Cocaine's fall and marijuana's rise: questions and insights based on new estimates of consumption and expenditures in US drug markets

Jonathan P. Caulkins[1,2], Beau Kilmer[2], Peter H. Reuter[2,3] & Greg Midgette[2,4]

Heinz College, Carnegie Mellon University, Pittsburgh, PA, USA,[1] RAND Drug Policy Research Center, RAND, Santa Monica, CA, USA,[2] Criminology and Criminal Justice Department, University of Maryland, College Park, MD, USA[3] and Pardee RAND Graduate School, RAND, Santa Monica, CA, USA[4]

ABSTRACT

Aims Drug policy strategies and discussions often use prevalence of drug use as a primary performance indicator. However, three other indicators are at least as relevant: the number of heavy users, total expenditures and total amount consumed. This paper stems from our efforts to develop annual estimates of these three measures for cocaine (including crack), heroin, marijuana and methamphetamine in the United States. **Methods** The estimates exploit complementary strengths of a general population survey (National Survey on Drug Use and Health) and both survey and urinalysis test result data for arrestees (Arrestee Drug Abuse Monitoring Program), supplemented by many other data sources. **Results** Throughout the 2000s US drug users spent in the order of $100 billion annually on these drugs, although the spending distribution and use patterns changed dramatically. From 2006 to 2010, the amount of marijuana consumed in the United States probably increased by more than 30%, while the amount of cocaine consumed in the United States fell by approximately 50%. These figures are consistent with supply-side indicators, such as seizures and production estimates. For all the drugs, total consumption and expenditures are driven by the minority of users who consume on 21 or more days each month. **Conclusions** Even for established drugs, consumption can change rapidly. The halving of the cocaine market in five years and the parallel (but independent) large rise in daily/near-daily marijuana use are major events that were not anticipated by the expert community and raise important theoretical, research, and policy issues.

Keywords Cannabis, cocaine, drug markets, drug policy, economics, heroin, methamphetamine, United States.

INTRODUCTION

Drug policy strategies and discussions often use prevalence of drug use as a primary performance indicator; yet three other indicators are at least as relevant. The number of frequent or heavy users and the quantity (weight) consumed are better measures for public health planning and assessment purposes. Total expenditures are more indicative of criminal harms.

There are two general approaches for estimating consumption and expenditures: one based on supply indicators (e.g. source-country production) and another rooted in estimates of prevalence. The limits of both are well documented, and any responsible estimate must recognize the tremendous uncertainties involved [1,2].

This essay stems from our effort to develop new demand-side estimates of consumption and expenditures

for the White House Office of National Drug Control Policy (ONDCP), providing annual figures for four illicit drugs from 2000 to 2010: cocaine (including crack), heroin, marijuana and methamphetamine [3]. After summarizing the key findings and methodological innovations, we raise two questions:

1 Why did US cocaine consumption fall so sharply—roughly 50%—from 2006 to 2010?
2 Why did marijuana use—particularly daily/near-daily use—rise sharply from 2006 to 2010?

METHODS

To estimate expenditure and consumption for each drug we estimate the numbers of four different types of past-month users (defined by frequency, ranging from those

who use only occasionally to those who use daily or near-daily), multiply by type-specific rates of consumption or spending, and then sum. The estimates exploit the complementary strengths of a general population survey (the National Survey on Drug Use and Health, or NSDUH) and both survey and urinalysis test result data for arrestees (from the Arrestee Drug Abuse Monitoring Program, or ADAM), and are supplemented by a range of other data sources (e.g. county-level data on mortality, treatment admissions, employee drug testing, demographics, socio-economic indicators).

The approach for marijuana differs from that used for cocaine, heroin and methamphetamine (hereinafter meth). To simplify, the marijuana estimates are rooted in the general population survey, NSDUH, but augmented with additional information on arrestees (ADAM) and youth (Monitoring the Future, or MTF). Basing consumption estimates for the other drugs on NSDUH data is hopeless; the great bulk of the daily and near-daily users who dominate consumption do not show up in NSDUH-based statistics. Rather, estimates of cocaine, heroin and meth consumption in the United States must be rooted in ADAM and then supplemented with NSDUH and other sources.

The reports produced for ONDCP describe the calculations in detail (a 120-page main report and a 70-page technical report) [3]. Below are the eight major steps we used to estimate the numbers of chronic users of cocaine, heroin and meth. We employ the term 'chronic drug user' (CDU) to maintain consistency with the previous estimation methodology, but note that it has nothing to do with duration of use. It merely means use on 4 or more days in the past month.

