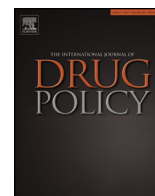




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Research paper

## Who sells what? Country specific differences in substance availability on the Agora cryptomarket

Joe Van Buskirk<sup>a,\*</sup>, Sundresan Naicker<sup>a</sup>, Amanda Roxburgh<sup>a</sup>, Raimondo Bruno<sup>b</sup>, Lucinda Burns<sup>a</sup><sup>a</sup> National Drug and Alcohol Research Centre (NDARC), University of New South Wales, Sydney, New South Wales 2052, Australia<sup>b</sup> University of Tasmania, School of Medicine, Hobart, Tasmania 7000, Australia

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## ABSTRACT

**Background:** To date monitoring of cryptomarkets operating on the dark net has largely focused on market size and substance availability. Less is known of country specific differences in these indicators and how they may corroborate population prevalence estimates for substance use in different countries.

**Methods:** All substance listings from the cryptomarket Agora were recorded over seven time points throughout February and March 2015. Agora was chosen due to its size as the second largest cryptomarket operating and the level of detail of information provided in individual substance listings. Data were collated and the number of unique sellers selling each substance by country of origin was analysed.

**Results:** An average of 14,456.7 substance listings were identified across sampled days from 868.7 unique sellers. The top five countries by number of listings were the USA, United Kingdom, Australia, China and the Netherlands, collectively accounting for 61.8% of all identified listings and 68% of all unique sellers. Australia was over represented in terms of sellers per capita, while China was over represented in new psychoactive substance (NPS) listings. When examined by number of listings per seller, the Netherlands and China stood out as particularly large, likely due to these countries' role in the local production of various illicit and new psychoactive substances.

**Conclusions:** Numbers of sellers by country of origin appear to be influenced by several factors. Australia's overrepresentation in sellers per capita may indicate its relative geographical isolation and the potential for profit margins from selling online, while China's overrepresentation in NPS listings may reflect domestic production of these substances. Continued monitoring will provide enhanced understanding of the increasingly complex and globalised nature of illicit drug markets.

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## Introduction

It has been estimated the global disease burden for illicit drugs attributable to mental, neurological and substance use disorders has increased by 37.6% between 1990 and 2010, with substance use disorders accounting for around 2% of all global disease burden (Whiteford, Ferrari, Degenhardt, Feigin, & Vos, 2013; Whiteford et al., 2015). This presents unique and complex challenges to health systems due to psychosocial and socioeconomic costs of addiction, adverse events and related criminal activity that may be associated with the acquisition and consumption of illicit substances (Chandler, Fletcher, & Volkow, 2009). The rise of the use of the internet over the past two decades has led to the development of

new methods of distribution of substances (Walsh, 2011). Initially this appeared driven by the sale of illicit pharmaceuticals, and later, the introduction of new classes of substances, deemed 'new psychoactive substances' (NPS), not subject to international legislative control (Boyer, Shannon, & Hibberd, 2005). The more recent advent of the 'dark net', using Tor ('The Onion Router'), which reroutes user connections through anonymising servers, to access websites has made it possible to sell and source substances online with greater anonymity and hence reduced risk of detection and prosecution. Since the dark net and its use for illicit drug trading reached public awareness in 2011 (Chen, 2011), it has become a well-established mode for both purchasing and selling illicit substances at an international level. Specifically, the development of increasingly secure and anonymous 'cryptomarkets', that operate on the dark net in a similar fashion to clear net marketplaces such as Ebay (Barratt, 2012). The number and capacity of dark net 'cryptomarkets' has increased since 2011, with current research reporting over 5000 unique sellers operating

\* Corresponding author at: National Drug and Alcohol Research Centre, University of New South Wales, 22-32 King St, Randwick 2031, Australia. Fax: +61 2 9385 0222.

E-mail address: [j.vanbuskirk@unsw.edu.au](mailto:j.vanbuskirk@unsw.edu.au) (J. Van Buskirk).

over the five largest marketplaces at the end of 2014 (Soska & Christin, 2015; Van Buskirk, Roxburgh, Bruno, & Burns, 2015).

