



Barriers to Harm Reduction: Heating and Filtration of Oxycodone Tablets Prior to Intravenous Use by People Who Inject Drugs in Australia

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KEY FINDINGS

- Intravenous use of oxycodone was examined among people who regularly inject drugs (PWID) interviewed as part of the Illicit Drug Reporting System (IDRS) from 2005 to 2013; behaviours reported by the Tasmanian subsample were specifically examined to illustrate trends associated with an illicit drug market characterised by low heroin availability and high pharmaceutical opioid use.
- The proportion of PWID in the national sample reporting recent injecting use of oxycodone increased from 2005 (17%) to 2013 (31%). Rates of intravenous use in the Tasmanian sample were high, rising from 26% in 2005 to 60% reporting recent use in 2013. The increase in price over time in Tasmania (\$40 in 2005 to \$80 in 2013 for an 80mg tablet) reflected this increase in demand.
- Injection of oxycodone tablets can cause harms both from the drug itself but also from the presence of tablet contaminants. The majority of participants nationally had used some sort of filter to remove these contaminants (2012: 99%; 2013: 97%). However, less than one-fifth had used filters capable of removing the majority of particulate contaminants present (i.e., wheel filters; 2012: 22%, 2013: 14%). Most of the 2012 and 2013 national sample also heated their oxycodone drug preparation, a risky practice as warmed particles may pass any filter but resolidify in the bloodstream. Since 2007, Tasmanian data showed an increase in harm reduction practices by PWID via use of a filter. However, analyses indicated relatively low uptake of wheel filters relative to cigarette/cotton wool filters. The finding that those who used less effective filters were more likely to adopt heat extraction provides a basis for further harm reduction endeavours.
- The typical profile of PWID who used cigarette/cotton wool filters versus wheel filters were quite similar, with the exception of indications that the latter used oxycodone intravenously more frequently, and were more likely to report intravenous use of pharmaceutical stimulants. While the rates of overall injecting-related harms typically did not vary according to oxycodone filtering practices, the high rate of other intravenous tablet use may have contributed to these outcomes.

BACKGROUND

Extra-medical prescription opioid use (use without a prescription or not as directed by a doctor; 1) is of significant public health concern in Australia and internationally. Higher rates of extra-medical use are thought to partially reflect a decrease in heroin availability (2), and an escalation in the number of opioid prescriptions (3), with a 152% increase in the number of opioid prescriptions in Australia between 2002-03 and 2007-08 (4). In Australia, the predominant pharmaceutical opioids used extra-medically comprise oxycodone and morphine (3). Oxycodone is a semi-synthetic opioid used to provide relief from moderate to severe pain (5). Rates of oxycodone prescriptions in Australia have increased relative to other opioids (e.g., morphine) due to superior absorption and bioavailability (4). Of concern, concomitant increases in Australian and international rates of injection of oxycodone tablet formulations injection are also apparent (5).

Oxycodone tablets are intended for oral administration; crushing and dissolving the tablets in water for intravenous use can lead to considerable harms for people who regularly inject drugs (PWID) (5). In addition to microorganisms (i.e., bacteria and fungi) in the injecting environment which can cause infection, oxycodone tablets contain inactive ingredients (e.g., talc, titanium dioxide, and magnesium stearate), otherwise known as excipients, which can be harmful to inject (6). Some of these excipients are not water-soluble; the undissolved particulate matter can travel along the vein until it causes an obstruction leading to inflammation (phlebitis) and formations of clots (embolism), heightening the risk of ischemia (7). These particles can also travel from the blood to lung tissue, causing inflammation and scar tissue, and heightening the risk of pulmonary difficulties, as well as causing issues in other organs.

Harm reduction practices adopted by PWID include using filters, and using heat when preparing substances for injection. Heat may be used on the assumption that it reduces microorganisms, helps separate active from

inactive tablet components, or ensures maximum drug extraction. However, microscopy research indicates that heating the preparation does not significantly increase the quantity of drug extracted. Furthermore, this practice increases the risk of injecting-related harms, as some excipients may pass into solution when heated, and pass through filters, only to re-solidify into particles when cooled in the bloodstream (7). Microscopy research has also revealed that failure to filter can result in intravenous injections containing very substantial numbers of particles (> 5µm) which can cause cardiac and vascular damage (6). Use of a filter does not guarantee removal of all particles; different types of filters have various rates of success in removing particles. While both cigarette (pore size approximately 20-50 µm) and commercial wheel filters (bacterial .22 µm and pill .45µm filters) successfully reduce the number of very large particles, the former still allows through substantial numbers of smaller particles able to cause harms. However, wheel filters tend to block easily (particularly for unheated preparations) without pre-filtering with a coarse filter (such as a cigarette filter), creating a barrier to adoption of this approach (6).