- Step 1. Quantify the relationship between (i) the proportion of positive drug tests among adult male arrest events recorded in ADAM jurisdictions and (ii) county and state-level covariates that are available for all counties in the country.
- Step 2. Project the share of positive drug tests among adult male arrest events in all counties using the model generated in Step 1.
- Step 3. For counties with reliable Uniform Crime Reports (UCR) arrest data from the Federal Bureau of Investigation, multiply this predicted rate by the number of adult male arrest events. This generates an estimate of the number of male arrest events that involve someone who would test positive.
- Step 4. Sum across these counties and scale up using UCR national estimates to project the national total of adult male arrest events involving someone who would test positive, including those counties lacking detailed UCR data.
- Step 5. Translate the number of adult male arrest events involving someone who would test positive to

adult male arrest events involving a CDU using the relationship observed in cities with ADAM data
- Step 6. Convert the total number of adult male arrest events involving a CDU to the total of adult male arrestees who were CDUs (i.e. from events to individuals).
- Step 7. Extrapolate from adult male arrestees who were CDUs to all adult male CDUs (i.e. inflate the estimate to include both those who were criminally active but happened to not get arrested in the last year and also those who were not criminally active apart from their drug use).
- Step 8. Combine data from several sources (e.g. treatment admissions, overdose deaths, NSDUH) to scale up the national total of adult male CDUs to account for females and juvenile CDUs.

The reports build on previous versions of ONDCP's *What America's User Spend on Illegal Drugs* series [2,4–6] and make a number of methodological contributions, including: (i) distinguishing among four different frequencies of drug use categories instead of two; (ii) expanding the number of data sources used to estimate the number of chronic drug users; (iii) recognizing that frequent cocaine, heroin and meth users often make many small, not a few bulk purchases, and so do not receive quantity discounts; and (iv) incorporating marijuana potency trends.

KEY FINDINGS

Chronic drug users

Table 1 presents CDU estimates for four drugs in the United States from 2000 to 2010. The 2000–03 marijuana estimates and 2000–06 meth estimates are not perfectly comparable to the later years because of changes in survey questions and methods. All these estimates are plagued by considerable uncertainty, but from different sources, and those differences are instructive.

The marijuana estimates are rooted in NSDUH because the usual concern about hidden populations does not pertain. So many people admit to marijuana use that there simply are not enough people outside the survey sampling frame to harm the estimate greatly [7], and several of those populations (notably active duty military personnel and those incarcerated) are known not to use at high rates [8].

Of course, respondents either under- or over-reporting their use is a concern. We adjust the prevalence rates of youth users to match the (age-specific) prevalence rates reported by MTF, and we adjust the prevalence rates of NSDUH users who report past-year involvement in the criminal justice system to match those reported in

Table 1 Chronic drug users (4+ days in the past month), 2000–10 (in millions).

Drug	Estimate	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cocaine	Middle	3.3	3.1	2.9	2.9	3.1	3.2	3.2	3.0	2.8	2.7	2.5
	Lower–higher	2.2–5.0	2.1–4.6	1.9–4.5	1.9–4.5	2.0–4.8	2.1–4.9	2.1–4.9	2.0–4.7	1.9–4.3	1.7–4.1	1.6–3.9
Heroin	Middle	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2.	1.3	1.5	1.5
	Lower–higher	0.7–2.4	0.7–2.4	0.7–2.2	0.7–2.1	0.7–2.1	0.7–2.0	0.7–2.0	0.7–2.0	0.7–2.2	0.8–2.5	0.8–2.6
Marijuana	NSDUH-adjusted	10.6	11.8	13.7	13.4	13.6	13.8	14.2	13.5	14.6	16.2	17.6
	NSDUH-raw	7.0	7.9	10.0	9.8	9.9	10.2	10.5	9.9	10.6	12.0	12.9
Meth	Middle	0.9	1.2	1.6	1.9	2.2	2.6	2.6	2.3	2.0	1.8	1.6
	Lower–higher	0.3–1.9	0.5–2.2	0.8–2.7	1.0–3.1	1.2–3.5	1.5–3.9	1.4–3.8	1.2–3.6	1.0–3.2	0.9–2.9	0.7–2.7

The lower and higher ends of the range are meant to give some sense of the uncertainty, but they should not be considered 95% confidence intervals or extreme bounds. The 2000–03 marijuana estimates and 2000–06 methamphetamine estimates are not perfectly comparable to the later years because of changes in survey questions and methods. NSDUH = National Survey on Drug Use and Health.

ADAM. The NSDUH adults not involved in the criminal justice system are adjusted upwards by 25%, based on Kilmer *et al.* [1]. These estimates are roughly 35–40% larger than the unadjusted estimates listed in the 'NSDUH-raw' row.

The situation is very different for the other drugs because the household survey under-estimates frequent use to a much greater degree. For example, based on the 2010 NSDUH, one would conclude there are only 60 000 daily or near-daily heroin users in the United States. Our ADAM-based projection models suggest that the correct figure is closer to 1 000 000.

