GM TRENDS

Young people's trend focus:
Nitrous oxide - DRAFT Not for circulation

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Content

Introduction

In recent years, there has been global recognition that **nitrous oxide** is used for psychoactive purposes (*Thomas, 2022*). In a UK context, despite attempts to reduce its availability, it has become the second most used substance amongst young adults (aged 16-25) across England and Wales (*CSEW, 2022; Sumnall, 2022*). This increased use has been accompanied by concerns regarding the prevalence of nitrous oxide related litter in public places (*Greater Manchester Local Drugs Information System, 2022*). It has become increasingly common to see discarded silver cannisters (see Image 1) and more recently, larger cannisters (see Image 2) on the roadside and in parks, with visible signs of use after large gatherings and events have taken place (*Allan et al., 2022*). One Dutch study found that the availability of the larger cannisters has led to increases in use amongst user groups (*Nabben et al., 2021*). Our findings support this.

More recently, discourse has heightened in relation to the health harms of recreational and chronic **nitrous oxide** use (see *Redmond et al., 2021; Home Office, 2021; Sky News, 2022*). **Nitrous oxide**-induced neurological disorders, associated with vitamin B12 deficiency and psychosis, have all been linked to chronic, prolonged use of nitrous oxide (*Randhawa & Bodenham, 2015; Garkani et al., 2016; Ehirim et al., 2018; Redmond et al., 2021; van Amsterdam et al., 2022; Marsden et al., 2022*). However, due to **nitrous oxide's** somewhat novel existence, the harms of recreational use are not entirely clear (*van Amsterdam et al., 2022; Stockton et al., 2017; Pratt et al., 2019*). The most apparent harm associated with recreational use is the risk of accidental injury from falling and *'ice burns'*. Due to the methods of use, **nitrous oxide** users must handle apparatus that rapidly drops in temperature. Direct contact with this apparatus can lead to third-degree burns on users' hands, the inside of their thighs, and possibly even the inside of their mouths (*Quax et al., 2020; Stone et al., 2021*).

Image 1. Single dose 8gm nitrous oxide cannisters

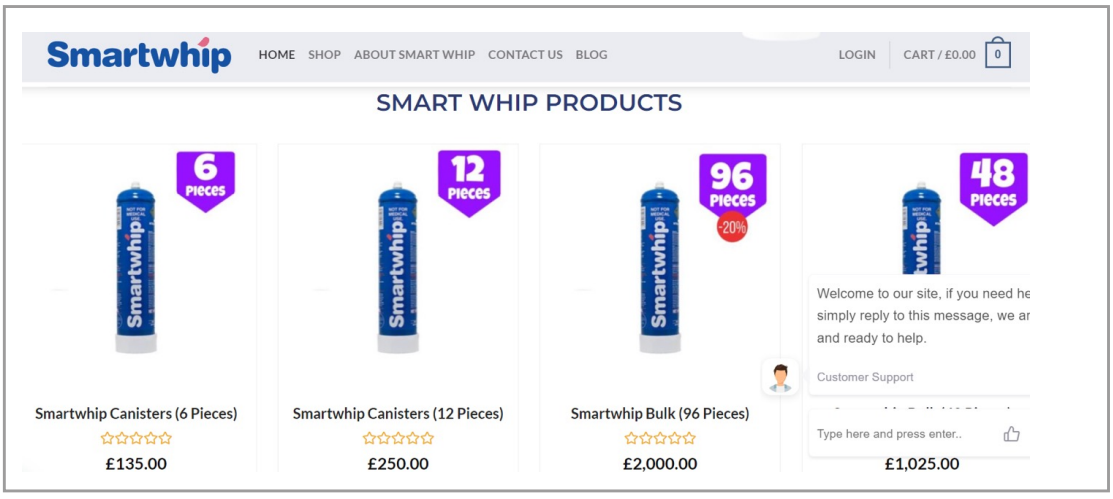

Image 2. Large (circa 640gm) nitrous oxide cannisters

Policy

In 2015 the *Advisory Council on the Misuse of Drugs* (ACMD) had concluded that **nitrous oxide** was not sufficiently harmful to warrant it becoming a controlled drug (*ACMD, 2015*). It was subsequently controlled under the *2016 Psychoactive Substances Act* (PSA). This Act made it an offence to produce, supply or offer to supply any psychoactive substance if the substance is likely to be used for its psychoactive effects, regardless of its potential for harm. However, possession was not an offence - apart from in a custodial institution.

Despite a lack of any evidence or indication of a rise in use during the pandemic (in fact, national data suggest a recent decrease in use), media coverage of discarded **nitrous oxide** canisters, particularly after two illegal raves in Greater Manchester in June 2020 (*Granada, 2020*), led to a short-lived moral panic and a parliamentary debate (*Hansard, 2020*). On September 3rd, 2021, the then Home Secretary asked the ACMD to look again at the legal status of nitrous oxide (*ACMD, 2021*). On the February 7th, 2023, Crime Minister Chris Philip wrote to the ACMD requesting that the review be finished by the end of February, stating that *"The Prime Minister has been clear that nitrous oxide has a detrimental impact on communities across the country, and contributes to anti-social behaviour".* The ACMD were asked to give advice on the available evidence relating to societal harms, including, but not limited to links between **nitrous oxide** misuse and antisocial behaviour, associated crime and impact on local communities and environmental impact, including littering (*ACMD (a), 2023*).

On the March 6th, 2023, the ACMD published its review. They found no substantive evidence of links between **nitrous oxide** use and crime or anti-social behaviour and recommended that **nitrous oxide** remain within the Psychoactive Substances Act, but with restrictions on sales, cannister sizes and paraphernalia (*ACMD (b), 2023*). The government quickly rejected this advice stating that **nitrous oxide** was to be controlled as a Class C drug under the *Misuse of Drugs Act* (MDA) (*ACMD (c), 2023*). The inclusion of **nitrous oxide** into the MDA may lead to the intended aim of reducing the overall number of young people using **nitrous oxide** recreationally. However, it is likely to increase the risk of harm for those who continue to use by handing control of the market to street dealers (*van Amsterdam et al., 2022*) and making it a criminal offence to be found in possession.

Prevalence

Previous attempts at reducing access and use have had limited success. According to the government's review of the 2016 PSA in November 2018, the inclusion of **nitrous oxide** into the Psychoactive Substances Act (PSA) made little difference; with prevalence remaining similar to levels before the Act's introduction (*Home Office, 2018*). Indeed, in recent years, **nitrous oxide** has been reported as the second most used substance behind **cannabis** for young adults (aged 16 to 24). The latest *Crime Survey of England and Wales*, *Drug Misuse Declared survey* reported that past year use of **nitrous oxide** has decreased from 2.4% to 1.3% of adults aged 16-59 and from 8.7% to 3.9% of young adults aged 16-24. This reduction in use has led to **nitrous oxide** dropping to the third most prevalent drug after **cannabis** and ***powder* cocaine** (*CSEW, 2022*). However, it should be noted that these results are not based on full year data and are derived from a lower response rate than in previous years[1]. Following a similar trend, the most recent (2021) national survey of school aged pupils aged 11-15, reported 1.8% nitrous oxide use in the last year, down considerably from 4.1% in 2018 (*ONS (b), 2022*).