While best practice for oxycodone use is oral administration where medically indicated, the reviewed studies indicate harm reduction strategies can be implemented to reduce the risk of vein and tissue damage and secondary complications if injected. Consequently, the aim of the present study was to determine application of these practices amongst PWID. Specifically, the objective was to overview rates of oxycodone injection reported in an annual survey of a sentinel group of Australians who regularly inject drugs, with a specific focus on heating and filtering practices and rates of injection-related harms. In addition to examining the behaviours reporting by the national IDRS sample, data collected from the Tasmanian subsample will be analysed. The Tasmanian illicit drug market is characterised by low availability of heroin, with higher rates of pharmaceutical opioid use relative to other states and territories in Australia (8); examination of trends in this sample will illustrate the harms evident in a prescription opioid-dominant consumer group.

METHOD

The Illicit Drug Reporting System (IDRS) is an annual study designed to monitor emerging trends in the illicit drug market in state and territory capital cities in Australia. Detailed information on the methodology of the survey and characteristics of PWID who participated in the IDRS survey between 2005 and 2013 can be found in the national and state reports available on the

NDARC website: <http://ndarc.med.unsw.edu.au/group/drug-trends>. Participants are recruited using a variety of methods, including advertisements distributed through Needle and Syringe Program (NSP) outlets, pharmacies (through flyers included with injection equipment) or health services, and snowball methods (recruitment of friends and associates through word of mouth). In order to satisfy eligibility criteria, participants had to: 1) be aged 17 years or older, 2) self-report injecting drugs at least monthly in the six months preceding the interview, and 3) self-report residing for at least the 12 months prior in the capital city in which the interview was conducted. Interviews were conducted face-to-face at locations convenient to the participant, such as health services and NSP outlets. Written informed consent was obtained prior to interview, and participation was voluntary and confidential.

Characteristics of the 2013 sample provide an example of the typical profile of participants. Between April and July 2013, 887 participants were recruited from the capital cities of each state and territory of Australia (New South Wales: n=151; Victoria: n=150; Northern Territory: n=91; Tasmania: n=107; Queensland: n=100; Western Australia: n=88; Australian Capital Territory: n=100; South Australia: n=100). Participants interviewed for the 2013 national IDRS sample (including Tasmanian participants) were on average 40 years old (SD=9, range=18-66 years), and two-thirds were male (64%). The majority were heterosexual (89%), spoke English as a first language (96%), and were not currently employed (84%). Only one-fifth (21%) had completed Year 12, with two-fifths reporting a trade/technical qualification (40%) and only one-tenth (9%) reporting a tertiary qualification. Just under half (47%) were currently in drug treatment, primarily methadone (31%) or Suboxone (10%) maintenance programs, and over half had previously been imprisoned (56%). The 2013 Tasmanian IDRS sample were similar to the national sample in terms of age (mean=37, range 19-63), sex (57% male), sexual orientation (90% heterosexual) and employment situation (77% not currently employed).

RESULTS

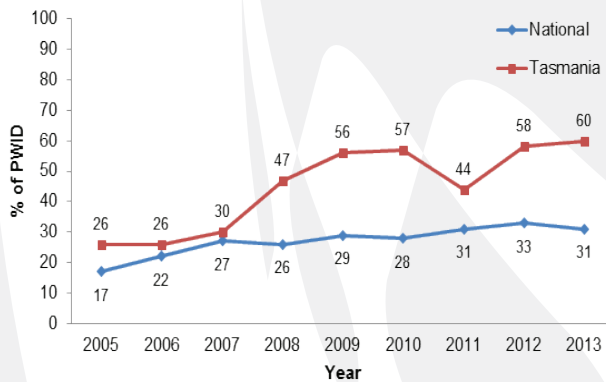
Recent Injection of Oxycodone Use, National and Tasmanian IDRS Samples, 2005-2013

Questions specific to oxycodone intravenous use were first included in the IDRS interview in 2005. In 2005, less than one-fifth (17%) of the national IDRS sample (including Tasmanian participants) reported injection of oxycodone preparations (e.g., Oxycontin®, Endone®, Oxynorm®, Targin®) (Figure 1) in the six months preceding the interview. This rate steadily

increased, peaking at one-third (33%) of the national IDRS sample in 2012.