Estimates of daily/near-daily use of hard drugs must be built up from systems that routinely encounter such people, such as booking facilities, public and private treatment programs and residential homeless shelters. Given the limited treatment funding in the United States, and the nation's massive deployment of criminal sanctioning, we work with arrestee data. However, whether one starts with those treated or those arrested, the US data systems are local, raising the challenge of extrapolating local-level estimates to the nation as a whole.

The extrapolation appears to work remarkably well for cocaine, which is used throughout much of the country. A readily available set of predictor variables, including demographics and drug-specific data such as proportion of pre-employment drug tests that are positive, explains most of the county-to-county variation in arrestees' rates of testing positive for cocaine. However, this approach is less useful for meth. Meth in the United States is concentrated in regions that are not well covered by ADAM, and it is not predominantly an urban drug, whereas most ADAM sites are in major cities. The situation for heroin is intermediate.

For cocaine, heroin and meth, the lower and higher ends of the ranges in Table 1 reflect only one source of uncertainty: the 95% confidence interval surrounding the share of adult male arrest events involving a positive drug test. As there are many other sources of uncertainty (e.g. the share of those with positive tests who are chronic users), readers should not consider these as lower or upper bounds or as confidence intervals. The approximate ratio of the higher to lower estimates for cocaine is 2 : 1, for heroin it is 3 : 1 and for meth it is 4 : 1.

Expenditures

Multiplying the numbers of users of each frequency type by average monthly spending rates for that type, and summing, yields an estimate of expenditure and underscores the importance of collecting survey data on users' spending behavior. Spending per day is correlated positively with days of use per month, so multiplying the total

number of use-days by the average spent per day would under-estimate aggregate spending to a considerable degree.

Figure 1 shows the resulting estimate of US expenditures on illegal drugs. We believe drug users in the United States spent on the order of $100 billion (adjusted for inflation) annually on cocaine, heroin, marijuana and meth throughout the decade, but the composition by drug shifted substantially with marijuana probably usurping cocaine as the largest market. Total US gross domestic product (GDP) in 2010 was approximately $14 trillion, so illegal drugs accounted for less than 1% of GDP; it was approximately 1% of total personal consumption expenditure.

There is uncertainty surrounding the figures for illicit drugs, as they are based on imperfect data, models and a series of assumptions. For example, consider the 2010 cocaine expenditure estimate of roughly $28 billion (Fig. 1). Incorporating just one source of uncertainty—the share of male arrest events involving a positive test for cocaine—generates lower and higher values, ranging from $18 billion to $44 billion. The comparable ranges for heroin and meth are $15–45 billion and $6–22 billion, respectively.

The figures for marijuana are complicated by changes in potency. The estimates that marijuana spending increased from roughly $30 billion to $40 billion between 2002 and 2010 assume that users continued to consume the same weight of marijuana per use day even though Δ-9-tetrahydrocannabinol (THC) levels were increasing. If, instead, the amount of THC consumed per use day had stayed constant (meaning total weight consumed decreased), the 2010 spending figure would be closer to $25 billion.

The analyses suggest that for each of the drugs CDUs account for more than 90% of total spending. Indeed, spending is driven by the minority of users who consume on 21 or more days each month. In 2010, these daily/near-daily users of heroin and marijuana accounted for

roughly 80% of spending; comparable figures for cocaine and meth were closer to 50%.

Consumption

Quantity consumed should be simple to estimate from total expenditures: simply divide by price. The trick is dividing by the right price—to simplify, past estimates of hard drug use divided by the price of a (pure) gram [2]. The problem is that the frequent users who account for most of the consumption rarely amass enough money to buy that much at once; their typical purchase sizes are only $20 or $30 or perhaps $50 [3]. They do not enjoy the large quantity discounts offered when buying as much as 1 (pure) gram at a time. Thus the frequent users who dominate consumption spend more per unit obtained, resulting in lower consumption estimates than had been calculated previously [2]. This effect is particularly pronounced for meth.

The situation is even more complicated for marijuana: the market spans relatively cheap 'commercial grade' and higher-potency variants (e.g. sinsemilla), there may (or may not) be price differences between black market marijuana and marijuana purchased at medical dispensaries, and marijuana is purchased increasingly in non-traditional forms (e.g. edibles, vaporizer pens, concentrates for 'dabbing').