[1]While this is the first comparable survey data with pre-coronavirus (COVID-19) pandemic data, they are not National Statistics and caution must be taken when using these data. The CSEW statistics presented in this release are based on nine months of data collection between October 2021 and June 2022, rather than the normal 12-month interview period and are based on a lower response rate, which may affect the quality of the estimates.

Seizures

The most recent Home Office drug seizures data reported that the number of **nitrous oxide** seizures in England and Wales increased from 256 to 373. Locally, *Greater Manchester Police* made 39 seizures. The quantity of **nitrous oxide** seized by police forces was 30% higher and for Border Forces 693% higher (a total of 2.05 million doses), which according to the Home Office is not indicative of changes in prevalence, but more to do with police and Border Force activity (*Home Office, 2022*).

Deaths and other harms

There were 56 **nitrous oxide** related deaths registered between 2001 and 2020, with 45 of those having been registered since 2010 (an average of four and a half a year) (*ONS, 2022b*). According to the 2020-2021 *National Poisons Information Service* (NPIS) annual report, there was an 3,600% increase in telephone enquiries about **nitrous oxide**, equating to an increase from 1 to 37 calls (NPIS, 2021). An article in *the Independent* stated that the (as yet unpublished) 2021/22 report shows a further 257% increase. No data on hospital admissions is provided, but the article features quotes from two neurologists claiming that the larger size 600+ gm canisters now more commonly available are responsible for the *'epidemic'* of young people seen with neurological injuries (*The Independent, 2022*).

The local context

In contrast to this recent national decline in use, our findings suggest that **nitrous oxide** use amongst young people in Greater Manchester is on the increase. The 2022 *young person trend survey* was completed by 386 young people aged 13 to 21 across Greater Manchester. The self-reported past year use of **nitrous oxide** increased significantly from 2% in 2021 to 15% in 2022. Furthermore, almost a quarter (23%) reported first time use in the past 12 months. This increased use was reflected in our *key professional survey*, completed by 137 professionals. We asked questions related to observed changes in use (decreased use, increased use, no change in use) of 44 different types of substances. **Nitrous oxide** was the substance with the fourth highest reported increase in use (following *benzodiazepines*, **alcohol** and *gabapentinoids*), with almost a third (31%) of professionals reporting the increased use of **nitrous oxide** in 2022.

In our subsequent interviews with over 70 professionals, including young person substance use treatment professionals from all 10 Greater Manchester areas and a range of other professionals working with young people (i.e.: youth justice, mental health, and education professionals), a shift from the use of the small, silver 8gm chargers to the larger, circa 640gm cannisters was frequently reported. These professional reports were often accompanied with some concern that firstly, this shift may have resulted in an increase in the amounts that were being used in a session, and secondly, that this was leading to increased harms, such as heightened risk of *'ice burns'* and neurological damage. These reported increases in use by young people and professionals, allied to concerns that the shift to use of larger cannisters was leading to increased risks has led to this year's young person trend report concentrating on **nitrous oxide**.

Twenty-two young people (aged between 15 and 21) and 12 professionals working with young people were interviewed. Police and hospital data were also requested on incidents related to **nitrous oxide**. The findings are presented in the following sections.

"The frequency and amounts used by students has been recognised by the online and face-to-face retailers supplying larger containers. The smaller silver type containers are less frequently seen in halls [of residence] or discarded on streets, as they have been replaced by larger cannisters, the smallest of which are ... equivalent to 80 of the small silver canisters and the largest can be up to 3 kg in full weight." (Head of Campus Security, Manchester)

The surveys and interviews with **nitrous oxide** users and professionals consistently highlighted a preference for the larger cannisters over the smaller ones. This was for numerous reasons, such as: i) a cheaper cost per unit, ii) the practicality of filling balloons quicker, iii) a perception that they are safer to use by some **nitrous oxide** users.

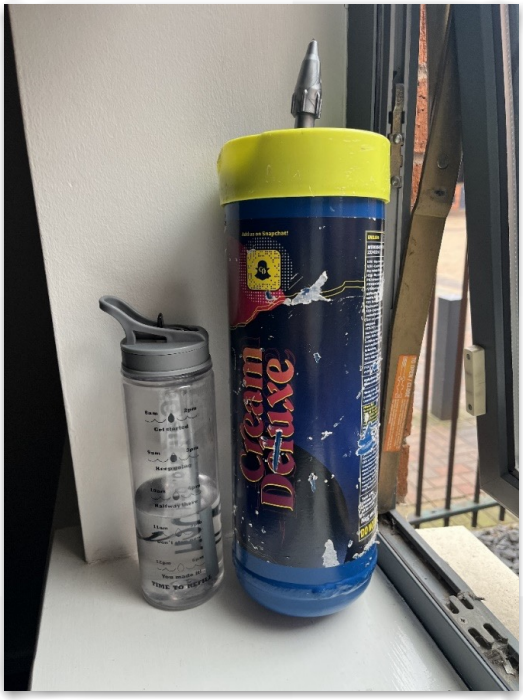

Image 3. Extra-large cannisters commonly found in student halls

Cost

The cost of both the small and the larger canisters were discussed in all interviews with **nitrous oxide** users. Whilst costs vary, the price remains somewhat consistent with the findings of the ***Nitrous Oxide Professionals Briefing*** (*Greater Manchester Local Drug Information System, 2022*).

"I use the bigger canisters now, Smart Whips. I used to use the smaller ones. I've been using it for about two or three years. I'd say I started using the larger canisters over the past eight months or so. People are using the larger ones more often. You get more for your money with the larger canisters. If you get the smaller ones, you get the exact amount you buy. Like 24 canisters is 24 balloons. A larger canister gives you way more for how much you're spending." (17-year-old male NOS user, Tameside)

"One user said he was spending a lot of money on the small canisters, but now with the large ones he wasn't having to spend as much. So, there's a chance that they are getting the larger canisters for a wholesale price." (Young Persons Substance Use Worker, Trafford)

"I used to get a box of 24 [small cannisters] for a tenner with my mate and share them. Now we buy one big one for twenty or twenty-five pounds. So it's cheaper to buy the big ones, definitely." (16-year-old male NOS user, Bury)

"Everyone buys the bigger ones because it's cheaper. We'd get one for £30 or two for £50." (15-year-old male NOS user, Tameside)

"I remember around three or four years ago, you'd get your balloons, cracker and canisters for around £16 to £20. So, the Smart Whips are much better value, in terms of how many doses they can get off them." (21-year-old female NOS user, Manchester)

Ease of Use

The larger cannisters were also seen to be easier to use than the smaller cannisters. This is due to the larger cannisters having a nozzle attached to them. The smaller cannisters require a *cracker* to extract the gas, which were noted to be difficult to use.

> *"You definitely use more with the big canister because it's easier to use. They're quicker. You don't need to use a cracker. It's less messing about."* (17-year-old male NOS user, Tameside)

> *"We see young people using the big ones so much more than the smaller canisters. It's so much easier to fill up a balloon. I know of someone who used four large canisters during one evening. He said he can get around 100 balloons from one Smart Whip. He said he had quite a numb leg during use and hasn't done it since."* (Substance Use Worker, Manchester)

The crackers were also said to be potentially harmful to use. Whilst the larger canisters can cause greater damage to the user (in relation to ice burns), the crackers were said to be more likely to inflict minor injury more often.

