Assessing the impact of drug law enforcement on illegal drug supply: An audit of international government surveillance systems

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-003077
Article Type:	Research
Date Submitted by the Author:	18-Apr-2013
Complete List of Authors:	Werb, Dan; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Kerr, Thomas; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Nosyk, Bohdan; BC Centre for Excellence in HIV/AIDS, Strathdee, Steffanie; University of California San Diego, Medicine Montaner, Julio; BC Centre for Excellence in HIV/AIDS, Wood, Evan; BC Centre for Excellence in HIV/AIDS,
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health policy, Public health
Keywords:	AUDIT, Public health < INFECTIOUS DISEASES, PUBLIC HEALTH

Assessing the impact of drug law enforcement on illegal drug supply: An audit of international government surveillance systems

Dan Werb; Thomas Kerr; Bohdan Nosyk; Steffanie Strathdee; Julio Montaner; Evan Wood

Dan Werb, Senior Research Assistant, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Thomas Kerr, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Bohdan Nosyk, Research Scientist, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Steffanie Strathdee, Associate Dean of Global Health Sciences, University of California San Diego, Institute of the Americas, 10111 N. Torrey Rd., La Jolla, CA, USA, 92093-0507

Julio Montaner, Director, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Evan Wood, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Send correspondence to:

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia

BC Centre for Excellence in HIV/AIDS
608-1081 Burrard Street, Vancouver, B.C. V6Z 1Y6
CANADA

Tel: (604) 806-9116
Fax: (604) 806-9044
Email: uhri-ew@cfenet.ubc.ca

Word Count: 2,155
Tables: 1
Figures: 4

Revised: April 17, 2013
Printed: April 17, 2013

ABSTRACT

Objectives: Illegal drug use continues to be a major threat to community health and safety. We used international drug surveillance databases to assess the impact of enforcement-based supply reduction strategies on long-term estimates of illegal drug price and purity.

Design: We systematically searched for longitudinal measures of illegal drug supply indicators to assess the long-term impact of enforcement-based supply reduction interventions.

Setting: Data from identified illegal drug surveillance systems were analysed using an *a priori* defined protocol in which we sought to present annual estimates beginning in 1990. Data were then subjected to trend analyses.

Main Outcome Measures: Data were obtained from government surveillance systems assessing price, purity, and/or seizures of illegal drugs; systems with at least 10 years of longitudinal data assessing price, purity/potency, or seizures were included.

Results: We identified 7 surveillance systems with longitudinal measures of price or purity/potency that met eligibility criteria. In the United States, the average inflation- and purity-adjusted prices of heroin, cocaine, and cannabis decreased by 81%, 80% and 86% respectively between 1990 and 2007, whereas average purity increased by 60%, 11%, and 161% respectively. Similar trends were observed in Europe, where during the same period the average inflation-adjusted price of opiates and cocaine decreased by 74% and 51% respectively. In Australia, the average inflation-adjusted price of cocaine decreased 14%, while the inflation-adjusted price of heroin and cannabis both decreased 49% between 2000 and 2010. During this time, seizures of these drugs in major production regions and major domestic markets generally increased.

Conclusions: With few exceptions and despite increasing investments in enforcement-based supply reduction efforts aimed at disrupting global drug supply, illegal drug prices have generally decreased while drug purity has generally increased since 1990. These findings suggest that expanding efforts at controlling the global illegal drug market through law enforcement are failing.

Word count: 300

Article Summary

Article focus

- Studies have demonstrated that illegal drug use remains a threat to community health and safety.
- However, less is known regarding the long-term impact of efforts to reduce the overall supply of illegal drugs.

Key messages

- Using longitudinal governmental surveillance data, this study demonstrates that over the past two decades, the supply of major illegal drugs has increased, as measured through a general decline in the price, and a general increase in the purity of illegal drugs in a variety of settings.

