$0-249	160	65.0	35.0	1.924	1.324-2.794	0.001**
	\$250-399	149	51.7	48.3	1.108	0.765-1.604	0.588
	\$400+	454	49.1	50.9	1.000		
Self-reported mental health problem	No	342	50.3	49.7	0.837	0.631-1.110	0.217
	Yes	444	54.7	45.3	1.000		
K10 score ≥30	No	665	53.2	46.8	1.008	0.693-1.466	0.966
	Yes	132	53.0	47.0	1.000		

<sup>a</sup>Among those aged ≥18 years old. \* $p < 0.050$ ; \*\* $p < 0.010$ ; \*\*\* $p < 0.001$ .



**Table 2: Correlates of self-reported recent use of nitrous oxide (multivariable logistic regression)**

Variable	Level	n	Recent use	No recent use	Multivariable		
			52.8% (n=382)	47.2% (n=342)	AOR	95% CI	P-Value
Jurisdiction	NSW	92	71.7	28.3	3.772	1.891-7.526	<0.001***
	ACT	86	59.3	40.7	1.240	0.650-2.363	0.514
	VIC	92	62.0	38.0	1.759	0.921-3.360	0.087
	TAS	97	33.0	67.0	0.625	0.329-1.189	0.152
	SA	87	41.4	58.6	0.670	0.350-1.282	0.226
	WA	88	59.1	40.9	0.828	0.439-1.565	0.562
	NT	89	38.2	61.8	0.860	0.442-1.672	0.656
	QLD	93	58.1	41.9	1.000		
Age group	18-19	208	68.8	31.3	5.128	3.040-8.652	<0.001***
	20-24	293	57.3	42.7	3.269	2.139-4.997	<0.001***
	≥25	223	31.8	68.2	1.000		
Gender	Female	295	46.4	53.6	0.600	0.430-0.839	0.003**
	Male	429	57.1	42.9	1.000		
Completed year 12 <sup>a</sup>	No	185	42.2	57.8	0.678	0.454-1.013	0.058
	Yes	539	56.4	43.6	1.000		
Tertiary qualification completed <sup>a</sup>	No	325	63.7	36.3	1.285	0.894-1.847	0.176
	Yes	399	43.9	56.1	1.000		
Studying	No	391	47.6	52.4	0.863	0.581-1.280	0.464
	Yes – trade	79	45.6	54.4	0.631	0.348-1.146	0.130
	Yes - uni	254	63.0	37.0	1.000		
Income per week	\$0-249	144	64.6	14.9	1.098	0.693-1.740	0.690
	\$250-399	139	51.8	19.6	1.086	0.701-1.681	0.713
	\$400+	441	49.2	65.5	1.000		

Bivariable Model  $\chi^2(16) = 134.665$ ,  $p < 0.001$ . Adjusted R square = 0.170 (Cox & Snell), 0.227 (Nagelkerke). Hosmer-Lemeshow goodness of fit test,  $p = 0.177$ ,  $n = 724$ , missing = 73. AOR, adjusted odds ratio; CI, confidence interval. <sup>a</sup>Among those aged  $\leq 18$  years old. \* $p < 0.050$ ; \*\* $p < 0.010$ ; \*\*\* $p < 0.001$ .

## Discussion

The findings presented in this bulletin show some increasing trends in nitrous oxide use amongst WA EDRS samples, in terms of any recent use, the frequency of recent use, and to a lesser extent, the maximum amount of bulbs being used per session. Whilst the WA findings appear consistent with a general upward trend in the national EDRS data, it is important to emphasise that the EDRS recruits a non-probability convenience sample. Thus, the findings cannot be generalised to the wider population of people who regularly use stimulants in Australia, and unfortunately, there are no known population-based surveys to triangulate these findings with as the National Drug Strategy Household Survey (NDSHW) does not ask specifically about the use of nitrous oxide (18). Additionally, the trends observed in the EDRS findings could reflect sample differences across data collection years (e.g. younger samples being recruited, given age was associated with recent use in the multivariable analysis).

However, while the median age of the WA sample significantly declined between 2019 and 2018, the median has consistently ranged between 19 and 20 years old since 2014, and the national median has shown no declining trend in age (consistently ranging between 20-22 years old). There also has not been an increase in the proportion of males in WA or national EDRS samples – another correlate of nitrous oxide use identified in the multivariable analysis. Thus, there are no obvious indications that the upward trends identified reflect sample differences in terms of age and gender. Additionally, the findings in this bulletin are consistent with other preliminary indications of increasing recreational use in Australia (1, 5, 6). Thus, limitations to the data notwithstanding, the findings in this bulletin warrant consideration.