> *"The small ones need a cracker - a lot of the time you'd freeze your hand on it or your balloon might not take, and it could pop. It's a lot easier if you use the bigger one because you just twist it [the nozzle], and it fills the balloon directly. The little plastic piece doesn't get as cold so you're not gonna burn get a freeze burn."* (19-year-old male NOS user, Trafford)

> *"Do you know what, I don't think they are more risky, them big ones you know. Interviewer: Why do you say that? Well, the little ones yeah, they give you burns on your fingers. They are not meant to be held like that. The bigger ones for me are actually safer because you don't need to hold them. You just turn the nozzle and its plastic, not metal, so you don't get the burns as easily."* (17-year-old male NOS user, Trafford)

> *"The bigger canisters are more prevalent now because they're easier to use and they're safer as well."* (19-year-old male NOS user, Salford)

> *"It's easier to use the bigger canisters because you just twist it to fill the balloon up. I fill it up the same amount when using the bigger one, because if I have the smaller canisters I'd put two in a balloon."* (15-year-old male NOS user, Tameside)

The larger canisters were recognised as being difficult to control doses. The smaller canisters are self-regulating, as each one contains the same amount (8gm). As the large canisters rely on the user to decide on the dose, it is easier for users to overfill the balloons.

> *"I'd be doing more if I have the Smart Whip. It's easier to use and quicker. You do doubles by accident because you don't know how much is going in."* (16-year-old male NOS user, Salford)

> *"I'd say most people are using the Smart Whips now. They're a lot better. You can make your balloon any size with the Smart Whip. You can put more in, or you can make them smaller."* (17-year-old male NOS user, Tameside)

Larger canisters and increased use

Preference for the larger cannisters raised concerns amongst professionals that they present increased health risk for **nitrous oxide** users. These adverse health effects were discussed by both professionals and **nitrous oxide** users. Our research found that increasingly common use of the larger (circa 640gm) cannisters appears to facilitate increased use through three main ways:

1. More nitrous oxide may be put into each balloon
2. Users report using more in one episode than they would using small canisters
3. Greater ease-of-use results in quicker re-use

Increased amounts of nitrous oxide in a balloon

The small silver cannisters contain 8gm of **nitrous oxide**. Typically, users reported using one to fill up a balloon, meaning they knew they were inhaling 8gm of nitrous oxide. A couple of **nitrous oxide** users reported sometimes using two silver cannisters but one per balloon was the standard amount used. When discussing use of the larger canisters, **nitrous oxide** users fairly consistently perceived that they were putting more into a balloon, with all but two of the 22 young people we interviewed stating they used more when purchasing the larger cannisters.

> *"You use more from the Smart Whips I think, definitely. You can just keep going and unlike the silver one's you don't know how much is in it."* (17 year-old male NOS user, Rochdale)

> *"I think now yeah, people use a lot more innit? It's so easy with the big ones to fill it up and you don't know yeah. But I think you just keep going 'til it's full so I think a lot more gets put into it [a balloon]."* (16 year-old male NOS user, Trafford)

Increased amounts purchased

The **nitrous oxide** users we interviewed would typically discuss buying a box or two boxes of 24 x 8gm silver cannisters canisters to use with a friend. They reported that buying by the box has been replaced by buying a large cannister that is typically the equivalent of 80 x 8gm silver cannisters. Hence, if they share a large cannister, this equates to using the equivalent of 40 8gm silver cannisters when they would previously have used a box (x24) each.

> "Interviewer*: So how much would you typically use in a session? We used to buy two boxes of silver cannisters and share then between us . . . me and my mate. Interviewer: How many in a box? Twenty, no, 24 I think. But now we just get the Smart Whips, they are just a lot easier to use and quicker as well."* (16 year-old female NOS user, Trafford)

> *"I just much prefer the big ones now. I'll still use the others if somebody has them or I can't get the big ones, but they are just easier to use, and you don't need a cracker. Interviewer: So, are they cheaper as well? I think so, we used to get two boxes of 24 [8gm silver cannisters] for £20. Now we get a big one for £25 or £30. So it costs a bit more but you get more in them. Interviewer: And do you use the whole big canister or save some? Yes, we would always use it all."* (17 year-old male NOS user, Manchester)

Amounts used in a shorter time period

Finally, **nitrous oxide** users who we interviewed consistently discussed how it would take them less time to use a large canister than it would to get through the smaller canisters.

"Interviewer: *How long does it take to get through that* [a large canister] *then? About an hour, depends, could be a little longer,* [an] *hour and ten, fifteen minutes or something.* Interviewer: *And how does that compare with if you were using the silver cannisters? Quicker, much quicker. It would probably take one and half hours or two hours to use them - you have to do the crackers, while with these bigger ones now yeah, you just do it straight from the nozzle. So it's much quicker."* (16 year-old male NOS user, Tameside)

"And another thing now yeah, you can get through those [big cannisters] *rapid.* Interviewer: *How long is 'rapid'? An hour, or less, . . . 45 minutes. Because you don't need no cracker you can just put the balloon straight on and do it quick, less messing and faffing about!"* (17 year-old male NOS user, Salford)

In summary, while usage varied, the most typical narrative to emerge was that when young people were previously using the 8gm silver cannisters, a couple of friends may have shared two boxes of 24 x 8gm cannisters over a period of approximately two hours by using one 8gm cannister per balloon – the equivalent of 192gm of **nitrous oxide** each over a two-hour period. However, they were now using a 640gm large cannister in around half the time. Which equates to them using a larger amount – 320gm – in approximately one hour rather than two. In addition, many reported that they were putting more **nitrous oxide** in each balloon than the 8gm they would put in from a silver cannister. This increases the likelihood of young people passing out due to increased amounts of **nitrous oxide** being inhaled in a short period, which may impact on the oxygen/**nitrous oxide** balance in the brain.

Adverse health effects

Respondents from all three *GM TRENDS* surveys (adult survey, the young person survey and the professionals' survey) reported concerns around adverse health effects from the use of **nitrous oxide**. Subsequently, during interviews with **nitrous oxide** users, we enquired about any first-hand experiences of negative health effects. Personal experience of adverse effects was rare. However, two **nitrous oxide** users reported headaches after use.

"I can have a headache the next day after use." (15-year-old male NOS user, Tameside)

"Sometimes when I do it, I'll finish one and start going fuzzy. I'll get a headache if I've been proper bashing it. I don't really get a come down of them though." (16-year-old male NOS user, Salford)

Two others had witnessed other people passing out after use.

"A girl I was with started shaking whilst doing one. She went down and was out for about two minutes. But then she got up and was like, 'Oh my god, I just passed out.' She was alright after that." (16-year-old male NOS user, Salford)

"A girl I know passed out for about five minutes. She ended up waking up. That was using the bigger ones." (15-year-old male NOS user, Tameside)

In addition to personally witnessing negative effects of use, several respondents raised concerns based on situations they had heard of through others.

"A bad experience, it wasn't me and I wasn't there, but one of my friends told me she did way too many [nitrous oxide balloons] - *like a full box and a bit - all by herself and she had a mini stroke. It was very intense, and she ended up in hospital. But that's the only bad experience I can think of."* (20-year-old female NOS user, Manchester)

"Some boy I know started losing feeling in his legs. I wasn't there but someone I know was. He was proper doing them, like going through a number of Smart Whips [larger 640gm canisters] *in one night. Like seven [large canisters], but he was sharing them about. Next thing you know, he's in hospital in a wheelchair. But I don't really know how it happens. The boy used to always do them. All the time, every weekend he'd get crates of them."* (16-year-old male NOS user, Salford)

It should also be noted that not all interviewees knew of anyone who had experienced any adverse health effects from **nitrous oxide** use. The most common response was that they had no personal experience of themselves, friends or peers experiencing any harms related to nitrous oxide use.