While research to date has investigated consumer and seller motivations for accessing cryptomarkets (Bancroft & Scott Reid, 2015; Barratt, Ferris, & Winstock, 2014; Barratt, Ferris, & Winstock, 2016; Van Hout & Bingham, 2013, 2014) and changes in substance availability over time (Van Buskirk, Roxburgh, Bruno, & Burns, 2013; Van Buskirk, Roxburgh, Bruno, & Burns, 2014a; Van Buskirk, Roxburgh, Bruno, & Burns, 2014b; Van Buskirk, Roxburgh, Bruno et al., 2015), less is known about country-specific differences in substance availability and the country of origin of sellers operating on these markets. Though previous research has reported on the distribution of substance listings across countries (Aldridge & Décary-Héту, 2014; Christin, 2013; Décary-Héту, Paquet-Clouston, & Aldridge, 2016; Soska & Christin, 2015), this has largely been descriptive, without country-specific implications being discussed. Previous research has indicated good correlation between the availability of (both traditional illicit and NPS) substances on cryptomarkets and those substances most commonly used among psychostimulant users in Australia (Burns, Roxburgh, Bruno, & Van Buskirk, 2014). That is, the most commonly sold substances on cryptomarkets are also those most commonly used among sentinel groups of people who use drugs. However, it is not known whether similar findings may apply to other countries. Findings will likely depend on the country's geographic location and legislation governing controlled substances, as well as other known factors such as price, availability, and proximity to production networks of these substances (Martin, 2014).

For example, Australia, due to its geographic isolation and relatively high drug prices (Sindicich & Burns, 2015), is likely to have more of a domestic market operating on the dark net, with Australian sellers selling largely to Australian consumers. Though the potential exists for Australians to import from international sellers, this carries an inflated risk due to stringent border control and screening of imported items (Van Buskirk et al., 2013). Domestic distribution avoids the risks associated with border control. Given the likelihood of a more domestically oriented market, the availability of substances listed on cryptomarkets by Australian sellers will more closely reflect Australian population usage patterns. By contrast, China, due to its strict control of internet access (Ensaifi, Winter, Mueen, & Crandall, 2015), tight control of psychoactive substances (Chen & Huang, 2007), proximity to the Golden Triangle (one of the largest opium producing areas in the world), and its active role in the domestic production of NPS (Smith & Garlich, 2013), may be more likely to export locally produced substances instead of distributing them domestically (Décary-Héту et al., 2016). Similarly, in the Netherlands, in which drug laws are relatively relaxed and drugs more readily available (Chatwin, 2015), with a large degree of domestic production of substances such as cocaine, MDMA and cannabis (EMCDDA, 2013) there would be seemingly less motivation for local consumers to source drugs from cryptomarkets and more motivation for Dutch sellers to export to foreign consumers (Décary-Héту et al., 2016).

The current study aims to investigate (1) internationally, which countries account for the greatest number of illicit substance listings on the largest cryptomarket at the time of data collection (being Agora); and (2) differences in the number and range of substances sold by sellers operating from those countries.

## Method

### Data selection

The cryptomarket Agora was chosen for analysis firstly due to its size: at the time of data collection, Agora was the largest

marketplace on the dark net. Second, Agora provides the most detail in each listing description compared to other cryptomarkets.

### Sampling schedule

A quasi random sample of seven days within the 28-day period from the 15th of February 2015 to the 15th of March 2015 was generated using Microsoft Excel to determine days on which data capture would take place. This sampling methodology was chosen to account for any potential variation in substance availability across days of the week, while the 28-day period was chosen to limit any effect of increased seller or listing numbers over time, as has been seen in previous trend data (Van Buskirk et al., 2014b). The seven dates generated for collection were the 18th, 20th, 24th, and 26th of February, 2015, and the 9th, 11th and 14th of March. Each listing on Agora contains a text description of what is for sale in that listing, the seller name, listing price and country of origin for the substance. While substances accounted for between 70 and 80% of listings across the sampling period, various other categories were for sale, including eBooks, forgeries, weapons and data, listed under associated parent categories.

### Data extraction

On the randomly generated days, data were collected from Agora by manually opening and saving copies of every page within the 'drugs' parent category. Each page was visually inspected by the researcher to identify partial loading of webpages, or if the user account had been logged out by the marketplace. Though time consuming, this approach overcomes many potential issues faced by other more automated approaches (Van Buskirk, Roxburgh, Naicker, & Burns, 2015). Data were then extracted from saved webpages using a VBA macro in Excel 2010 that parsed and collated the raw html data into a database detailing date of collection, listing description, seller name, country of origin and substance category (assigned by the marketplace).