The nitrous oxide trends identified in the EDRS samples raise concern for a number of reasons. Firstly, higher rates of use, and riskier patterns of use (in terms of frequency of use and quantity being used) heighten concern about the risk of associated harm. As mentioned in the introduction, there is a growing number of case reports/series documenting significant, and in some cases enduring, neurological consequences associated with recreational nitrous oxide use (3-5, 9-13, 19-21) and there have been concerns about increasing presentations to some EDs in Australia (1, 5). Additionally, the Global Drugs Survey found a small (3%, n=561) but significant proportion of respondents who had used nitrous reported symptoms indicative of neurological damage, and identified a strong dose dependent relationship (17). This raises concern that some EDRS participants could also be experiencing adverse effects associated with their use, but data on this was unfortunately not collected.

Secondly, the high number of bulbs used by some respondents in a single session raises questions about the route of administration (ROA) being used. For example, did participants first dispense the gas into a balloon (which is considered a safer ROA (22)) or were they inhaling directly from the bulbs or dispenser?

Unfortunately data about the ROA was not collected by the EDRS, but is of interest because certain ROAs can increase the risk of acute harms, such as cold burns/frostbite (23), ruptures in the lung (24) and hypoxia (25, 26). Since nitrous can also cause dizziness, perceptual and psychological disturbances, and loss of consciousness, there is also an acute risk of injury due to falling or misadventure. In 2018, a Surfers Paradise schoolie reportedly died after plunging from a balcony after consuming nitrous oxide (16).

Thirdly, the upward trends observed in the data are concerning because nitrous oxide remains very easy to access at low cost and in bulk. Moreover, a quick Google search (conducted June 25, 2020) identified at least 10 different 24/7 nitrous oxide delivery services in Perth which supply bulbs, dispensers and balloons. These services are clearly marketed for party rather than professional use, and some also offer a variety of other “party supplies” such as smoking/drug paraphernalia (e.g. bongs, scales, baggies, rolling papers) and “munchie” snacks.



Some of these delivery services appear to have an active social media presence (with thousands of followers) and promote bulk buy specials, Facebook competitions/promotions (e.g. tag your friends for discounts) and their physical presence at different events, including schoolies/leavers. Promotion of these services is a concern as it may encourage increased uptake of use, and heavier patterns of use. Thus, not only is it inevitable that nitrous oxide will continue to be used recreationally, popularity may continue to increase.

The finding that living in NSW (relative to Queensland), younger age, and male gender predicted recent nitrous oxide use is not surprising, but warrants consideration. Firstly, the low cost and easy access clearly makes nitrous oxide an appealing drug for young people. However, heavy and/or prolonged use among young people raises concern about the impact on the developing brain (27), further highlighting the importance of early intervention. Secondly, while male gender was associated with increased odds of reporting nitrous oxide use (consistent with other studies, e.g. (27)), almost half of the female participants also reported use. This is noteworthy as there is some evidence to suggest females of reproductive age may be at greater risk of experiencing neurological complications associated with nitrous oxide use, purportedly due to a higher prevalence of B12 deficiencies (e.g. 17). Lastly, the finding that residence in NSW was associated with greater odds of reporting recent use is consistent with ED data showing a sharp increase of presentations involving nitrous oxide since 2016 (1). However, it is important to note that recent nitrous oxide use was a majority behaviour in samples from all jurisdictions except Tasmania, South Australia and the Northern Territory. Thus, the potential for harm is certainly not limited to NSW.

Overall, these findings have multiple implications for harm reduction and supply control. Firstly, there may be a need to review existing regulation of nitrous oxide in Australia. However, regulations vary across jurisdictions. For example, it is an offence to sell/supply nitrous oxide for recreational use in the Northern Territory, NSW, Victoria and South Australia (SA) (28-30) (although this is very difficult to enforce), and SA recently also made it an offence to sell to people under 18, sell between the hours of 10pm and 5am and make nitrous oxide visible or accessible in retail stores (30). Other jurisdictions, including WA, should consider the strengths and weaknesses of implementing similar restrictions to SA, particularly to reduce the risk of 24/7 delivery services, marketed at young people, attracting new users with their online presence and promotions. Indeed, youth advocates have already made calls for this type of improved regulation (e.g. 31). However, others have expressed concern that stricter regulation on bulbs and dispensers could trigger riskier methods of use, such as inhalation from tanks and masks which provide continuous delivery of nitrous oxide, even when loss of consciousness occurs (unlike administration via balloons) (22). There is also a risk that regulatory changes could inadvertently increase demand by drawing more attention to their recreational value (32).