"I've not known of anyone getting hurt and having to go to hospital because of them." (17-year-old male NOS user, Tameside)

"I've never known of anything serious happen when someone's used them." (17-year-old male NOS user (2), Tameside)

Whilst these experiences of stories they had heard from others are unverifiable, there is a growing body of medical evidence that **nitrous oxide** can negatively affect users' health. Several medical case studies have been published in recent years which highlight the health risks of nitrous oxide use. Excessive use of nitrous oxide can cause the user to have deficiencies in vitamin B12 (*Campdesuner et al., 2020; Stockton et al., 2017; Lan et al., 2019; Razaq & Qureshi, 2020; Winstock & Ferris, 2020*). Vitamin B12 deficiency can cause the following symptoms: extreme tiredness; a lack of energy; pins and needles (*paraesthesia*); a sore and red tongue; mouth ulcers; muscle weakness; disturbed vision; and psychological problems - which may include depression and confusion; problems with memory, understanding and judgement (*NHS, 2019*). Our interviews with professionals uncovered several incidents in Greater Manchester relating to vitamin B12 deficiency and neurological damage amongst nitrous oxide users that led to A & E attendance.

"We had one in May who was over 18, one in July who was 17 and one in August who is 17. The one in August came in with numbness, pins and needles in his legs. He'd been using on a daily basis for around 12 months." (A & E Nurse, Oldham, Rochdale & Bury)

"A 17-year-old Asian young man who came in with falls, pin and needles to legs and loss of sensation to legs after stopping nitrous oxide use. Prior to stopping he had been using on a daily basis for 12 months. ... He denied any other drug or alcohol use." (A & E Nurse, Oldham, Rochdale & Bury)

"The young person [Patient A] *informed me that at that specific time he was using four boxes of nitrous oxide per day [this equated to 96 canisters per day]. It became clear after completing the health assessment that Patient A had been using a large amount of nitrous oxide and he was demonstrating possible neurological symptoms in his lower limbs. Longer term use or in high doses, has been linked to the inactivation of vitamin B12. Low vitamin B12 levels can cause neurological damage. He did agree to an appointment with the Specialist GP within our service. During this time Patient A's neurological status had deteriorated and he was increasingly concerned about his balance - he was falling and dropping to the floor. Patient A was found to have a low vitamin B12 level, likely leading to his neurological symptoms. He is now being treated by the GP for vitamin B-12 deficiency. This case study highlights the need for more*

awareness amongst young people regarding the effects of using nitrous oxide and the possible life changing neurological concerns that individuals can face." (Specialist Adolescent Health and Wellbeing Nurse, Bolton)

Unfortunately, on one occasion, this led to a **nitrous oxide** related death.

"Prior to that, we had a young 18/19-year-old Asian young man in with cardiac arrest. He had been using for 12 months, stopped for two days, then started using again and had a cardiac arrhythmia. He sadly passed away. ... Nitrous oxide use can lead to cardiac arrythmia, which in turn would lead to cardiac arrest." (A & E Specialist Nurse, Oldham)

What was noticeable from these accounts is that where serious health risks including neurological damage and cardiac arrhythmia occurred, all these cases involved chronic use.

"It's a really small percentage of our referrals, but the concern is that the cases with [B12] deficiencies, it's been chronic use." (A&E Nurse, Oldham, Rochdale & Bury)

All reports of vitamin B12 deficiency, related neurological damage and cardiac arrhythmia followed a similar pattern of extreme use. This included daily use for a prolonged period of six months or more with the consumption of large amounts of 50 to 100 or more balloons a day.

Our attempts at obtaining reliable hospital admissions data were not always successful due to lack of response or available data. In one case, an A & E consultant reported an increase based on anecdotal evidence. In one area (Stockport), a young person's substance use service reported an increase in hospital admissions over the past year: from none in the previous year to two in the first seven months of 2022. Another hospital (Royal Oldham) reported an increase from four nitrous oxide related admissions in the last financial year to five in the first five months of 2022/23. No other areas reported data.

In addition, it was consistently reported by young person's substance use treatment services and young people alike that **nitrous oxide** was typically used as a secondary or tertiary substance, typically used with **alcohol** and/or **cannabis**.

"We don't get many using it as a primary substance. It tends to be secondary or tertiary with alcohol and/or cannabis when it comes up." (Advocacy Worker, Manchester)

"To be honest we don't see that many. I think there may have been an increase, or maybe we are just more aware, more attuned shall we say to it. But still, I think you are definitely still talking single figures." (Outreach Worker, Stockport)

"Between 2021-2022, we had five cases. It was mainly a secondary drug. Usually they'd use alcohol, cannabis, ecstasy or cocaine or another drug, with nitrous oxide. This year we've had two purely nitrous oxide referrals." (A&E Nurse, Oldham, Bury & Rochdale)

In summary, the findings from our research suggest that, whilst there is a risk of adverse health effects from using **nitrous oxide**, the risk from occasional, recreational use is low. Neurological damage, caused by vitamin B12 deficiency or cardiac arrythmia is associated with prolonged, chronic use. Understanding the motivations of these chronic users could reduce the overall number of those experiencing the adverse health effects highlighted in this report.

Ice burns

Beyond neurological damage caused by vitamin B12 deficiency, the other main concern raised by professionals was in relation to ice burns. The route of administration requires **nitrous oxide** to be decanted into balloons before the gas can be inhaled. Direct inhalation from **nitrous oxide** cannisters is dangerous and likely to inflict severe internal ice burns to the user (*Greater Manchester Local Drug Information System, 2022*). Whilst decanting into a balloon reduces the risk of internal ice burns, there is still a risk to the user's extremities. The available literature suggests the use of larger nitrous oxide canisters poses a serious risk of ice burn (*Quax et al., 2022; Baran et al., 2020*). Users have been reported to develop serious ice burns to the inside of their thighs when using the large canisters to fill up balloons (*Stone et al., 2021*).

We received one such report from Stockport of a 16-year-old female who suffered third degree burns after holding a large canister between her legs. Nevertheless, whilst the evidence suggests the larger canisters pose a greater risk of ice burns, the risk of injury still exists with smaller canisters. The small, single dose canisters require a 'cracker' to extract the gas (see Image 4). This is a manual process, which involves the user twisting the device to break the seal on the cannister. The gas is released and exits from the top of the cracker. A balloon is attached to the cracker to capture the released gas. The head of the cracker rapidly reduces in temperature as the gas escapes from the canister and fills the balloon. If a user's hand remains at the top of the cracker during this process, the risk of ice burn arises.

Image 4. A cracker, alongside a single dose cannister and balloon.

Ice burns and physical injury were recognised as a potential risk of harm by respondents in the *young person's, adults'* and the *key professionals survey*. This was discussed in relation to both the small silver cannisters and the large *'SmartWhip'* type cannisters. However, the young **nitrous oxide** users we interviewed focussed mainly on the risk of injury in relation to the smaller canisters.