Although Agora includes a category for each listing within the 'drugs' parent category, previous research has found this to be often unreliable (Soska & Christin, 2015). Categories were thus recoded into 12 distinct substance class categories using the vector form 'lookup' function in Excel 2010, to identify keywords in the listing description. A list of keywords was developed consisting of substance names, as well as common descriptors, slang terms, misspellings and foreign language terms. This method has been developed over time with previous monitoring and tested on smaller marketplaces with manual verification, and found to have a high degree of accuracy. When new substances or keywords are identified, these are added to the lookup array to further increase accuracy. Across all dates in the sampling period, this method successfully categorised 79% of all listings, with the remaining 21% of listings coded manually by inspection of listing description. For any listing with an unclear description, the original html page was consulted, as listings were often accompanied with a thumbnail image of the product. If the listing could still not be classified, it was excluded. Approximately 250 listings were excluded in this way (0.2% of all listings). The 12 mutually exclusive categories were chosen to give a broad coverage of substance classes available on Agora and distinguish between primarily prescribed and non-prescribed substances, and were informed by categories used in population-level substance use surveys from the USA (National Institute on Drug Abuse, 2015), United Kingdom (Home Office, 2015) and Australia (Australian Institute of Health and Welfare, 2014). The pharmaceuticals category, though very broad, contains all substances whose use is generally prescribed. These categories have been used in previous monitoring systems in Australia and have been developed iteratively by participants reports of

**Table 1**  
Description of classified substance classes.

Substance class	Description
Pharmaceuticals	Including benzodiazepines, pharmaceutical opioids, nootropics (such as modafinil) and other pharmaceutical substances generally requiring prescription
Cannabis	Including leaf cannabis, hash, tetrahydrocannabinol (THC) infused foods, cannabis seeds, oils and other substances related to the cannabis plant
MDMA (3,4-methylenedioxy-methamphetamine)	Including pressed 'ecstasy' pills, MDMA powder, MDMA crystal and pre-packaged MDMA capsules
Cocaine	Including cocaine powder and crack cocaine
New psychoactive substances (NPS)	Including substances often classed as 'research chemicals', 'synthetics' or 'legal highs'. Examples include mephedrone, methylone, NBOMe and the 2C-x family. For more detailed description of NPS that have been identified, please see the 2015 European Monitoring Centre for Drugs and Drug Addiction Annual report ( <a href="#">European Monitoring Centre for Drugs and Drug Addiction, 2015</a> )
Methamphetamine	Including methamphetamine crystal (ice), powder (speed), and wax (base)
Illicit opioids	Including heroin and opium
Hallucinogens	Hallucinogenic substances not otherwise classified as NPS, including lysergic acid diethylamide (LSD) and psilocybin ('magic') mushrooms
PIEDs (performance and image enhancing drugs)	Including any substances designed for the enhancement of athletic performance or body image, such as anabolic steroids, human growth hormones and clenbuterol
Ketamine	A synthetic anaesthetic dissociative drug used in pharmaceutical contexts for the management of pain, but was separated from the pharmaceuticals category due to its common recreational use
Synthetic cannabinoids	Any chemical designed to mimic the effects of cannabis in its effect on THC receptors, either in chemical form, or sprayed onto plant matter
GHB (gamma-hydroxybutric acid)	An anaesthetic drug often used for recreational purposes for its stimulant and aphrodisiac effects

substance categories ([Sindicich & Burns, 2012](#); [Van Buskirk et al., 2013](#)). A description of these substance categories is outlined in [Table 1](#).

#### Outcome variables

The primary outcome variable of interest was number of listings, with any listing not advertising a substance excluded. The secondary outcome of interest was number of unique sellers, which was determined by the seller's unique pseudonym assigned to each listing.

While previous research has used volume of sale as an outcome variable ([Christin, 2013](#); [Soska & Christin, 2015](#)), this method relies on analysing feedback scores and transaction numbers, for which Agora only provides aggregated scores. Specifically, sellers are classed into intervals based on number of transactions, with interval width increasing as transactions increase (e.g. 1–2 transactions, 3–5 transactions, increasing to 200–300 transactions, 300–500 transactions, 500–1000 transactions, etc.). This precluded the replication of such an analysis in the current study.

#### Predictor variables

The country of origin of the substance was included in the listing description. We feel it is a reasonable assumption that sellers would accurately list such information as parcels shipped internationally detail country of origin for consumers to verify. Misleading consumers could result in negative feedback for sellers, potentially harming future sales ([Van Hout & Bingham, 2014](#)). For sellers who nominated their country of origin as 'undeclared', described it in a way that is unclear, or had multiple countries of origin across listings, country of origin was coded as 'unclear'. This represented a total of 21% of all listings coded. An average of 3082.4 listings (58.4% from multiple countries of origin, 30.0% from an 'unclear' country of origin and 11.5% from an undeclared country of origin) and 114.8 unique sellers (35.1% from multiple countries of origin, 50.4% from an 'unclear' country of origin and 14.6% from an undeclared country of origin) were coded in this way, and were included and analysed as a separate category. The top five countries by listing numbers across the sampled days, along with those with sellers of unclear origin, were then separated and entered into a Poisson regression.