The overall trend, however, stands out above such complications (Table 2). US marijuana consumption increased by perhaps 33% from 2006 to 2010, while the amount of cocaine consumed fell sharply, by about 50% over those same 5 years. Heroin consumption remained fairly stable, although there is some evidence of an increase in the later years. Meth consumption varied; it increased sharply over the first half of the decade, and then declined through 2008. For 2008–10 the most defensible position concerning meth trends is simply to admit that the data are insufficient to provide clear guidance.
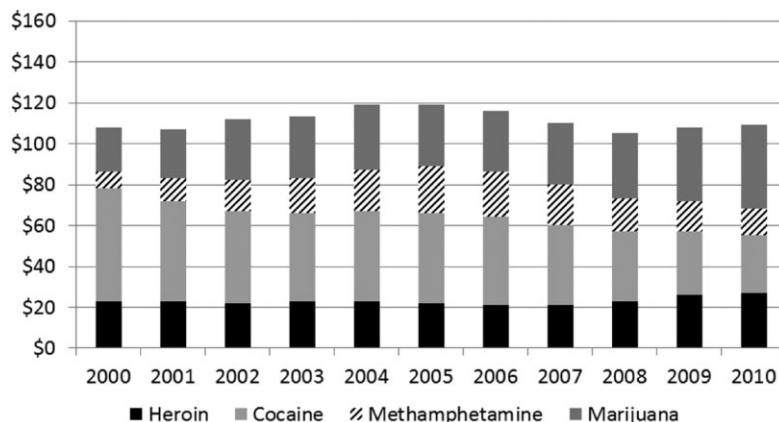

Figure 1 Annual expenditures in US drug markets (in billions, $2010). The 2000–03 marijuana estimates and 2000–06 methamphetamine estimates are not perfectly comparable to the later years because of changes in survey questions and methods

Table 2 Consumption of illicit drugs, 2000–10 (in pure metric tonnes, except marijuana).

Drug	Estimate	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cocaine	Middle	292	258	278	278	324	327	322	282	200	161	145
	Lower–higher	193–440	175–386	183–428	182–428	209–500	211–501	208–494	182–431	132–302	105–248	92–227
Heroin	Middle	22	25	22	23	23	22	22	24	26	27	24
	Lower–higher	11–37	13–41	12–37	12–38	12–37	12–36	12–36	13–39	14–42	15–45	13–40
Marijuana (1000 MT)	Middle	3.0	3.5	4.0	4.0	4.2	4.1	4.3	4.3	4.7	5.1	5.7
	Lower–higher	2.0–3.9	2.3–4.7	2.9–5.7	2.9–5.8	3.0–6.1	3.1–6.1	3.1–6.2	3.1–6.2	3.4–6.8	3.8–7.5	4.2–8.4
Meth	Middle	20	26	41	48	61	85	58	54	39	40	42
	Lower–higher	8–43	11–49	20–70	24–77	32–95	47–127	32–88	28–83	20–63	19–66	19–71

For marijuana, the lower estimate is based on the unadjusted National Survey on Drug Use and Health (NSDUH) figures and the higher estimate is that value multiplied by two. The 2000–03 marijuana estimates and 2000–06 methamphetamine estimates are not perfectly comparable to the later years because of changes in survey questions and methods. Meth = methamphetamine.

QUESTIONS FOR DEBATE

The most interesting substantive findings of this study have been the sudden contraction of the cocaine market and upturn of the marijuana market.

Why did US cocaine consumption fall so sharply—roughly 50%—from 2006 to 2010?

The US cocaine market has been remarkably large and destructive. Until recently it accounted for perhaps two-thirds of drug-related harm in the United States, occupying the position that heroin does in most other Organization for Economic Co-operation and Development countries [9].

Cocaine problems have also been stubbornly persistent. Although consumption peaked in the early 1990s and has been slowly ebbing since [6,10], the market has seemed all but impervious to even the truly enormous control efforts thrown at it for decades by all levels of government [11]. Had experts been asked in 2006 to predict its evolution over the next 5 years, most would have anticipated a continuation of long-standing trends. It is doubtful whether one would even have recognized that the nation was on the cusp of an extraordinary decline.

Thus, our finding that pure cocaine consumption in the United States decreased by approximately 50% over a 5-year period is quite significant. The market is still large—we estimate that there were about 2.5 million chronic users in 2010. Nevertheless, the downturn competes with the 2001 Australian heroin drought as the greatest 'success' in modern recorded drug history at the population level. Declines associated with the Australian heroin drought were proportionately larger—closer to 80%—but the US cocaine market is vastly larger in absolute size. We consider several possible explanations; they are neither exhaustive nor mutually exclusive.

Decrease in Colombian coca available for cocaine production

Upstream interventions in source countries can sometimes suppress consumption in one country for a short period, but as there is no shortage of places with poor farmers and without effective state control, it appears that production usually displaces to another location (e.g. see Paoli, Greenfield & Reuter [12]). Hence, a strong consensus has emerged in the academic literature that source country interventions have no effect on downstream consumption in final market countries [13]. However, it may be judicious to temper that certainty somewhat.