> *"The only time I've been hurt is when the cracker was leaking gas. I didn't want to waste it. So, I put it to my lips to take it in, but my lips got stuck to it. I had to pull it off and it pulled a bit of my lips off."* (19 year-old male NOS user, Trafford)

> *"When it starts running out, it starts going freezing cold and the bottom - it'll start frosting up. The top doesn't burn your hands so much because it has a plastic nozzle. But it's the actual metal canister and the bottom that goes really cold. Usually, it more [often] happens with the small canisters. You can see the frost on the SmartWhip but the burns come from the cracker more so. The larger ones are less risky. The canisters are more likely to burn you."* (16-year-old male NOS user, Salford)

"The small canisters are more dangerous. I heard the cracker exploded on someone once and gave them a wound on the leg. The cracker can get ice cold as well which makes your hand stick to it. You can get friction burns with the crackers as well because of how hard you've got to twist it." (17-year-old male NOS user, Tameside)

As this young person's outreach worker notes, these ice burns tend to result in minor injuries to the fingers that typically do not lead to the need for medical attention.

"A lot of the young people say to me they've had 'freeze burns' as they call it. Often not too serious where they need to go to A & E or anything, but frequent reports of burns to their fingers or mouth and lips through doing balloons. I don't think they realise that it's compressed and freezing when it comes out and what the risks are." (Young Person's Outreach Worker)

However, the frequency with which ice burns were recounted by professionals and **nitrous oxide** users highlights the need for awareness raising of this risk and appropriate harm reduction advice.

Usage practice and antisocial behaviour

Most **nitrous oxide** users we interviewed discussed the using of **nitrous oxide** in social settings. This was usually at parties or gatherings (referred to as 'motives' by some of the younger respondents).

"I'd use it in a group situation, party vibes kind of thing. I wouldn't use it on my own. I've done them outdoors and stuff. But it's more like when you're with a group of mates drinking." (17-year-old male NOS user, Tameside)

"Usually, we'd get a Smart Whip and get a bag [undisclosed substance]. We'd do them at parties or motives." (16-year-old male NOS user, Salford)

"Basically, it's become a party drug. Or a free gaff [house]. If you're at a little sesh, or something, you'll use a balloon." (17-year-old male NOS user, Tameside)

This trend in use is consistent with young people's purchasing habits. It was regularly discussed that multiple people would split the cost of either the large canisters or a box of the smaller canisters.

"Four or five of us would share one or two big canisters in one session. Like around a third each. Out of one canister we'd get around 30 balloons. We'd get through that in about one or two hours." (19-year-old male NOS user, Trafford)

"Between four of us, we'd use two boxes of the small canisters. There are 24 in a box. If we were using the big canister, we'd use a full one between all of us. It takes longer to get through the smaller canisters because you have to use the cracker." (15-year-old male NOS user, Tameside)

"If I got a Smart Whip, I'd put to with someone else. We'd have two or three using one large [cannister]. It would last about an hour and a half." (16-year-old male NOS user, Salford)

Use in vehicles

It was also noted in the professionals' interviews that some people were known to be using **nitrous oxide** in cars.

> *"If you want to see NOS [nitrous oxide use] just come to Whalley Range on a night, especially weekends - Friday, Saturday night. You will see bare people just driving up and down doing balloons in cars."* (Young Person's Substance Use Team Leader, Manchester)

This was perceived to be a trend among young Asian men in particular in some areas.

> *"You see it especially with the young Asian lads. If you walk around the street where we live you will see them parked up in their cars doing balloons and you can see where they've been using in the cars and just dumped a load of empty cannisters by the roadside."* (Manager, Young Person's Substance Use Service, multiple GMCA areas)

> *"It seems to be a bit of thing with young Asian – Pakistani – lads. You see them doing it in their cars. Interviewer: Is that parked up or driving? Both. You see them parked up a lot, but I've also seen them driving down the road doing it."* (Advocacy Worker, Manchester)

The use of **nitrous oxide** by young Asian men was also raised as a concern by health professionals working in the Oldham and Rochdale area.

> *"As for the other young man, the 17-year-old. These falls, pins and needles to feet/legs and loss of sensation to legs seemed to be as a direct consequence of long-term nitrous oxide use. What both cases have in common for me are ethnicity, age and gender. It might be that they don't see nitrous oxide as a drug and therefore acceptable to use in their culture/religion. My concern is that there may be groups of Asian young men/young adults that are not known to services and therefore unaware of the risks associated with nitrous oxide use."* (Alcohol Nurse Specialist, Oldham, Rochdale & Bury)

One professional knew of a young person involved in a car accident due to this practice.

> *"A kid I know now, did a balloon in his car. Next thing, he drives off and Bam! Straight into the back of a car, wrote his car off!"* (Youth Worker, Manchester)

Police data provided from Manchester's *Community Safety Team* reveal that in the past two years there have been 76 incidents recorded where concerns were raised about drivers of vehicles inhaling from balloons (sometimes while in the act of driving), as well as a further 26 reports of vehicle occupants more generally using balloons. Many calls about drugged drivers describe dangerous driving – speeding, weaving through traffic, causing actual or near collisions, driving very slowly and/or causing an obstruction, doing handbrake turns and running red lights. Some of these incidents also involve the throwing of cannisters from vehicles, and abusive or aggressive behaviour. Reports of **nitrous oxide** use associated with vehicles also often include complaints about loud music, as well as a smaller number of incidents where vehicle occupants have harassed pedestrians (*Manchester Community Safety Team, 2022*).

Currently, Manchester City Council are considering prohibiting consumption of **nitrous oxide** in the city centre through a PSPO (*Public Space Protection Order*). Data obtained from Manchester, covering October 2021 to September 2022, highlighted a significant increase in incidents in the City Centre relating to the use of **nitrous oxide** - doubling from 55 in the previous year to 109 (*Manchester City Council, 2023*). Interviews with Manchester City Centre

residents were conducted over the phone to discuss their experience with **nitrous oxide** related antisocial behaviour by the anti-social behaviour team. The impact on city centre residents is illustrated below.

> *"Since towards the end of the pandemic I have been disturbed by the sound of people using canisters to fill balloons to use nitrous oxide on the street in the city centre. Previously people used small silver cannisters that were about 3 inches long but now people are using huge canisters that are the size of a coffee flask or slightly bigger. Thursday to Sunday, between the hours of late evening (around 10pm) until 5am or 6am. They play loud music from their vehicles with the car doors open. They do not appear to drink alcohol and are aged from late teens into their 30s. On one occasion I saw a lad in his early 20s sat in his car, he put the metal rod from the large cannister straight into his mouth. On behalf of residents I have spoken to, I can say that numerous people are disturbed by the anti-social behaviour caused by people using nitrous oxide in the city centre."* (City Centre Resident (1))

> *"Over the last couple of years, since 2019 prior to the pandemic, I have been disturbed by people congregating in and around cars in the city centre to use nitrous oxide and play loud music from the vehicles. It usually happens on a Saturday night into the early hours of Sunday morning every month, two or three weekends out of the four. It's worse in the summer months and can go on for longer into the earlier hours. They appear to be in their early 20s to mid 30s, men and women. When the vehicles park up, they open the car doors and play really loud music. They don't hide that they are taking the nitrous oxide. They move between the cars, rev vehicle engines and play the loud music. The following morning the street is littered with canisters. One Sunday morning I picked up 155 canisters and a couple of weeks ago I collected 70. Recently I found a used box of the large blue canisters. I have noticed a shift from people using the smaller silver tabs to the large canisters."* (City Centre Resident (2))

> *"Over the last 18 months, since the lifting of lockdown and bars opening, we have been disturbed at weekends, from late evening into the early morning, by the sounds of people using nitrous oxide. People park up and congregate, they take balloons, socialise, and play loud music from their cars with the car doors open. It's like a party atmosphere. When we leave the building the following morning, we struggle due to the dozens of silver canisters and larger canisters littered on the street near the exit we use."* (City Centre Resident (3))

These interviews with residents suggest **nitrous oxide** users present a considerable disturbance to city centre residents. The city centre *PSPO* would give Greater Manchester Police more power to tackle this kind of antisocial behaviour incidents until **nitrous oxide** is brought under the control of the *Misuse of Drugs Act* and may offer a more practical way of addressing nitrous oxide related *ASB* for *ASBAT* and neighbourhood policing teams.