Approximately one-quarter (26%) of the Tasmanian IDRS sample had recently injected oxycodone in 2005 (Figure 1). Since then, Tasmania has consistently recorded high rates of recent oxycodone injection. Between 2009 and 2013, over half (56%-60%) of the Tasmanian IDRS sample reported recent oxycodone injection. It should be noted that only two-fifths (44%) of the sample reported recent injection in 2011, however these rates returned to previous levels in the following years.

Figure 1: Percentage of PWID reporting intravenous use of oxycodone in the six months preceding the interview, National and Tasmanian IDRS Samples 2005-2013.



Illicit Oxycodone Price, National and Tasmanian IDRS Samples, 2005-2013

Changes in the median price of Oxycontin®, the primary oxycodone preparation reportedly consumed by PWID, have generally reflected trends in prevalence of intravenous use (Figure 2). Nationally, the median reported price of 80mg Oxycontin from 2006 to 2013 consistently ranged between \$40 and \$50, or approximately \$0.50 per milligram. In Tasmania, the price of 80mg Oxycontin increased twofold from 2005 (\$40) to 2008 (\$80); since then, the median price has typically remained around \$1 per milligram.

Oxycodone Heating

Questions regarding heating of oxycodone prior to intravenous use were included in the Tasmanian IDRS interview from 2010 and in the national IDRS interview from 2012 (Figure 3). Approximately three-fifths (60% to 63%) of the Tasmanian IDRS 2010 to 2012 samples who had recently injected oxycodone reported heating the preparation prior to their last injection. In 2013, there was a slight decrease in the number of participants reporting heating, with just over half (54%) reporting this practice. Three-quarters (75% in 2012,

78% in 2013) of those who reported recently injecting oxycodone in the national IDRS samples had heated the preparation prior to injecting on the last occasion.

Figure 2: Median current street price of 80mg Oxycontin® according to PWID in the National and Tasmanian IDRS Samples 2005-2013. Note that this data was not collected nationally in 2005.

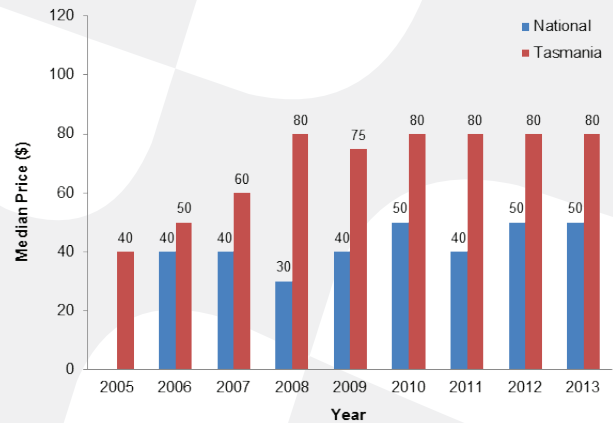
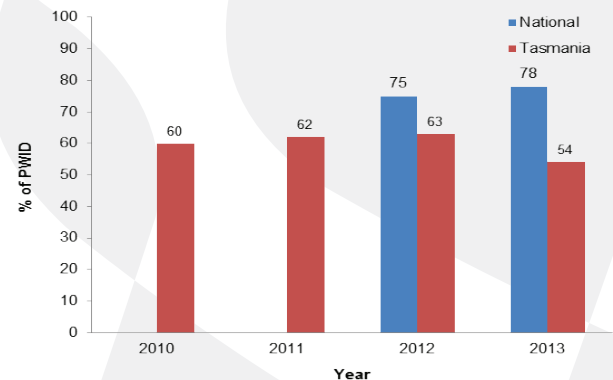


Figure 3: Percentage of PWID who had reported recent intravenous oxycodone use who had heated the preparation on their last occasion of injecting, National and Tasmanian IDRS Samples 2010-2013.