#### Statistical analyses

A Poisson regression model was fitted to the generalized estimating equation (GEE) with an autoregressive working correlation matrix specified, in order to account for the effect of clustering in each extraction period, when counting the number of listings ([Gardiner, Luo, & Roman, 2009](#)). This type of working correlation matrix was chosen due to the proportional relationship between the numbers of drugs listed within countries over each extraction period with the total number of listings. A Wald Chi-square statistic was used to assess the change in the proportion of listings across countries. SPSS 22 was used to address each of these outcomes, and to model the Poisson regression within the GEE.

#### Results

##### Poisson regression

Country of origin (USA, UK, Australia, Netherlands, China and unclear origin) was strongly associated with the number of drug listings on Agora (Wald Chi-Squared = 29,769,  $p < 0.001$ ). This very large magnitude of the effect can be attributed to the large disparity among seller country of origin with regard to both the number of substances listed and the category substances available on the Agora cryptomarket. The incidence of drug listings occurring from sellers not showing USA as country of origin was significantly lower across all other countries of origin examined in addition to those of unknown origin. These differences are summarised in [Table 2](#).

##### Number of listings and unique retailers

Estimated marginal means were used to determine the average number of listings and unique sellers across the sampling period. Agora was found to have an average of 14,456.6 substance listings (SE = 135.7), with an average of 868.6 unique sellers (SE = 17.5).

The Poisson regression revealed the top five countries by mean number of listings to be the USA ( $m = 3669.3$ , SE = 36.6), the United Kingdom ( $m = 1457.9$ , SE = 9.4), Australia ( $m = 1283.2$ , SE = 8.5), China ( $m = 1151.6$ , SE = 22.9) and the Netherlands ( $m = 1129.8$ , SE = 12.2). Listings from sellers with unclear country of origin accounted for an average of 3082.4 listings (SE = 77.9) across the

**Table 2**

Parameters estimates from the Poisson regression fitted to generalised estimating equations by seller country of origin.

Predictor	Parameter estimate (SE)	Incidence risk ratio (95% confidence interval)
Australia	−1.05 (0.01)	0.35 (0.34–0.36) <sup>***</sup>
China	−1.16 (0.02)	0.31 (0.30–0.33) <sup>***</sup>
Netherlands	−1.18 (0.01)	0.31 (0.30–0.32) <sup>***</sup>
Unclear	−0.18 (0.02)	0.84 (0.81–0.87) <sup>***</sup>
United Kingdom	−0.86 (0.01)	0.42 (0.41–0.43) <sup>***</sup>
USA <sup>a</sup>	–	1

<sup>a</sup> Denotes reference category.

<sup>\*\*\*</sup>  $p < 0.001$ .

sampling period. These six country categories collectively accounted for 82.1% of all listings, and 81.7% of all unique seller numbers. For more detail, please refer to [Table 3](#).

#### Retailers per capita estimates for top five countries

Using recent population estimates obtained from [The World Bank \(2015\)](#) and calculating a per capita estimate of sellers in the population, Australia had the highest estimate with 4.73 sellers per million, 1.7 times higher than the Netherlands with a per capita estimate of 2.72 sellers per million. United Kingdom had the third highest estimate of 1.52 sellers per million, the United States came next with an estimated 1.04 sellers per million, while China had 0.01 sellers per million ([Table 3](#)).

#### Number of listings and substance classes per retailer

Overall, each seller had an average of 16.6 listings (95% CI: 15.6–17.8) for sale across 1.9 substance class categories. This figure, however, varied greatly across the top five countries, from 11.1 listings per seller (95% CI: 10.0–12.3) across 1.7 substance classes in the USA to 111.9 listings per seller (95% CI: 61.6–204.0) across 3.1 substance categories in China. This suggests that while the USA had the highest number of listings and sellers, sellers tended to be more specialised in their approach, while those listings from China were largely accounted for by a small group of sellers selling multiple categories of substances. This also appeared to be the case with sellers from the Netherlands, albeit to a lesser degree, where sellers listed an average of 24.7 listings each (95% CI: 18.6–32.8) across 2.4 substance categories. The UK and Australia were comparable in the average number of listings per seller, with an average of 15.8 (95% CI: 13.1–19.1) and 11.6 (95% CI: 9.7–13.8) listings per seller, and 2.0 and 1.9 average substance classes per seller, respectively. Retailers with an unclear country of origin

averaged 26.8 listings per seller (95% CI: 22.5–32.1) across 2.2 substance classes.

Sixty two percent of sellers from the USA only sold one substance class (i.e. were ‘specialist sellers’), with 52.0% of sellers from the United Kingdom and 47.9% of sellers from Australia also offering listings across only one substance class. There were relatively fewer specialist sellers from both the Netherlands (33.9%) and China (36.4%).