Litter and waste

While the often-seen discarded silver canisters have been a litter concern for several years, the shift to the use of the larger canisters causes concerns over waste and health and safety.

> *"The canisters are pressurized and hazardous and should not be stored in residential premises. This also causes an issue in terms of waste in collection and recycling and will require handling by specialised companies. [. . .] There is a risk of explosion with any pressurised gas. The containers do not look of a suitable standard and the warnings are not clear. This poses a risk of harm to users."* (Head of Campus Security, Manchester)

Ease of Access

Respondents of the *PWUD* survey discussed where they source **nitrous oxide** from. Three main avenues were highlighted: physical shops, online (see Image 5), or through dealers.

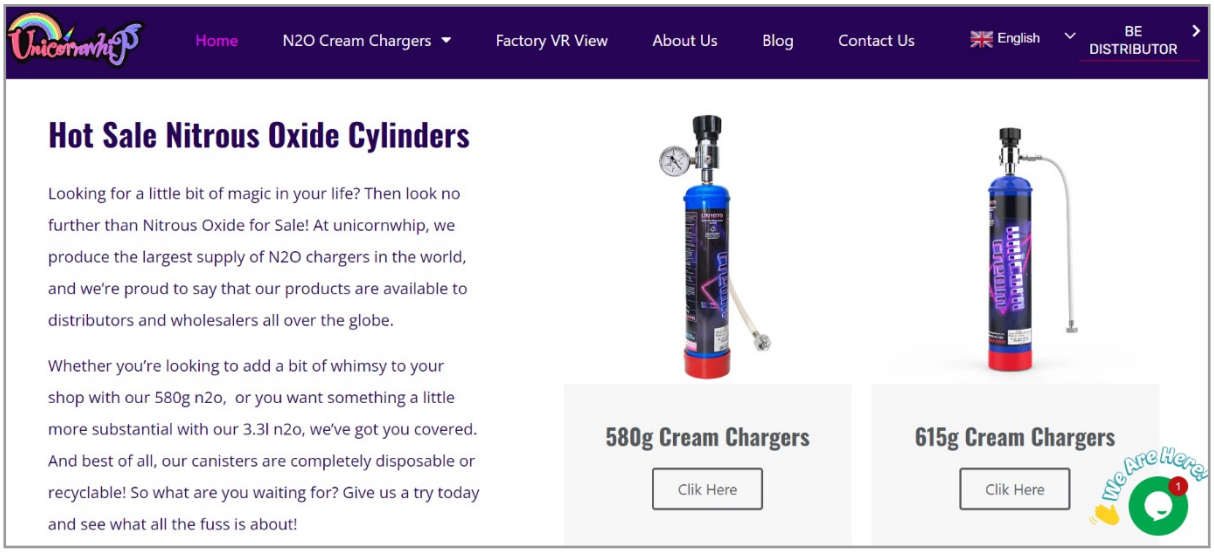

Image 5. Online store selling large nitrous oxide cannisters.

> *"I get them from G-Whips* [online store]." (17-year-old male NOS user, Tameside)

> *"At the moment, you can get them online. I know the law is changing though, so that's gonna change soon. There are a few places online I know about. It's £40 for one of the big ones. Or two for £70. And then the small ones, it's £10 for 20."* (19-year-old male NOS user, Trafford)

In addition to dedicated online sellers, they were reported to be easily accessible from large online marketplace platforms such as *Amazon* and *Ebay*.

> *"You can get them off Amazon as well, I forgot to mention that. We got them once off Amazon during lockdown."* (20-year-old female NOS user, Manchester)

Many young people reported that they were also readily available locally from a range of local retail outlets or people who sold other drugs.

> *"It was mostly like Spar or little shops like that, it was close to Birley* [university campus]." (20-year-old female NOS user, Manchester)

> *"There are petrol stations you can buy them from, but people sell them. Like where I get weed from, they also sell NOS."* (17-year-old male NOS user (2), Tameside)

> *"Usually, I get them from a dealer or a shop. But the shops do it on the down low. Usually, the dealers are selling other stuff like weed, ket, pills and stuff."* (16-year-old male NOS user, Salford)

Access at festivals was also commonly discussed, although often at inflated price when buying nitrous oxide balloons at public events.

> *"People at Parklife were selling one balloon for a fiver."* (16-year-old male NOS user, Salford)

With the costs of a large canister reported to be between £20 to £30, and the size (640gm) equating to being able to fill as many as 80 balloons, the potential profit (80 nitrous oxide filled balloons x £5) is in excess of £350 per large canister. Reports of this were scarce but the prevalence of **nitrous oxide** related litter after music events (see Image 6) suggests this may be more common than previously known.

Image 6. Empty cannisters collected after the 2022 Parklife Festival .

Our findings highlight the ineffectiveness of current legislation to reduce the ease of access to **nitrous oxide**. Whilst the *Psychoactive Substances Act 2016* criminalises the selling of **nitrous oxide** for recreational purposes, its legitimate uses make prohibition difficult to implement. The government intention to control **nitrous oxide** under the *Misuse of Drugs Act*, may inhibit accessing the substance through 'legitimate' sellers (such as physical and online retailers). This is likely to give illegitimate sellers (such as street dealers) total control of the market (*van Amsterdam, 2022*). Such an outcome would likely increase the risk of harm for those continuing to use **nitrous oxide**.

Harm reduction

There have been numerous calls for harm reduction practices to be recognised and promoted amongst **nitrous oxide** users by various authors (*Jay, 2008; Asmussen Frank et al., 2020; Allan et al., 2022; MacLean et al., 2022; Sumnall, 2022*). We asked those involved in our interviews to discuss what harm reduction advice they would offer to those who intend to use nitrous oxide.

Professionals recognised the need for harm reduction practices to be disseminated amongst **nitrous oxide** users.

> *"There needs to be more in the way of harm reduction - safe practice in use. And raising awareness about the issues around prolonged use."* (Young Persons Substance Use Worker, Trafford)

> *"I think it's important to identify more standardised usage practices. If someone is saying they use a certain number of balloons, it would be useful to know how big those balloons are. Using the small canisters, we can tell exactly how much they're using. With the Smart Whips, there's a lot of variability. I know of one young person who filled up a large balloon, like one with handles. They don't realise they need to take a rest and take in some oxygen at times."* (Substance Use Worker, Manchester)

The **nitrous oxide** users we interviewed were asked to disclose their own harm reduction practices and advice. Physical harm was more commonly associated with the smaller canisters, which were considered to have a greater risk of causing ice burns. Respondents

most commonly highlighted the potential harm in using **nitrous oxide** for a prolonged period. This coincides with the medical case studies presented earlier. Their advice often centred on i) advising people to not to put too much in a balloon. ii) to limit the number of balloons used in a session, and iii) to take breaks in-between using to allow the rebalance of oxygen to return to the brain.