Oxycodone Filtering

Questions regarding filtering of oxycodone prior to intravenous use were included in the Tasmanian IDRS interview from 2007 and in the national IDRS interview from 2012 (Figure 4). The majority of the national IDRS sample reported use of any filter in 2012 (99%) and 2013 (97%). Around one-quarter of the national sample report using cotton wool filters (24% in 2012 and 31% in 2013) however cigarette filters were the most common type of filter used (47% in 2012 and 2013). While one-fifth of the 2012 national IDRS sample used a wheel filter prior to last intravenous use, only 14% of the 2013 national IDRS sample reported wheel filter use. Assessment of filtering practices in future national IDRS interviews will clarify whether these outcomes indicate a downward trend in wheel filter use. It should be noted that combined filter use (e.g., cigarette and

wheel filter combined use) was not assessed in the national interview.

In 2007, over one-third of the Tasmanian IDRS sample who had recently injected oxycodone reported that they did not use a filter when last preparing oxycodone for intravenous use (Figure 5). This percentage has decreased over the years, with less than one-tenth of the Tasmanian IDRS samples from 2010 onwards failing to use a filter on their last injection occasion. The predominant type of filter adopted across all years of interviewing has been cigarette filters. While commercial ('wheel') filter use increased from 2007 (4%) to 2009 (31%), rates have fluctuated since, with between one-fifth (2010: 19%) and one-third (33%) reporting use prior to last intravenous use. Less than 8% of the Tasmanian IDRS samples have reported combined use of cigarette or cotton wool filters with wheel filters, which is the current best practice for harm reduction when injecting oxycodone tablets.

Figure 4: Percentage of PWID who had filtered oxycodone on their last occasion of injecting in the preceding six months, National IDRS Samples 2012-2013.

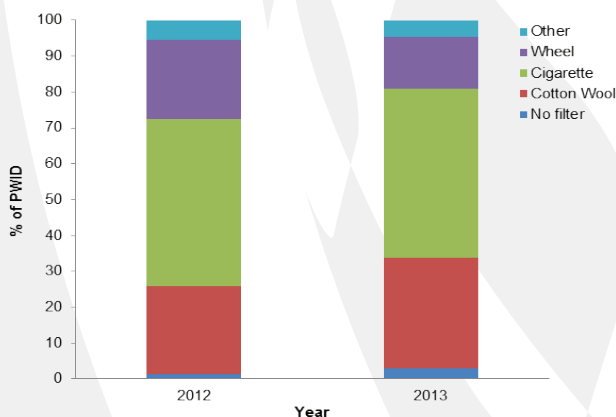
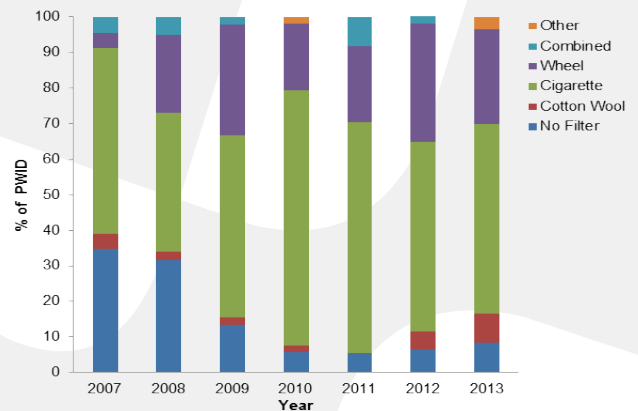


Figure 5: Percentage of PWID who had filtered oxycodone on their last occasion of injecting in the preceding six months, Tasmanian IDRS Samples 2007-2013.



Characteristics of PWID According to Oxycodone Filtering Practices

Comparison of the characteristics of PWID sample according to oxycodone filtering practices was undertaken to determine whether safer injecting practices were more common amongst certain subgroups of consumers. Analyses were restricted to comparison of those PWID in the national 2012 and 2013 IDRS samples who reported use of a cigarette filter or cotton wool versus a wheel filter; the small number of participants reporting non-filtration precluded any reliable comparison of those who filtered versus those who did not filter when last preparing oxycodone for intravenous use.