#### Substances for sale

[Table 4](#) outlines the most common substances listed by country of seller. Over all listings, the substance categories with the most listings and unique sellers selling them were cannabis, pharmaceuticals and MDMA, accounting for 24.4%, 21.5% and 12.4% of all listings respectively. From USA sellers, the top three substances by average number of listings were cannabis ( $m = 1623.3$ ,  $SE = 15.5$ ), pharmaceuticals ( $m = 610.4$ ,  $SE = 15.8$ ) and NPS ( $m = 295.6$ ,  $SE = 11.2$ ); UK sellers the top three substances were pharmaceuticals ( $m = 409.2$ ,  $SE = 4.0$ ), cannabis ( $m = 368.0$ ,  $SE = 9.9$ ) and cocaine ( $m = 172.2$ ,  $SE = 3.0$ ); Australian sellers—pharmaceuticals ( $m = 226.4$ ,  $SE = 4.2$ ), MDMA ( $m = 208.5$ ,  $SE = 4.9$ ) and cannabis ( $m = 201.3$ ,  $SE = 7.7$ ); China—NPS ( $m = 667.6$ ,  $SE = 18.5$ ), synthetic cannabinoids ( $m = 259.6$ ,  $sd = 1.1$ ) and pharmaceuticals ( $m = 77.9$ ,  $sd = 8.9$ ); the Netherlands—MDMA ( $m = 495.4$ ,  $SE = 7.5$ ), cannabis ( $m = 161.4$ ,  $SE = 1.5$ ) and cocaine ( $m = 138.8$ ,  $SE = 2.4$ ); Results are outlined in [Table 4](#).

#### Discussion

This paper outlines for the first time comparisons by country in the availability of substances, and the number of sellers by country of origin, listed on the largest cryptomarket (at time of data collection) on the dark net, Agora. A very large magnitude of effect was observed for seller country of origin in predicting the number of listings on Agora. This is due to the significant differences in the number of listings and type of substances listed across countries, as the USA was by far the most represented country of origin on Agora. In addition, the incident ratio of listings from sellers with “unclear” country of origin was at least two times greater than other countries examined, excluding the USA.

A number of key findings have emerged. Firstly, both cannabis and pharmaceuticals were commonly listed across four of the five countries examined, and are reflective of population prevalence data which list these substances as the most commonly consumed scheduled substances globally ([United Nations Office on Drugs and Crime, 2014](#)). Secondly, there is a notable difference observed among countries in the number of substance classes listed per

**Table 3**

Top five countries of origin, along with listings from sellers with unclear countries of origin, by average number of listings, average number of unique sellers, and 2014 population estimates.

Country	Listings		Unique retailers		Listings by retailer (95% confidence interval)	Average substance classes per seller	Specialist retailers	2014 Population estimate <sup>a</sup>	Estimated sellers per 1,000,000
	Mean	SE	Mean	SE					
USA	3669.3	36.6	330.4	2.7	11.1 (10.0–12.3)	1.7	62.0%	318,857,056	1.04
Unclear	3082.4	77.9	114.8	1.6	26.8 (22.5–32.1)	2.2	45.6%	–	–
United Kingdom	1547.9	9.4	98.0	2.3	15.8 (13.1–19.1)	2.0	52.0%	64,510,376	1.52
Australia	1283.2	8.5	111.0	1.7	11.6 (9.7–13.8)	1.9	47.9%	23,490,736	4.73
China	1151.6	22.9	10.3	0.3	111.9 (61.6–204.0)	3.1	33.9%	1,364,270,000	0.01
Netherlands	1129.8	12.2	45.8	0.2	24.7 (18.6–32.8)	2.4	36.4%	16,854,183	2.72

<sup>a</sup> Estimates sourced from [The World Bank \(2015\)](#); SE = standard error; specialist retailers refer to sellers who only offered one substance class across listings; means and standard errors were estimated from a generalised estimated equation model accounting for differences across days of monitoring; listed countries of origin accounted for 82% both of listings and unique sellers.