> *"If I was telling somebody using for the first time I'd say don't use too often. Just use now and again and don't use more than about 10 [balloons] in a sesh yeah. Because some people, they get greedy, they just want to use and use and don't allow enough time in-between. Interviewer: So is that how you use then? Yes, me and my mates, we'd do about 8 to 10, maybe 12, depends. And all have a laugh and that but then we'd chill, have a spliff and a drink then maybe do another 8 or 10 again half an hour later."* (18-year-old male NOS user, Trafford)

> *"…especially if it was the first time, I would tell people to not do doubles and that kind of stuff, just go for one [small canister], people would try to do like a triple or four and it's so much. I would say be aware they can be dangerous. I did do them but there's always that fear in your mind - like what if a [blood] vessel pops? You don't want to be the one person where things go wrong so just be careful and be aware. It could happen to anyone."* (20-year-old Female NOS User, Manchester)

One way of ensuring that not too much **nitrous oxide** is used in a balloon is to use small canisters rather than the larger ones.

> *"I would say it's probably better to do canisters than Smart Whips. I'd say take it slow. The feeling leaves after 15 seconds but then there's an afterglow. I'd tell people to wait until the afterglow goes before doing another one."* (16-year-old male NOS user, Salford)

Taking gaps in between reusing was another common piece of advice. Consistent reports that the trend is towards use of the large canisters raises concerns that this will lead to shorter periods between re-use – increasing the need for wide promotion of harm reduction advice.

> *"I'd say to stop getting the feeling of being dizzy, I'll take gaps between breaths on an individual balloon. If you're doing it too quickly, you'll start to get a headache, so you know when to stop for a bit."* (17-year-old male NOS user, Tameside)

> *"I'd say take a break for a few minutes before doing another one. Also, not to overfill the balloon."* (17-year-old male NOS user, Tameside)

In addition to advice around taking breaks throughout a session, one interviewee suggested not using for more than two consecutive nights.

> *"I'd say don't do it more than two nights in a row - that's when you start to feel the effects. You feel your brain is going at a slowing rate, like brain fog."* (19-year-old male NOS user, Trafford)

Summary

It appears that for most young people, nitrous oxide use is recreational and does not lead to any short or longer-term harms. However, for a small number of users, the health effects can be serious. There have been cases within Greater Manchester that suggest the harms of chronic **nitrous oxide** use are serious and potentially life threatening. Both the medical literature and our own findings suggest that where neurological damage (caused by vitamin B12 deficiency) or cardiac arrythmia do occur, they are typically associated with daily use of large amounts of **nitrous oxide** (50 to 100 or more balloons) over a prolonged period (six months or more). Understanding the motivations of these users could help reduce the number of young people experiencing such adverse health effects.

All of the nitrous oxide users that we interviewed were aware of the potential risks involved with using **nitrous oxide** recreationally and most users took part in some form of harm reduction practice when using. However, targeted harm reduction advice about safer use would be beneficial, especially for less experienced and 'drug wise' young people.

The popularity of the larger (circa 640gm) canisters arising from them being relatively cheap, practical to use and the perception that they are safer raises some specific concerns. Compared to patterns of consumption with the small canisters, this increasingly common use of the larger canisters is associated with higher quantities of nitrous oxide being used, as it facilitates:

1. More **nitrous oxide** being put into each balloon
2. Use of a greater quantity of balloons per episode
3. More frequent use of balloons due to greater ease-of-use of large canisters.

While user reports suggest that the trend of purchasing larger canisters may actually reduce the risk of 'ice burns' on the fingers/hands, the use of larger canisters against bare skin - particularly when positioned against between the thighs in the summer - can lead to serious ice burns and specific harm reduction advice in relation to the increasingly common use of larger cannisters should be developed.

In addition to harms to users, the use of **nitrous oxide** has a wider community impact. There is a need to respond to any associated anti-social behaviour. Use in cars, particularly driving shortly after use or when using, poses risks to both users and the public. Finally, littering and the safe disposal of the large canisters also needs addressing.

Recommendations

Harm Reduction

We recommend the development of clear harm reduction advice that raises awareness of:
1. Forthcoming legislative changes that will make possession an offence;
2. How to use safely: allowing breaks between reusing and not driving after use;
3. The risks related to chronic, prolonged use of nitrous oxide; and
4. The need to avoid ice burn injury from holding large cannisters against bare skin.

Our research suggests that there may be a need to target awareness raising of harms associated with chronic use and harm reduction advice to specific communities/ demographics (e.g., Young Pakistani men, university students).

Awareness Raising

We recommend the distribution of this report together with the recently developed professional guidance on nitrous oxide created by Linnell Communications for the Greater Manchester Local Drugs Information System, to professionals working with young people, including young adults.

Community Safety

We recommend further consideration towards the reduction of antisocial behaviour associated with the use of nitrous oxide via the use of Public Space Protection Orders (PSPOs) as a (temporary) alternative to the forthcoming changes to the Misuse of Drugs Act.

References

ACMD, 2015. *ACMD advice on nitrous oxide abuse*. Retrieved from GOV.UK: https://www.gov.uk/government/ publications/acmd-advice-on-nitrous-oxide-abuse

ACMD, 2021. *Nitrous Oxide: Home Secretary's letter to the ACMD*. Retrieved from GOV.UK: https://www.gov. uk/government/publications/nitrous-oxide-home-secretarys-letter-to-the-acmd

ACMD, 2023 (a). *Supplementary letter from the Minister for Crime, Policing and Fire about the ACMD's updated harms assessment*. Retrieved from GOV.UK: https://www.gov.uk/government/publications/nitrous-oxide-home-secretarys-letter-to-the-acmd/supplementary-letter-from-the-minister-for-crime-policing-and-fire-about-the-acmds-updated-harms-assessment-accessible-version

ACMD, 2023 (b). *Publication of ACMD's review on nitrous oxide*. Retrieved from GOV.UK: https://www.gov.uk/government/news/publication-of-acmds-review-on-nitrous-oxide

ACMD, 2023 (c). *GOV.UK*. Retrieved from Government response: ACMD nitrous oxide review: https://www.gov.uk/government/publications/nitrous-oxide-updated-harms-assessment/government-response-acmd-nitrous-oxide-review-accessible

Asmussen Frank, V., MacLean, S. and Herold, M.D., 2020. Nitrous oxide use among young people–new trends, policy challenges, and knowledge gaps. *Drugs and Alcohol Today*, 20(4), pp.383-392.

Allan, J., Cameron, J. and Bruno, J., 2022. A systematic review of recreational nitrous oxide use: implications for policy, service delivery and individuals. *International journal of environmental research and public health*, 19(18), p.11567.

Baran, K.C., van Munster, I.G., Vries, A.D., Gardien, K.L., van Trier, T. and Pijpe, A., 2020. Severe nitrous-oxide frostbite injuries on the rise in The Netherlands; let's raise awareness. *Burns*, 46(6), pp.1477-1479.