Demographics

Comparison of PWID according to filtering practices revealed few differences in regards to the sex, age, and educational attainment of those who reported last

Table 1: Demographics of PWID Reporting Recent Intravenous Oxycodone Use According to Last Filter Used for Intravenous Oxycodone Use, National IDRS Sample, 2012-2013

Characteristic	2012 National IDRS Sample			2013 National IDRS Sample		
	Cigarette/ Cotton Wool Filter (n=198)	Wheel Filter (n=62)	p value	Cigarette/ Cotton Wool Filter (n=205)	Wheel Filter (n=38)	p value
Age (mean years, range)	38	38	.873	39	40	.710
Sex (% male)	70%	60%	.142	73%	71%	.867
Employment (% not employed/on a pension)	88%	82%	.258	86%	68%	.008
Sexual orientation (% heterosexual)	88%	77%	.042	92%	92%	.935
Tertiary education (% post-secondary qualification)	59%	57%	.766	50%	47%	.787
Currently in drug treatment (%) [^]	62%	45%	.022	43%	53%	.269
Prison History (%)	62%	38%	.001	61%	61%	.964

Note. Significance tests were run using χ^2 tests with 1 degree of freedom (categorical data) or independent-sample t-tests (continuous data).
[^] Refers to any form of drug treatment, including pharmacotherapies, counselling, detoxification, etc.

using a cigarette/cotton wool filter versus those who used a wheel filter (Table 1). In the 2012 national IDRS sample, those who used a cigarette/cotton wool filter were significantly more likely to be heterosexual, to be currently engaged in drug treatment, and to have been incarcerated, than those who used a wheel filter. These trends were not revealed in the 2013 sample; the only discrepancy between the groups related to employment. Those PWID who had used a cigarette/cotton wool filter were significantly more likely to report current full-time employment than those PWID who had used a wheel filter.

Other Recent Intravenous Drug Use

Analyses indicated that there was no significant difference in frequency of PWID reporting daily injection according to oxycodone filter type ($p > .057$) in the 2012 and 2013 national IDRS samples. Around half (2012: 59%; 2013: 54%) of those who reported using cigarette/cotton-wool filter in the 2012 national IDRS sample had daily intravenous use of any drug in the last month. The frequency of those reporting daily intravenous use (2012: 45%; 2013: 50%) was similar for those who had used wheel filters.

The proportions of PWID in the national 2012 and 2013 IDRS samples reporting recent intravenous use of other typically non-tablet formulation drugs, such as heroin, methadone syrup, and methamphetamine, were similar for those who had used a cigarette/cotton wool filter versus those who had used a wheel filter during their last oxycodone preparation (Table 2). Rates of injecting prescription medications available in tablet formulation varied. The proportion of PWID reporting recent intravenous use of morphine and benzodiazepines did not differ according to oxycodone filtering practices.

The rate of buprenorphine intravenous use was significantly higher for PWID who used cigarette/cotton wool filter versus wheel filter in the 2013 national IDRS sample. However, this comparison should be treated with caution due to low cell counts for chi-square approximation. Across both years of data collection, the proportion of PWID reporting recent intravenous use of pharmaceutical stimulants (e.g., dexamphetamine, methylphenidate), tablet formulations intended only for oral administration, was significantly higher amongst those who reported last using a wheel filter compared to those who last used a cigarette/cotton wool filter.

Frequency of Oxycodone Use

In the 2012 national IDRS sample, PWID who had last used a cigarette/cotton wool filter reported injecting oxycodone on a median of 8 days of the previous 180; less than one-tenth (6%, $n=11$) reported daily oxycodone injection. In contrast, PWID who had last used a wheel filter reported injecting oxycodone on a median of 20 days; less than one-tenth (7%, $n=4$) reported daily injection of oxycodone. As such, data from the 2012 national IDRS sample suggest that those PWID using more effective filters report greater frequency of oxycodone use, particularly intravenous use.

However, data from the 2013 national IDRS sample contradicted this trend, showing that reported frequency of oxycodone use was not distinguished by the type of filter adopted by PWID. PWID who had last used a cigarette/cotton wool filter reported injecting oxycodone on a median of 12 days; one-tenth (10%, $n=21$) reported daily oxycodone injection. Similarly, PWID who had last used a wheel filter reported injecting

Table 2: Percentage of PWID Reporting Recent Intravenous Use of Drugs According to Last Filter Used for Oxycodone Intravenous Use, National IDRS Samples 2012-2013