**Table 4**  
Average number of listings for each substance category by top five countries and overall.

Substance class	USA			United Kingdom			Australia			Netherlands			China			Unclear			Overall		
	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank	<i>m</i>	SE	Rank
Cannabis	1623.3	15.5	1	368	9.9	2	201.3	7.7	3	161.4	1.5	2	10.7	0.4	6	359.7	7.2	3	3520.8	20.3	1
Pharmaceuticals	610.1	15.8	2	409.2	4	1	226.4	4.2	1	24.3	2.6	8	86.1	3.4	3	1238.5	13.3	1	3109.1	68.8	2
MDMA	213	9.6	5	136.5	8.1	4	208.5	4.9	2	495.4	7.5	1	71.8	0.7	4	191.6	5.2	5	1790.5	13.3	3
NPS	295.6	11.2	3	105.5	1.2	7	85.6	2.7	7	60.4	4	6	667.6	18.5	1	340.6	7.0	4	1750	31.7	4
Cocaine	242.5	3.6	4	172.2	3	3	138.4	2.2	6	138.8	2.4	3	8.2	1.1	7	150.6	4.6	6	1000.7	16.5	5
PIEDs	137.4	9.8	8	132.6	3.4	5	148.4	3.6	4	0	0	11	7	0.9	8	451.6	8.0	2	886.6	12	6
Methamphetamine	185.3	2.5	7	58.7	4	8	142.6	3.8	5	75.3	2.5	5	25.7	3.5	5	114.9	4.1	7	812.1	16.9	7
Hallucinogens	203.8	5.8	6	115.8	5.5	6	53.4	4	9	118.7	2.2	4	0	0	10	99.7	3.8	8	717.3	14	8
Illicit opioids	115.5	4.8	9	32.7	1.1	9	59	1.8	8	32.2	0.5	7	0	0	10	78.9	3.4	9	389.5	6.4	9
Synthetic cannabinoids	27.7	2.2	10	4	0	12	11.1	0.5	10	0	0	11	272.6	2.2	2	26.0	1.9	10	358.7	2.5	10
Ketamine	7.9	2.2	12	7.5	0.5	10	3.4	0.4	12	15.4	0.8	9	1	0	9	15.6	1.5	11	74.3	5.4	11
GHB	11.3	1.6	11	4.1	0.8	11	5	0.9	11	9.6	0.7	10	0	0	10	12.6	1.3	12	41.9	1.2	12
Total average	3669.3	36.6	-	1547.9	9.4	-	1283.2	8.5	-	1129.8	12.2	-	1151.6	22.9	-	3082.4	77.9	-	14,451.3	135.68	-

NPS = new psychoactive substances, excluding synthetic cannabinoids; PIEDs = performance and image enhancing drugs; GHB = gamma-hydroxybutyric acid; SE = standard error; overall figures include those listings with unclear countries of origin; means and standard errors were estimated from a Poisson regression model fitted to generalised estimated equations; listed countries of origin accounted for 82% both of listings and unique sellers.

seller, with the United States, UK and Australia having fewer substance classes on average for sale per seller. In contrast the Netherlands and China have a higher seller to substance class ratio. This would appear to indicate that drugs listed on the dark net from the Netherlands, and China may be driven by a smaller number of sellers with greater access to a variety of substances.

Retailers from the USA have the greatest number of listings on Agora with cannabis ( $m = 1623.3$ ) and pharmaceuticals ( $m = 610.1$ ) by far the most commonly listed drugs. This data appears concordant with national trends with cannabis (with 15.9% of persons aged 12 and over having used in the preceding 12 months) and prescription drugs used non-medically (grouped in this paper as pharmaceuticals; 6.4% recently used aged 12 and over) the most commonly reported drugs of use reported in the 2013 National Survey on Drug Use and Health (NSDUH) (National Institute on Drug Abuse, 2015).

Legal context may affect use of the dark net. For example, the prominence of listings for cannabis on Agora could also be accounted for by the changing political and legislative framework within the USA with four states completely legalising cannabis (Alaska, Washington, Oregon and Colorado), while other states have progressively decriminalised cannabis possession and consumption, or legalised it for medicinal purposes (Governing, 2015). Hence the penalty for selling and buying cannabis and cannabis related products on the dark net may be negligible depending on source of origin and destination within the USA (Hall & Weier, 2015). In this way, consumers residing in states in which cannabis has been legalised may turn to cryptomarkets as a method of distributing cannabis to buyers in states in which cannabis is not legal, without facing the additional risk of international exportation. However, data from the original Silk Road predating these state-specific legalisations indicated a high prominence of cannabis listings (Christin, 2013). It would thus appear that such legality does not account for the continued prominence of cannabis among dark net product listings. Similarly, varying jurisdictions have different laws regarding access to scheduled pharmaceuticals, though again it is unclear how this may affect domestic supply networks on the dark net. The high number of pharmaceutical drug listings in the USA is of particular concern due to the increasing rates of opioid-analgesic poisoning dates observed since 1999 (Hernandez & Nelson, 2010; Jones, Mack, & Paulozzi, 2013). Future research will look at further categorising the 'pharmaceuticals' substance class on dark net marketplaces to investigate their role in expanding the availability of these substances online and their potential contribution to the rising rate of drug related harms.