It is believed that most of the cocaine consumed in the United States originates from coca grown in Colombia [14]. Separate analyses from the US Government and the

United Nations Office on Drugs and Crime (UNODC) both conclude that there were large reductions in the amount of coca available to be converted to cocaine in Colombia from 2006 to 2010; the former shows a 52% decline from 148 000 metric tonnes of coca leaf to 71 000, while the latter shows a 41% decrease from 154 130 to 91 600 [14,15]. This is consistent with US intelligence estimates that the amount of cocaine departing towards the United States fell by 30% from 2006 to 2010 (the reduction is closer to 50% if 2007 is the baseline [16]).

The UNODC attributes much of the reduction in Colombian coca available to intense spraying and a large increase in manual eradication efforts [17]. According to the UNODC, the hectares of coca bush eradicated manually in Colombia increased from 6234 in 2004 and 31 980 in 2005, to a peak of 95 634 hectares in 2008 [15]. Because it typically takes 18–24 months before coca cultivated in Colombia ends up on US streets [18,19], this correlates with the large drop in consumption observed after 2007. Further, the UN notes that: 'Since 2005, probably due to increased counter-narcotics pressure, the per-hectare yields of coca fields went down in many growing regions of Colombia' [15].

Factors other than law enforcement must also be considered. For example, some coca farmers in Colombia may have shifted to other activities. It could also have been the case that some traffickers in Colombia moved into other businesses [20]. For example, Felbab-Brown notes that: 'Actors who control gasoline smuggling in bulk and can bring it all the way from Venezuela to Bogotá can make more money than those who smuggle cocaine to Colombia's borders while facing far less law enforcement' [21].

Crackdown and violence in Mexico

Mexican drug trafficking organizations (DTOs) have always perpetrated violence, but the levels skyrocketed after President Calderon launched his aggressive war on the DTOs in December of 2006 [22]. Hence, the crackdown and associated horrendous violence and instability occurred over the same period as the massive reduction in US cocaine consumption. Perhaps instability and battles with rival DTOs and law enforcement agencies made it more difficult to move cocaine through Mexico and to the United States. However, it is important to understand why only cocaine supply may have been affected; after all, Mexico is an important source and/or transit country of all four drugs being studied here.

Increase in non-US demand for cocaine

In the 1980s and into the 1990s the United States dominated global cocaine consumption, but use elsewhere has been growing. What matters to US markets is not just quantities available for export, but quantities available for export relative to global demand. One expects that shortages will affect least the markets with the highest import prices [23], and UNODC reports that, from 2008 to 2010, 'Cocaine from Colombia accounted for 25% of all cocaine seizures in volume terms in Europe', where cocaine is generally more expensive than in the United States [15]. Also, cocaine destined for the United States has largely passed through Mexico since the late 1990s [24]. Mexican DTOs may capture much of the export-to-import markup on cocaine shipped from Colombia to the United States via Mexico. Is it possible that in the face of scarce supplies, Colombian traffickers have prioritized other markets?

Decrease in US demand for cocaine

Table 1 documents that the number of chronic cocaine users decreased by more than 20% from 2006 to 2010. At this point in the epidemic heavy cocaine users are becoming older and some are probably aging out [25]; however, it seems unlikely that such a large number would age out over such a short period of time. We are also unaware of research documenting that heavy cocaine users suddenly switched to other substances (e.g. prescription drugs).

It is more likely that users adjusted their consumption because of price changes due to a reduction in cocaine availability. From 2006 to 2009 the price per pure gram for both powder cocaine and crack cocaine at the retail level increased by approximately 40% [26].

Summary

We suspect that some supply-side factor or factors contributed to the decline in US cocaine consumption, simply because consumption is dominated by long-term high-frequency users whose demand is stubbornly persistent, but draw no other conclusions. Rather, our point is that this extremely important development warrants attention from researchers (the Australian heroin drought generated at least 10 papers in this journal alone; see e.g. [27–29]).

Why did marijuana use—particularly daily/near-daily use—rise sharply from 2006 to 2010?

Our analysis broke down CDUs into three groups: regular (4–10 days in the past month), heavy (11–20 days) and daily/near-daily users (21 or more days in the past month). This is important, as those who use more frequently consume more marijuana per use day [30–32].

Increases in overall marijuana prevalence were noteworthy between 2006 and 2010 at 18%, but daily/near-daily users rose by more than 40%, so total consumption

and spending were raised by more than one-third. This suggests that merely monitoring past-month or past-year prevalence can be misleading.

We do not know why there was such a large increase in the number of daily/near-daily users. National attitudes about marijuana softened during the decade (e.g. opposition to legalizing marijuana use decreased from 64% in 2000 to 50% in 2010; [33]), but it is difficult to disentangle this from the changes in use or changes in marijuana policy.