Strengths and limitations

- This study was limited by the quality and consistency of surveillance data on illegal drug supply
- This study presents over two decades of data on trends in illegal drug supply in a variety of settings, including consumer and export drug markets

OBJECTIVES

The United Nations (UN) recently estimated that the global illegal drug trade is worth at least $350 billion USD annually,[1] and illegal drug use remains a major threat to community health and safety.[2, 3] In addition to the range of harms associated with the direct health effects of drugs, including fatal overdose,[4, 5] illegal drug use is also one of the key global drivers of blood borne disease transmission, in particular human immunodeficiency virus (HIV) infection.[6, 7] Illegal drug markets also contribute to community concerns such as high rates of violence in settings where the trade proliferates.[8]

In response to the health and social concerns associated with illegal drug use, several UN conventions were created to criminalize the possession, consumption, and manufacture of illegal drugs.[9-11] Accordingly, over the last several decades, most national drug control strategies have prioritized drug law enforcement interventions to reduce drug supply, despite recent calls by experts to explore alternative models of drug control.[12, 13] While some unintended consequences of this approach, such as record incarceration rates, have been well-documented,[14-16] the impact of enforcement-based interventions on drug supply, measured through indicators of drug price, purity/potency and seizures, has not been subjected to systematic evaluation. The present study therefore sought to systematically identify international data from publicly available illegal drug surveillance systems to assess the impact of enforcement-based supply reduction strategies on long-term estimates of illegal drug supply.

DESIGN

Outcomes of interest

The primary outcomes of interest were long-term patterns of illegal drug supply, measured through indicators of price and purity/potency for three major illegal drugs: cannabis, cocaine, and opiates (e.g., opium and heroin). Amphetamine-type stimulants were not included given inconsistent data collection (e.g., reclassification) and fluctuating surveillance data quality. A secondary outcome of interest was defined as patterns of illegal drug seizures in a) major illegal drug source regions and, b) major destination markets, as identified by the United Nations Office on Drugs and Crime (UNODC).[17] These secondary outcome data were used as an additional proxy measure to assess the availability of illegal drugs in specific regions, as has been done previously.[18, 19] All outcomes were systematically identified through publicly available illegal drug surveillance systems. Linear by linear association trend tests were carried out on annualized estimates of all outcomes of interest. All price estimates are expressed in 2011 USD and are, where possible, adjusted for purity.[20]

Illegal drug surveillance systems

A search of illegal drug surveillance systems using two *a priori* defined inclusion criteria was carried out. First, because we specifically sought to assess the long-term impact of enforcement-based supply reduction strategies on illegal drug price and purity/potency, only surveillance systems that included continuous longitudinal assessments of these outcomes of interest for at least 10 years were prioritized for inclusion. Second, data extraction was restricted to 1990 and onwards to focus on patterns of supply during recent decades.

Data were obtained through systematic searches of registries of surveillance systems, governmental reports, and peer-reviewed publications, as

well as through data requests to relevant organizations including the UNODC. All authors had complete access to all data and all had final responsibility to submit for publication. Ethics approval was not required given that we relied exclusively on publicly available data.

RESULTS

We identified 7 government surveillance systems that met inclusion criteria. Of these, 3 (43%) reported on international data, 3 (43%) reported on data from the United States (US), and 1 (14%) reported on data from Australia. The longest-running surveillance system identified, the US-based Marijuana Potency Monitoring Project, is funded by the U.S. National Institutes of Health and was established in 1975, while the most recent surveillance system was established in 2001 (e.g., the US-based *National Drug Threat Assessment*). With respect to international surveillance systems, the UNODC administers two separate surveillance systems that collect data from all participating United Nations member states: the Annual Reports Questionnaire surveillance system that collects price and purity/potency data, and the Drug Seizures Database that collects seizure data. Finally, the European Monitoring Centre for Drugs and Drug Addiction administers the Reitox drug surveillance system network, which aggregates data from a number of country-level surveillance systems in Europe, as described below.[21]

Price and Purity/Potency

Table 1 presents surveillance systems that matched search criteria. An assessment of data provided by these surveillance systems demonstrated a number of broad trends. First, purity and/or potency of illegal drugs generally

remained stable or increased overall during the study period. Second, the price of illegal drugs, with few exceptions, generally decreased. Third, seizures of cannabis, cocaine and opiates generally increased in major drug production regions and major domestic markets.