Australia follows a similar pattern to the USA and UK, with pharmaceuticals being the most commonly listed substance on Agora ( $m = 230.9$ ) closely followed by MDMA ( $m = 206.7$ ) and cannabis ( $m = 196.4$ ). This is consistent with national prevalence data which shows that cannabis, pharmaceuticals and MDMA are respectively the most prevalent drugs used in Australia (Australian Institute of Health and Welfare, 2014). It must be noted that while Australia has a similar seller-to-listing ratio to the USA, indicative of multiple sellers selling fewer items and potentially specialising in certain substances. Australia also has the greatest number of unique sellers operating on Agora on a per capita basis at 4.82 per million. This overrepresentation of Australia relative to listings and sellers in the other countries examined may be explained by three interrelated factors. Firstly Australia's relative geographical isolation and strict border protection policies make it onerous for many overseas dark net sellers to offer shipping to Australian buyers (Australian Crime Commission, 2014). This may be conducive to a more substantial domestic market, with listings from Australian sellers potentially being shipped within Australia rather than exported overseas. Second, research shows that prices from

international sellers on the dark net are cheaper than Australian seller prices (Van Buskirk et al., 2013). This provides Australian sellers with the opportunity to buy internationally on the dark net, and sell domestically at an inflated price, resulting in a highly profitable marketplace (Caulkins, 2007; Sindicich & Burns, 2015). Lastly, domestic production of both methamphetamine and cannabis appears to be rising (as evidenced by law enforcement seizures of increasing numbers of clandestine laboratories, and seized cannabis crops) (Australian Crime Commission, 2014) providing greater opportunity for online sales of these substances without the risk of importation and border seizures. Though this last point may be explained by increased law enforcement and targeting of domestic production, there is clearly an incentive for Australian sellers to limit the amount of trafficking substances across borders by producing substances domestically. According to publicly available information, the vast majority of Australians charged with offences related to dark net marketplaces to date have either purchased from, or shipped to, countries outside of Australia (Branwen, 2015), indicative of the elevated level of risk of detection associated with international purchasing.

The UK follows a similar trend to the USA with pharmaceuticals, cannabis and cocaine as the most commonly listed item by UK sellers, with the second lowest per capita level of sellers, after the USA (1.62 per one million population). Population prevalence estimates in the UK and Wales show cannabis is the most commonly used illicit drug (6.7% reporting use in the preceding 12 months), with cocaine second (2.4% reporting recent use), suggesting good corroboration in terms of substance availability rankings (Home Office, 2015). The UK has the second highest number of listings but a comparable number of unique sellers to Australia. This may reflect a more accessible illicit market in the UK, with greater access to illicit substances through other means that may favour social supply through a range of interpersonal and peer networks (Coomber & Moyle, 2014). This is corroborated by data from the Global Drug Survey, suggesting that Australians are more likely than UK residents to cite lower cost as a motivation to use the dark net to source drugs (Barratt et al., 2014).

The relatively diverse nature of listings by a smaller group of sellers observed for the Netherlands and China likely reflects geopolitical contexts specific to each country. Current research indicates that both of these countries are more likely to list wholesale quantities of substances and may have more motivation to export substances internationally (Aldridge & Décarry-Héту, 2016; Décarry-Héту et al., 2016). China has steadily raised its drug surveillance capacity, with the number of drug-related arrests having risen by 34% between 2013 and 2014, with synthetic drugs being of specific concern (Dai & Gao, 2014). In China, accessing the drug markets on the dark net through Tor is relatively difficult and takes much greater technical expertise than the other countries examined in this paper. The Chinese government maintains a very strict level of internet filtering and active blocking, known colloquially as the “Great Firewall of China” (Ensafi et al., 2015). Furthermore, the consequences of conviction for both selling and purchasing illicit drugs on dark net markets poses significantly greater risks including the death penalty (Dai & Gao, 2014). It is therefore unsurprising that there were on average just 10 unique sellers operating on Agora from China. These sellers list the largest variety of substances with an average 90 listings per seller over three different drug categories. The most commonly listed substance from Chinese sellers differed markedly from the other countries examined, with NPS ( $m=667.6$ ) being followed by synthetic cannabinoids ( $m=272.6$ ), accounting for 38.1% and 76.0% of all listings in these categories, respectively. This appears to match government concerns over the increasing use of new psychoactive substances, particularly synthetic cannabinoids (Sun, Bao, Zhou, Meng, & Lu, 2014). In addition, it is believed that China is

responsible for much of the global production of NPS and synthetic cannabinoids (Davison, 2015; Winstock & Wilkins, 2011), and this proximity to production likely facilitates access to these substances (Martin, 2014). Given the relative difficulty of distribution domestically within China, this may incentivise sellers towards exportation, as is seen in traditional economies (Décarry-Héту et al., 2016; Diamantopoulos, Schlegelmilch, & Allpress, 1990; Martin, 2014).