Since 1996, more than 20 states have permitted some form of access to marijuana for medical purposes. There is heterogeneity in how medical marijuana is supplied and for what conditions it can be used [34,35]. Not all states allow retail dispensaries, and the evolution of retail markets has varied greatly from state to state. For example, dispensaries proliferated in California after the passage of SB420 in 2003, and in Colorado once the 'Five Patient Policy' was overturned in 2007 [36,37]. Rigorous studies find evidence suggesting that medical marijuana laws increase adult marijuana prevalence [35,38], but the debate continues about how these laws affect youth consumption [35,38–41].

A related explanation is that a falling cost per hour of marijuana intoxication increased heavy use. Anderson *et al.* found that states adopting medical marijuana laws had lower prices for high-potency varieties [38], and potency-adjusted prices for the more common commercial-grade material imported from Mexico also fell [42]. In particular, we find that although the inflation-adjusted average price paid per unit weight was stable, the average amount of THC in seizures believed to be from Mexico increased by almost 50% [3]. This suggests that price per unit of THC could have decreased for most of the country over the decade.

There is also a possibility that changes in attitudes and policy led survey respondents to be more forthcoming about their use. However, the fact that it was the number of daily/near-daily users that increased the most suggests that this is probably not the major contributor. It is hard to gain insight into this, as the last study to validate the US national survey with drug testing was conducted in 2001 [43].

CONCLUSIONS

New estimates of US drug consumption and retail expenditures raise significant questions about what happened to US drug markets in the late 2000s. Notwithstanding efforts to exploit all available data, there remains great uncertainty surrounding all these estimates. The implications for researchers in other countries appear quite depressing as more data sets are available in the United States, and often of higher quality, than those available in other nations. If even with these resources the estimates are so imprecise, what can be carried out elsewhere to give policymakers useful population-level indicators?

Substantively, the study shows that even for established drugs, consumption can change rapidly. The halving of the cocaine market in 5 years and the parallel (but independent) large rise in daily/near-daily marijuana use are major events that were not anticipated by the expert community, and raise important theoretical, research, and policy issues.

The study also points to the very serious limitations of general population surveys for tracking a nation's drug problems. Especially for the hard drugs, the bulk of users responding to those surveys consume only occasionally, and account for a negligible share of current consumption. Those using four or more times per month account for more than 90% of spending on all four drugs. Because uncertainties concerning chronic users' consumption are greater than plus or minus 10%, it is not clear that national consumption and expenditure estimates should even be concerned with less frequent users, or at least should not invest much effort in estimating their use. Even in the case of marijuana, it would be much more informative to have time–series describing changes in the prevalence of daily and near-daily users, as well as information about their typical consumption per use day and weekly spending. Developing such series requires new data collection methodologies.

There is, however, a more pressing issue to address: the US federal government has just eliminated the ADAM program, which is central for our estimates of cocaine, heroin and methamphetamine consumption and expenditures. In the late 1990s and early 2000s there were roughly 35 jurisdictions participating in ADAM and serious discussions about expanding it to 75; unfortunately, the program was eliminated from 2004 to 2006 and brought back on a much smaller scale from 2007 to 2013. No funds were allocated for ADAM in 2014. As noted by Kilmer & Caulkins, 'Even at its peak ADAM cost only about $10 million per year, roughly one-fifth of what it costs to operate NSDUH—and less than one one-hundredth of one-percent of the social cost imposed by abuse of the drugs it tracked' [44]. If ADAM is not re-funded or replaced with something that allows researchers to interview and test large numbers of frequent users of hard drugs (in both urban and rural areas), it will be extremely difficult, if not impossible, to measure total consumption and spending on these substances. Allowing this to happen would be a step backwards for public health and safety. Good policy needs a foundation in good data.

Declaration of interests

None.

References

1. Kilmer B., Caulkins J., Pacula R., Reuter P. Bringing perspective to illicit markets: estimating the size of the U.S. marijuana market. *Drug Alcohol Depend* 2011; **119:** 153–60.

2. Office of National Drug Control Policy. *What America's Users Spend on Illegal Drugs, 2000–2006*. Prepared by W. Rhodes, C. Dyous, D. Hunt, J. Luallen, M. Callahan & R. Subramanian. Washington, DC: Executive Office of the President; 2012.

3. Office of National Drug Control Policy. *What America's Users Spend on Illegal Drugs, 2000–2010*. Prepared by B. Kilmer, S. Everingham, J. Caulkins, G. Midgette, R. Pacula, P. Reuter, R. Burns, B. Han & R. Lundberg. Washington, DC: Executive Office of the President; 2014.