While there is still merit in reviewing existing regulation to try and curb growing popularity and reduce high risk patterns of use, as others have argued (e.g. 17), the primary focus of public health efforts should perhaps be on education and harm reduction. This could include targeted campaigns aimed at raising awareness of the risks, protective behaviours and early neurological symptoms (e.g. tingling, numbness). As mentioned previously, evidence suggests early diagnosis and intervention is critical in preventing permanent damage (8, 10, 14). While there are already numerous online resources providing harm reduction information on nitrous oxide (e.g. Dancewize, the Australian Drug Foundation and Drug Aware), consideration should be given to adding advice on dose limits per session and frequency of use. Improved promotion and delivery of online resources should also be considered. Lastly, clinicians in both primary and tertiary healthcare settings should be aware of potentially increasing trends in use, particularly among young people, and alert to the variety of presenting symptoms associated with nitrous oxide use.

## Conclusion

Increasing trends in reports of recent nitrous oxide use, days of use and typical use of over 20 bulbs per session among EDRS samples raises concern about the risk of associated harms. While there are implications for reviewing existing regulation of this inhalant (particularly with regards to delivery services/promotions), in recognition that nitrous oxide use will continue regardless of regulation and policing, responses should include public health interventions that focus on education and harm reduction. There are also implications for more closely monitoring the use of this drug in Australia, and investigating consumer knowledge about the associated risks.

## References

1. Bethmont A, Harper CE, Chan BS, Dawson AH, McAnulty J. Increasing illicit use of nitrous oxide in presentations to NSW emergency departments. *Med J Aust.* 2019;211(9):429-e1.
2. Kaar SJ, Ferris J, Waldron J, Devaney M, Ramsey J, Winstock AR. Up: The rise of nitrous oxide abuse. An international survey of contemporary nitrous oxide use. *J Psychopharm.* 2016;30(4):395-401.
3. Zheng D, Ba F, Bi G, Guo Y, Gao Y, Li W. The sharp rise of neurological disorders associated with recreational nitrous oxide use in China: A single-center experience and a brief review of Chinese literature. *J Neurol.* 2020;267(2):422-9.
4. Algahtani H, Shirah B, Abdelghaffar N, Abuhawi O, Alqahtani A. Nitrous oxide recreational abuse presenting with myeloneuropathy and mimicking Guillain-Barre syndrome. *Intractable Rare Dis Res.* 2020;9(1):54-7.
5. McArdle DJT, Gaillard F. Pernicious azotaemia? A case series of subacute combined degeneration of the cord secondary to nitrous oxide abuse. *J Clin Neurosci.* 2020;72:277-80.
6. Ferris J, Puljevic C, Wilson H, Winstock A. Recreational use of nitrous oxide: Is it really harmless? 2020. Available from: <https://stories.uq.edu.au/medicine/blog/2019/recreational-use-of-nitrous-oxide/index.html>
7. Randhawa G, Bodenham A. The increasing recreational use of nitrous oxide: History revisited. *Br J Anaesth.* 2016;116(3):321-4.
8. Thompson AG, Leite MI, Lunn MP, Bennett DLH. Whippits, nitrous oxide and the dangers of legal highs. *Pract Neurol.* 2015;15(3):207-9.
9. Blair C, Tremonti C, Edwards L, Haber P, Halmagyi M. 118 Case series: Subacute combined degeneration of the spinal cord in vitamin B12-replete recreational nitrous oxide abusers. *J Neurol Neurosurg Psychiatry.* 2019;90(e7):A38.2-A9.