In contrast the Netherlands has continued with its official policy of harm minimisation, prevention and education, typified by its government’s self-described “toleration of soft drugs”; however recent years have seen a shift in that stance (Spapens, Müller, & van de Bunt, 2015). In this context, it would appear that sellers from China and the Netherlands may be motivated to use dark net marketplaces as less risky than internal distribution (Décarry-Héту et al., 2016). However, without data on the number of local consumers in these countries, and data on where sellers are shipping to, it is difficult to tell if this is indeed the case. Nonetheless, a large portion of cannabis and MDMA in Europe is produced in the Netherlands, with especially large scale production of MDMA (EMCDDA, 2013). It is likely that a significant proportion of listings were for consumption within the Eurozone and elsewhere (Aldridge & Décarry-Héту, 2016; Décarry-Héту et al., 2016). National data corroborate that local consumption of both licit (cannabis) and illicit drugs are among the lowest in the OECD (Chatwin, 2015). Specifically, the Netherlands ranks 24th out of 27 reporting countries in recent cannabis usage, 24th out of 25 reporting countries on ecstasy usage, and 23rd out of 26 reporting countries on cocaine usage (EMCDDA, 2015). Future research should investigate the relationship between consumers and sellers on these marketplaces to determine the likelihood of dark net consumers also being sellers. Also of interest is the extent to which dark net purchasers use these marketplaces for international purchasing and importation as opposed to purchasing locally listed substances.

Due to the anonymous nature of Tor coupled with the inherently haphazard nature of data recording within these marketplaces, a limitation of the current paper is the relatively large amount of data (21%) with an unclear country of origin listed. Those sellers with an unclear country of origin appeared to be similar to countries such as Netherlands and China in that they offered a relatively high number of listings per seller. It is therefore conceivable that sellers opting to either conceal their country of origin or nominating multiple countries of origin, may have a similar seller profile to sellers from China and the Netherlands. This group of sellers (where the country of origin is unclear) may warrant future investigation for potential differences in seller profile. Previous research indicates that sellers are, by and large, professional and transparent in their activity on cryptomarkets, with a commitment to providing accurate descriptions of substance listings (Van Hout & Bingham, 2014). This would suggest that sellers are also motivated to accurately list their country of origin in an effort not to compromise consumer relationships, or receive negative feedback that may impact upon future sales. However, it remains a possibility that sellers could mislead customers in order to break into domestic markets. Deception is often an inherent part of illicit transactions, and becomes more complex given the anonymity afforded by cryptomarkets. The level of this deception is difficult to measure. Data presented represent only one cryptomarket. However, at the time of data collection, Agora was the largest cryptomarket operating on the dark net, providing a good opportunity to investigate seller characteristics and provide a snapshot of seller activity over a short period of time. Another limitation is the focus solely on substance listings rather than purchases by consumers, as the specific format of Agora precluded such analysis. It is relatively

trivial for sellers to have multiple listings on dark net marketplaces in order to increase exposure while not necessarily having a high number of sales. Similarly, it is possible for sellers to sell a large number of small weight items which do not amount to a large total volume of sale. However, there does appear to be some corroboration between the listings on these cryptomarkets and published data on dark net purchasing patterns (Soska & Christin, 2015; Winstock, 2015), especially when considering substances such as cannabis, MDMA and NPS. This would appear to indicate that sellers offer substance classes in line with established consumer purchasing patterns. Finally, the randomisation procedure for data collection dates may have introduced some bias due to variation in numbers of listings across days.

## Conclusions

The emergence of online drug markets presents an important new data source for understanding both the dynamics and the relative size of marketplaces within a domestic and international context. The current paper is the first to identify an overrepresentation of Australian sellers on Agora, likely driven by Australia's relative geographical isolation and historically higher prices for illicit drugs. Data presented here also corroborate China's suspected leading role in the production and distribution of new psychoactive substances internationally (Davison, 2015). Findings suggest a small number of Chinese sellers accounting for 38.1% of all listings for new psychoactive substance and 76.0% of all listings for synthetic cannabinoids available on Agora. The differences in substance availability across the top five countries is also novel, and appears driven by an interplay of domestic drug policy, geographic location and population prevalence of substance use. Continued data monitoring including analysis of price points and contextualising country of origin of buyers via other monitoring systems, may glean further information on the global and country-specific dynamics of cryptomarkets on the dark net. This will further the utility of monitoring such markets as both a potential alert system for current and future drug trends and to better understand the nature of an increasingly integrated, more complex and globalised illicit drug market.

## Conflict of interest

The authors declare that they have no conflict of interest.

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