4. Office of National Drug Control Policy. *What America's Users Spend on Illegal Drugs, 1988–1995*. Prepared by W. Rhodes, S. Langenbahn. R. Kling & P. Scheiman. Washington, DC: Executive Office of the President; 1997.

5. Office of National Drug Control Policy. *What America's Users Spend on Illegal Drugs, 1988–1998*. Prepared by W. Rhodes, M. Layne, P. Johnston, & L. Hozik. Washington, DC: Executive Office of the President; 2000.

6. Office of National Drug Control Policy. *What America's Users Spend on Illegal Drugs, 1988–2000*. Prepared by W. Rhodes, M. Layne, A. Bruen, P. Johnston, & L. Becchetti. Washington, DC: Executive Office of the President; 2001.

7. Kilmer B., Caulkins J., Midgette G., Dahlkemper L., MacCoun R., Pacula R. *Before the Grand Opening: Measuring Washington State's Marijuana Market in the Last Year Before Legalized Commercial Sales* (TR-466). Santa Monica, CA: RAND; 2013.

8. Barlas F. M., Higgins W. B., Pflieger J. C., Diecker K. *2011 Health Related Behaviors Survey of Active Duty Military Personnel*. Washington, DC: Department of Defense; 2013.

9. Caulkins J., Kleiman M. Drugs and drug policies in the United States. In: Schuck P., Wilson J., editors. *Understanding America: The Institutions and Policies that Shape America and the World*. New York: Public Affairs Publishing; 2007, pp. 563–93.

10. Caulkins J., Behrens D., Knoll C., Tragler G., Zuba D. Markov chain modeling of initiation and demand: the case of the US cocaine epidemic. *Health Care Manag Sci* 2004; **7:** 319–29.

11. Reuter P. Why has American drug policy changed so little over 30 years? In: Tonry M., editor. *Crime and Justice: A Review of Research*, **42**. Chicago, IL: University of Chicago Press; 2013, pp. 75–140.

12. Paoli L., Greenfield V., Reuter P. *The World Heroin Market: Can Supply be Cut?* New York: Oxford University Press; 2009.

13. Babor T., Caulkins J., Edwards G., Foxcroft D., Humphreys K., Mora M. *et al. Drug Policy and the Public Good*. New York: Oxford University Press; 2010.

14. US State Department. *2013 International Narcotics Control Strategy Report*. 2013. Available at: http://www.state.gov/j/inl/rls/nrcrpt/2013/vol1/index.htm (accessed 1 July 2014) (Archived at http://www.webcitation.org/6QkreOHpQ on 1 July 2014).

15. United Nations Office on Drugs and Crime (UNODC). *World Drug Report 2011*. Vienna: UNODC; 2011.

16. Office of National Drug Control Policy. *Cocaine Smuggling in Year 2010*. Washington, DC: Executive Office of the President; 2012.

17. United Nations Office on Drugs and Crime (UNODC). *UNODC Reports Steep Decline in Cocaine Production in Colombia, 19 June 2009 Press Release*. Vienna: UNODC, as of 23 January 2014. Available at: http://www.unodc.org/unodc/en/press/releases/2009/june/unodc-reports-steep-decline-in-cocaine-production-in-colombia.html (accessed 1 July 2014) (Archived at http://www.webcitation.org/6QkrpTzYe on 1 July 2014).

18. Ehleringer J. R., Casale J. F., Barnette J. E., Xu X., Lott M. J., Hurley J. 14C calibration curves for modern plant material from tropical tegions of South America. *Radiocarbon* 2011; **53:** 585–94.

19. Ehleringer J. R., Casale J. F., Barnette J. E., Xu X., Lott M. J., Hurley J. 14C analyses quantify time lag between coca leaf harvest and street-level seizure of cocaine. *Forensic Sci Int* 2012; **214:** 7–12.

20. Rico D. *La Dimensión Internacional del Crimen Organizado en Colombia: Las Bacrim, sus Rutas y Refugios* [The International Dimensions of Organized Crime in Colombia: The BACRIM, Their Roots and Refuges]. Washington, DC: Woodrow Wilson International Center for Scholars; 2013. http://www.wilsoncenter.org/sites/default/files/Daniel%20Rico.pdf (accessed 1 July 2014) (Archived at http://www.webcitation.org/6QlhCWcye on 2 July 2014).

21. Felbab-Brown V. *Lords of the flies in Colombia*. 2013. Available at: http://www.brookings.edu/research/opinions/2011/02/22-colombia-felbabbrown# (accessed 1 July 2014) (Archived at http://www.webcitation.org/6QkrumJcc on 1 July 2014).

22. Rios V., Shirk D. *Drug Violence in Mexico: Data and Analysis through 2010*. San Diego, CA: Transborder Institute; 2011.