## References continued

10. Lan S-Y, Kuo C-Y, Chou C-C, Kong S-S, Hung P-C, Tsai H-Y, et al. Recreational nitrous oxide abuse related subacute combined degeneration of the spinal cord in adolescents – A case series and literature review. *Brain Dev.* 2019;41(5):428-35.
11. Gupta S. Recreational nitrous oxide abuse causing ischemic stroke in a young patient: A rare case report. *Cureus.* 2018;10(12).
12. Johnson K, Mikhail P, Kim MG, Bosco A, Huynh W. Recreational nitrous oxide-associated neurotoxicity. *J Neurol Neurosurg Psychiatry.* 2018;89(8):897-8.
13. Oussalah A, Julien M, Levy J, Hajjar O, Franczak C, Stephan C, et al. Global burden related to nitrous oxide exposure in medical and recreational settings: A systematic review and individual patient data meta-analysis. *J Clin Med.* 2019;8(4).
14. Garakani A, Jaffe RJ, Savla D, Welch AK, Protin CA, Bryson EO, et al. Neurologic, psychiatric, and other medical manifestations of nitrous oxide abuse: A systematic review of the case literature. *Am J Addict.* 2016;25(5):358-69.
15. Bäckström B, Johansson B, Eriksson A. Death from Nitrous Oxide. *J Forensic Sci.* 2015;60(6):1662-5.
16. Bruce-Smith A. Father of dead schoolie calls for 'nangs' to be regulated 2018. Available from: <https://10daily.com.au/news/australia/a181213dnr/father-of-dead-schoolie-calls-for-nangs-to-be-regulated-20181214>.
17. Winstock AR, Ferris JA. Nitrous oxide causes peripheral neuropathy in a dose dependent manner among recreational users. *J Psychopharm.* 2019;34(2):229-36.
18. Australian Institute of Health and Welfare. National drug strategy household survey 2016: Detailed findings. 2016.
19. Middleton JA, Roffers JA. Peripheral neuropathy due to recreational use of nitrous oxide presenting after an ankle sprain with foot drop. *Orthopedics.* 2018;41(3):E432-E3.
20. Johnson K, Philopatir M, Kim MG, Bosco A, Huynh W. Recreational nitrous oxide-associated neurotoxicity. *J Neurol Neurosurg Psychiatry.* 2018;89(8):897.
21. Egan W, Steinberg E, Rose J. Vitamin B12 deficiency-induced neuropathy secondary to prolonged recreational use of nitrous oxide. *Am J Emerg Med.* 2018;36(9):1717.e1-.e2.
22. Jay M. Nitrous oxide: Recreational use, regulation and harm reduction. *Drugs and Alcohol Today.* 2008;8(3):22-5.
23. Hwang JCF, Himel HN, Edlich RF. Frostbite of the face after recreational misuse of nitrous oxide. *Burns.* 1996;22(2):152-3.
24. McDermott R, Tsang K, Hamilton N, Belton M. Recreational nitrous oxide inhalation as a rare cause of spontaneous pneumomediastinum. *BMJ Case Rep.* 2015;2015:bcr2015209750.
25. Backstrom B, Johansson B, Eriksson A. Death from nitrous oxide. *J Forensic Sci.* 2015;60(6):1662-5.
26. Ng J, O'Grady G, Pettit T, Frith R. Nitrous oxide use in first-year students at Auckland University. *The Lancet.* 2003;361(9366):1349-50.
27. Ehirim EM, Naughton DP, Petróczi A. No laughing matter: Presence, consumption trends, drug awareness, and perceptions of "hippy crack" (nitrous oxide) among young adults in England. *Front Psychiatry.* 2018;8:312-.
28. Drugs, Poisons and Controlled Substances Act 1981: Version 129 2020 1 July 2020. Available from: <https://www.legislation.vic.gov.au/in-force/acts/drugs-poisons-and-controlled-substances-act-1981/129>.
29. Thomas J, Jones R. Doctors warn of dangerous rise in use of 'nangs' 2017. Available from: <https://www.abc.net.au/news/2017-10-16/doctors-warn-of-dangerous-use-of-nangs-or-nitrous-oxide/9046574>.
30. Government of South Australia. Nitrous oxide regulations 2020. Available from: <https://www.agd.sa.gov.au/justice-system/changes-law/nitrous-oxide-regulations#:~:text=Under%20the%20new%20Controlled%20Substances,the%20public%20in%20retail%20stores>.
31. Ross H, Sapwell G, White L. Youth advocates call for better regulation of nitrous oxide canisters known as 'nangs' 2018. Available from: <https://www.abc.net.au/news/2018-12-13/calls-for-better-regulation-of-nitrous-oxide-canisters/10584356>.
32. Lee N, Bright S. Explainer: What is nitrous oxide (or nangs) and how dangerous is it? 2018. Available from: <https://theconversation.com/explainer-what-is-nitrous-oxide-or-nangs-and-how-dangerous-is-it-108019>.

## Participating researchers and research centres

- Antonia Karlsson, Julia Uporova, Daisy Gibbs, Rosie Swanton, Olivia Price, Georgia Kelly, Professor Louisa Degenhardt, Professor Michael Farrell and Dr Amy Peacock, National Drug and Alcohol Research Centre, University of New South Wales;
- Brittany Ciupka, Amy Kirwan, Cristal Hall and Professor Paul Dietze, Burnet Institute Victoria;
- Callula Sharman and Associate Professor Raimondo Bruno, School of Psychology, University of Tasmania;
- Jodie Grigg and Professor Simon Lenton, National Drug Research Institute, Curtin University, Western Australia; and
- Catherine Daly, Jennifer Juckel, Leith Morris and Dr Caroline Salom, Institute for Social Science Research, The University of Queensland.

## Other acknowledgements

- We would like to thank all the participants who were interviewed for the EDRS.
- The EDRS is funded by the Australian Government under the Substance Misuse Prevention and Service Improvement Grants Fund.

## Suggested citation

Grigg, J. & Lenton, S. (2020). Increasing trends in self-reported use of nitrous oxide among WA EDRS samples. Drug Trends Bulletin Series. Sydney: National Drug and Alcohol Research Centre, University of New South Wales.