Campdesuner, V., Teklie, Y., Alkayali, T., Pierce, D. and George, J., 2020. Nitrous oxide-induced vitamin B12 deficiency resulting in myelopathy. *Cureus*, 12(7).

Crime Survey of England and Wales (2022) Drug misuse in England and Wales: year ending June 2022: An overview of the extent and trends of illicit drug use. Data are from the Crime Survey for England and Wales. https://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/articles/drugmisuseinenglandandwales/yearendingjune2022

Ehirim, E.M., Naughton, D.P. and Petróczi, A., 2018. No laughing matter: presence, consumption trends, drug awareness, and perceptions of "hippy crack"(nitrous oxide) among young adults in England. *Frontiers in psychiatry*, 8, p.312.

Garakani, A., Jaffe, R.J., Savla, D., Welch, A.K., Protin, C.A., Bryson, E.O. and McDowell, D.M., 2016. Neurologic, psychiatric, and other medical manifestations of nitrous oxide abuse: a systematic review of the case literature. *The American journal on addictions*, 25(5), pp.358-369.

Granada, 2020. *Drug researchers warn of the dangers of 'laughing gas' following illegal raves*. Retrieved July 2020, 2020, from https://www.itv.com/news/granada/2020-06-17/drug-researchers-warn-of-the-dangers-of-laughing-gas-following-illegal-raves/

Greater Manchester Local Drug Information System, 2022. *Nitrous Oxide (N20) A Briefing for Professionals*

Hansard, 2020. *Misuse of Nitrous Oxide*. Retrieved August 10, 2020, from https://hansard.parliament.uk/commons/2020-07-21/debates/A3366F76-6E00-4928-82F3-FA47FD2ACABA/MisuseOfNitrousOxide

Home Office, 2018. *Review of the Psychoactive Substances Act 2016*. Retrieved August 3, 2020, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/756896/Review_of_the_ Psychoactive_Substances_Act__2016___web_.pdf

Home Office, 2021. *Home Secretary seeks expert advice on 'laughing gas'*. Available at: https://www.gov.uk/government/news/home-secretary-seeks-expert-advice-on-laughing-gas (Accessed: 20 February 2023)

Home Office. (2022, February 4). *Seizures of drugs in England and Wales, financial year ending 2021*. Retrieved from GOV.UK: https://www.gov.uk/government/statistics/seizures-of-drugs-in-england-and-wales-financial-year-ending-2021/seizures-of-drugs-in-england-and-wales-financial-year-ending-2021

Jay, M., 2008. Nitrous oxide: recreational use, regulation and harm reduction. *Drugs and Alcohol Today*, 8(3), pp.22-25.

Lan, S.Y., Kuo, C.Y., Chou, C.C., Kong, S.S., Hung, P.C., Tsai, H.Y., Chen, Y.C., Lin, J.J., Chou, I.J., Lin, K.L. and PCHAN Study Group, 2019. Recreational nitrous oxide abuse related subacute combined degeneration of the spinal cord in adolescents–a case series and literature review. *Brain and Development*, 41(5), pp.428-435.

MacLean, S.J., Riddell, O., Herold, M.D. and Frank, V.A., 2022. Becoming a nitrous oxide user on social media: Learning to maximise pleasures and minimise harms. *International Journal of Drug Policy*, 109, p.103861.

Manchester Community Safety Team (2022) Greater Manchester Police and Manchester Community Safety Team Official Incident Data.

Marsden, P., Sharma, A.A. and Rotella, J.A., 2022. Clinical manifestations and outcomes of chronic nitrous oxide misuse: A systematic review. *Emergency Medicine Australasia*, 34(4), pp.492-503.

NHS, 2019. Vitamin B12 or folate deficiency anaemia. Available at: https://www.nhs.uk/conditions/vitamin-b12-or-folate-deficiency-anaemia/ (Accessed: 20 February 2023).

NPIS. (2021, September). *Annual Report 2020/21*. Retrieved from National Poisons Information Service: https://www.npis.org/

ONS (a). (2022, September 6). *Smoking, Drinking and Drug Use among Young People in England, 2021*. Retrieved from NHS Digital: https://digital.nhs.uk/data-and-information/publications/statistical/smoking-drinking-and-drug-use-among-young-people-in-england/2021

ONS (b). (2022, February 28). *Deaths related to volatile substances, helium and nitrogen in England and Wales: 2001 to 2020 registrations*. Retrieved from Office for National Statistics: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/deathsrelatedtovolatilesubstancesheliumandnitrogeninenglandandwales/previousReleases

Pratt, D.N., Patterson, K.C. and Quin, K., 2020. Venous thrombosis after nitrous oxide abuse, a case report. *Journal of Thrombosis and Thrombolysis*, 49, pp.501-503.

Quax, M.L.J., Van Der Steenhoven, T.J., Antonius Bronkhorst, M.W.G. and Emmink, B.L., 2022. Frostbite injury: An unknown risk when using nitrous oxide as a party drug. *Acta Chirurgica Belgic*a, 122(2), pp.140-143.

Randhawa, G. and Bodenham, A., 2016. The increasing recreational use of nitrous oxide: history revisited. *BJA: British Journal of Anaesthesia*, 116(3), pp.321-324.

Razaq, J. and Qureshi, S., 2020. Recreational nitrous oxide abuse causing B12 deficiency with subacute combined degeneration of the spinal cord: A case report. Journal of Family Medicine and Primary Care, 9(11), p.5772.

Redmond, J., Cruse, B. and Kiers, L., 2022. Nitrous oxide-induced neurological disorders: an increasing public health concern. *Internal Medicine Journal*, 52(5), pp.740-744.

Sky News, 2022. *Laughing gas sparks 'epidemic' of youngsters being hospitalised - as doctors warn about dangers of nitrous oxide*. Available at: https://news.sky.com/story/laughing-gas-sparks-epidemic-of-youngsters-being-hospitalised-as-doctors-warn-about-dangers-of-nitrous-oxide-12685121 (Accessed: 20 February 2023).

Stockton, L., Simonsen, C. and Seago, S., 2017. Nitrous oxide–induced vitamin B12 deficiency. *Proceedings (Baylor University. Medical Center)*, 30(2), p.171.

Stone, M.J., Roberts, N.M. and Anwar, M.U., 2021. Burn injury from filling balloons with nitrous oxide. *BMJ Case Reports* CP, 14(12), p.e247077.\

Sumnall, H., 2022. Recreational use of nitrous oxide Smart legislation, prevention, and harm reduction are required to reduce the risks. British Medical Journal, 378.

The Independent. (2022, July 25). *Doctors warn 'dangerous' laughing gas is becoming an 'epidemic' amid rise in hospitalisations*. Retrieved from The Independent: https://www.independent.co.uk/news/health/laughing-gas-epidemic-nitrous-oxide-canister-warning-b2130659.html

Thomas, S.P., 2021. Increased misuse of nitrous oxide: No laughing matter. *Issues in Mental Health Nursing*, 42(3), pp.207-207.

van Amsterdam, J.G., Nabben, T. and van den Brink, W., 2022. Increasing recreational nitrous oxide use: Should we worry? A narrative review. Journal of Psychopharmacology, 36(8), pp.943-950.

Winstock, A.R. and Ferris, J.A., 2020. Nitrous oxide causes peripheral neuropathy in a dose dependent manner among recreational users. *Journal of Psychopharmacology*, 34(2), pp.229-236.

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