23. Caulkins J., Hao H. Modeling drug market supply reductions: where do all the drugs not go? *J Policy Model* 2008; **30:** 251–70.

24. United Nations Office on Drugs and Crime (UNODC). World Drug Report 2010. Vienna, Austria: UNODC; 2010.

25. Kilmer B., Caulkins J., Pacula R., Reuter P. *The U.S. Drug Policy Landscape: Insights and Opportunities for Improving the View* (OP-393). Santa Monica, CA: RAND; 2012.

26. Office of National Drug Control Policy. *2013 National Drug Control Strategy: 2013 Data Appendix*. 2013. Available at: http://www.whitehouse.gov/sites/default/files/ondcp/policy-and-research/2013_data_supplement_final2.pdf (accessed 1 July 2014) (Archived at http://www.webcitation.org/6Qks0H89Q on 1 July 2014).

27. Weatherburn D., Jones C., Freeman K., Makkai T. Supply control and harm reduction: lessons from the Australian heroin 'drought'. *Addiction* 2003; **98:** 83–91.

28. Degenhardt L., Reuter P., Collins L., Hall W. Evaluating explanations of the Australian 'heroin shortage'. *Addiction* 2005; **100:** 459–69.

29. Wood E., Stoltz J. A., Li K., Montaner J. S., Kerr T. Changes in Canadian heroin supply coinciding with the Australian heroin shortage. *Addiction* 2006; **101:** 689–95.

30. Zeisser C., Thompson K., Stockwell T., Duff C., Chow C., Vallance K. *et al.* A 'standard joint'? The role of quantity in predicting cannabis-related problems. *Addict Res Theory* 2011; **20:** 82–92.

31. Caulkins J., Kilmer B. Estimating the size of the EU cannabis market. In: Trautman F., Kilmer B., Turnbull P., editors. *Further Insights into Aspects of the Illicit EU Drugs Market*. Luxembourg: Publications Office of the European Union; 2013, pp. 289–322.

32. van Laar M., Frijns T., Trautmann F., Lombi L. Cannabis market: user types, availability and consumption estimates. In: Trautman F., Kilmer B., Turnbull P., editors. *Further*

Insights into Aspects of the Illicit EU Drugs Market. Luxembourg: Publications Office of the European Union; 2013, pp. 73–182.

33. Gallup. *For first time, Americans favor legalizing marijuana.* 2013. Available at: http://www.gallup.com/poll/165539/first-time-americans-favor-legalizing-marijuana.aspx (accessed 1 July 2014) (Archived at http://www.webcitation.org/6QksXxomm on 1 July 2014).

34. Pacula R., Chriqui J. F., Reichmann D., Terry-McElrath Y. State medical marijuana laws: understanding the laws and their limitations. *J Public Health Policy* 2002; **23:** 413–39.

35. Pacula R., Powell D., Heaton P., Sevigny E. *Assessing the Effects of Medical Marijuana Laws on Marijuana and Alcohol Use: The Devil is in the Details* (no. w19302). Cambridge, MA: National Bureau of Economic Research; 2013.

36. Blevins J. Courts offer some sketchy guidance on amendment's gray areas. *Denver Post*, 14 September 2008.

37. Bartels L. Clouds hang over pot issue: Sen. Romer plans to introduce medical-marijuana bill to clarify regulations. *Denver Post*, 22 October 2009.

38. Anderson D. M., Hansen B., Rees D. I. Medical marijuana laws, traffic fatalities, and alcohol consumption. *J Law Econ* 2013; **56:** 333–69.

39. Anderson D. M., Rees D. I. The legalization of recreational marijuana: how likely is the worst-case scenario? *J Policy Anal Manage* 2014; **33:** 221–32.

40. Choo E., Benz M., Zaller N., Warren O., Rising K., McConnell K. The impact of state medical marijuana legislation on adolescent marijuana use. *J Adolesc Health* 2014; doi: 10.1016/j.jadohealth.2014.02.018.

41. Pacula R., Sevigny E. Natural experiments in a complex and dynamic environment: the need for a measured assessment of the evidence. *J Policy Anal Manage* 2014; **33:** 232–5.

42. Kilmer B., Caulkins J., Bond B., Reuter P. *Reducing Drug Trafficking Revenues and Violence in Mexico: Would Legalizing Marijuana in California Help?* Santa Monica, CA: RAND; 2010.

43. Harrison L. S., Martin S. S., Enev T., Harrington D. *Comparing Drug Resting and Self-Report of Drug Use Among Youths and Young Adults in the General Population* (SMA) 07-4249. Rockville, MD: Office of Applied Studies; 2007.

44. Kilmer B., Caulkins J. Hard drugs demand solid understanding. *USA Today*, 8 March 2014.