Characteristic	2012 National IDRS Sample			2013 National IDRS Sample		
	Cigarette/Cotton Wool Filter (n=198)	Wheel Filter (n=62)	p value	Cigarette/Cotton Wool Filter (N=205)	Wheel Filter (n=38)	p value
Heroin	69%	65%	.540	66%	61%	.489
Methamphetamine	73%	74%	.881	72%	68%	.681
Methadone syrup	30%	36%	.399	37%	37%	.978
Morphine	66%	65%	.869	57%	68%	.192
Buprenorphine [#]	17%	15%	.623	19%	5%	.043
Pharmaceutical stimulant	14%	27%	.012	11%	26%	.013
Alprazolam	13%	15%	.700	7%	11%	.499
Other benzodiazepine [#]	4%	5%	.641	1%	5%	.056

Note. Significance tests were run using χ^2 tests with 1 degree of freedom. [#] Chi-square test should be treated with caution as at least one count in a cell was 5 or less.

oxycodone on a median of 11 days; just over one-tenth (13%, n=5) reported daily injection of oxycodone.

Oxycodone Intravenous Preparation Practices

Further analyses of data from the 2012 and 2013 national IDRS samples showed that PWID who used cigarette filters/cotton wool on their last oxycodone injection occasion were significantly more likely to use hot extraction relative to those who used wheel filters (2012: $\chi^2 (1_{n=243})=6.76, p=.009$; 2013: $\chi^2 (1_{n=220})=13.20, p=.001$; Figure 6). These results suggest that PWID adopting less effective filtering techniques are more likely to have other potentially hazardous preparation practices: in this case, heating the extraction and increasing the risk of larger particles forming once cooled.

Rates of Recent Injecting-Related Harms

Injecting-related harms are regularly assessed in the national IDRS interview, however analyses were restricted to data from 2012, when a range of questions on harms related to infection, vein and tissue damage,

and organ damage were included (Table 3). These questions were adopted from Dwyer and colleagues' study (9) which focused on experience of non-viral injecting-related injuries and diseases (IRID). While the majority (71%) of PWID reporting recent

Figure 6. Percentage of PWID reporting heating last oxycodone intravenous preparation according to type of filter used, National IDRS Samples 2012-2013.

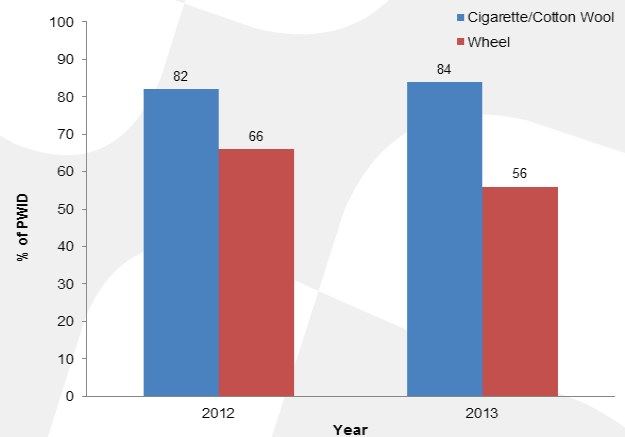


Table 3: Rates of Injecting-Related Harm amongst PWID in Last Six Months According to Last Filter Used for Intravenous Oxycodone Use, 2012 National IDRS Sample

Experienced harm	Cigarette/Cotton Ball (n=198)		Wheel Filter (n=62)		p value	Recent Oxycodone Intravenous Use (N=308)	
	%	N	%	N		%	N
Redness	35%	69	39%	24	.580	35%	107
Swelling	30%	60	37%	23	.317	33%	103
Hives	28%	56	23%	14	.377	26%	80
'Dirty hit'	23%	45	23%	14	.981	23%	70
Cellulitis	11%	21	21%	13	.035	14%	44
Skin abscess	8%	16	10%	6	.693	8%	24
Abscess inside body [#]	4%	8	3%	2	.771	4%	11
Phlebitis	22%	44	15%	9	.189	20%	60
Endocarditis [#]	1%	2	0%	0	.427	1%	3
Other serious infection	3%	6	10%	6	.029	4%	13
Thrombosed veins	24%	47	32%	20	.181	24%	75
Pitting oedema	17%	34	11%	7	.267	17%	51
Deep vein thrombosis [#]	2%	4	7%	4	.078	3%	8
Artery injection	14%	28	16%	10	.699	14%	43
Nerve damage	26%	52	39%	24	.060	28%	87
Gangrene [#]	2%	4	0%	0	.259	2%	5
Amputation [#]	0%	0	0%	0	-	0%	0
Lymphoedema	12%	23	8%	5	.431	11%	33
Venous ulcer	5%	9	2%	1	.295	4%	13
Fistula [#]	6%	11	7%	4	.792	6%	19
Any harm	69%	136	79%	49	.117	71%	218

Note. A 'dirty hit' refers to the experience of feelings of nausea, headache and fever straight after injecting. Significance tests were run using χ^2 tests with 1 degree of freedom. [#] Chi-square test should be treated with caution as at least one count in a cell was 5 or less.

was generally no significant difference in the rate of harms according to last filter adopted for intravenous use of oxycodone. Those PWID who reported use of a wheel filter were significantly more likely to report recent experience of cellulitis (severe inflammation of the skin due to bacteria) or a serious injection (e.g., septic arthritis, osteomyelitis, or septicemia). As aforementioned, the median number of days injecting oxycodone was almost triple for those who used a wheel filter (median=22 days recent oxycodone intravenous use) relative to those who used cigarette/cotton wool filter (median=9 days) in the 2012 national IDRS sample. Rates of other harms related to vein and tissue damage (e.g., phlebitis, thrombosed veins) did not differ according to last oxycodone filtering practice. It should be noted that reported harms were not tied specifically to injection of oxycodone, and may be a consequence of intravenous use of other drugs, including non-pharmaceutical drugs (e.g., methamphetamine).

CONCLUSIONS AND IMPLICATIONS

Rates of intravenous use of oxycodone is high amongst samples of PWID in Australia, particularly in Tasmania, a jurisdiction characterised by greater pharmaceutical opioid extra-medical use, with elevations in price reflecting the increasing demand. Despite this increase in intravenous use, the current study did not indicate an increased uptake of harm reduction practices related to the preparation of oxycodone for injection. Heat extraction of oxycodone is still a common practice, meaning that consumers are placing themselves at increased risk of vein and tissue damage, as dissipated particles merge once the preparation has cooled and the wax has re-solidified (6). Data from the Tasmanian IDRS samples shows a decline in the number of PWID reporting preparing oxycodone without some form of filter, suggesting a shift towards safer injecting practices over time. However, the majority of those filtering oxycodone prior to intravenous use reported using cigarette filters or cotton wool which are less effective at removing particles smaller than 10-20µm relative to commercial syringe filters (6). In addition, those using the former filters were also more likely to be adopting heat extraction. Self-reported barriers to using wheel filters cited in past research include 1) frequent obstruction of the filter (particularly when not heating), 2) lengthening of the preparation time, 3) need for concentration, 4) commitment to existing injecting practices, 5) erroneous perceptions of filtering (e.g., only necessary if regularly injecting, reduces the amount of target drug extracted), 6) availability (including daily limits and individual costs), and 7) concern regard losing the active drug (10). While these

results suggest a shift to safer injecting practices over time, the high rate of hazardous practices highlights the need for continued targeted harm reduction strategies to address these barriers, such as increased emphasis on peer-based education to ensure evidence-based practices, and making filters more available through NSPs and vending machines.

The available data suggest little difference in the rates of injecting-related harms for PWID according to oxycodone filtering practices, however there was a high prevalence of recent intravenous use of other drugs (e.g., heroin, methadone, morphine, and methadone) amongst both groups; this high rate of other intravenous drug use could obscure those harms specific to oxycodone injecting practices. While the characteristics of those who used cigarette/cotton wool filters versus wheel filters were generally quite similar, there was indication that the latter group may use oxycodone intravenously more frequently. This fits with past research (10) indicating that PWID who inject drugs more regularly are more likely to use wheel filters, potentially perpetuating the aforementioned belief that filtering is only required when regularly injecting. Those PWID reporting use of wheel filters were also more likely to report intravenous use of pharmaceutical stimulants, another tablet formulation containing excipients which require filtration to reduce the risk of injecting-related harms (11). Analyses of the 2012 dataset indicated that this group's filtering practices extended to their pharmaceutical stimulant intravenous use, with all reporting use of wheel filters on their last injection occasion. These results support previous research showing that PWID often generalise their filtering practice to all intravenous drug use (10). Effective education regarding best practice for minimising harms from intravenous oxycodone use, including demonstrations of appropriate filter use, distribution of information regarding the benefits of filtering, and peer-based advocacy, may help promote uptake of safer oxycodone and other drug intravenous preparation practices.

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