Figure 1 presents data from the US Drug Enforcement Administration's System To Retrieve Information from Drug Evidence (STRIDE). As can be seen, between 1990 and 2007 (the last year for which data are publicly available), the purity of heroin and cocaine, and the potency of cannabis in the US increased, while the inflation- and purity-adjusted prices of these three drugs declined.[22] Specifically, heroin purity increased by 60% ($p = 0.568$), cocaine purity increased by 11% ($p = 0.181$), and cannabis potency increased by 161% ($p < 0.001$) during this time. During the same period, the prices of heroin, cocaine, and cannabis decreased 81% ($p < 0.001$), 80% ($p < 0.001$), and 86% ($p < 0.001$) respectively.

Figure 2 presents data collected by the UNODC on the street price of cocaine and opiates in participating European countries (i.e., Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Iceland, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Ireland).[23] In these countries, between 1990 and 2009, the aggregate average retail street price of cocaine decreased by 51%, from $198 USD per gram to $98 USD per gram ($p < 0.001$). Similarly, the aggregate average price of opiates in Europe decreased 74%, from a high of $295 USD per gram in 1990 to $77 USD per gram in 2009 ($p < 0.001$).

Data from the Australian Illicit Drug Reporting System (IDRS) were available from 2000 to 2010. IDRS data suggest that the price of illegal drugs in

Australia fluctuated substantially during this period. Specifically, after adjustment, the price of heroin decreased by 49%, from approximately $460 USD per gram to approximately $235 per gram ($p < 0.001$), the price of cocaine decreased 14% from approximately $255 AUD per gram to $220 AUD per gram ($p = 0.477$), and the price of cannabis decreased 49% from approximately $25 AUD per gram to $13 AUD per gram ($p < 0.001$).[24]

Seizures

Domestic Markets

Figure 3 presents data on cannabis and cocaine seizures in the US between 1990 and 2010. As shown, data from the US Drug Enforcement Administration's STRIDE surveillance system demonstrate that the amount of cannabis herb seized by the Drug Enforcement Administration both in, and destined for, the US rose 465%, from approximately 130,000 kilograms in 1990 to approximately 720,000 kilograms in 2010 ($p < 0.001$). During this same period, despite fluctuations, the amount of cocaine seized by the US Drug Enforcement Administration decreased 49%, from approximately 57,000 kilograms in 1990 to 29,000 in 2010 ($p = 0.409$), while the amount of heroin seized increased 29% from approximately 535 kilograms in 1990 to 690 kilograms ($p = 0.979$, heroin seizure data not shown).[25]

Figure 4 presents data on cannabis, cocaine and heroin seizures in countries participating in the European Monitoring Centre for Drugs and Drug Addiction's Reitox surveillance network (i.e., European Union member countries, as well as Croatia, Norway, and Turkey), between 1995 and 2009. As can be seen, annual estimates of the quantity of both cocaine and cannabis seized

fluctuated throughout this period; however, the quantity of heroin seized increased relatively steadily. Specifically, the number of kilograms of cannabis herb seized was at a low of approximately 57,000 kilograms in 1995, and peaked one year later in 1996 at approximately 138,000 kilograms (p = 0.446). The number of cocaine seizures was at a low of approximately 21,000 kilograms in 1995, and peaked at approximately 121,000 kilograms in 2006 (p = 0.018). Finally, the number of kilograms of heroin seized increased 380% from a low of approximately 5,000 in 1995 to a high of approximately 24,000 in 2009 (p < 0.001).

Production Regions

With respect to opiate seizures, the Golden Triangle includes parts of Thailand, Lao, Viet Nam and Myanmar, and according to the UNODC, this region is the second largest supplier of heroin globally.[26] Here, seizures of opium more than doubled from 3,198 kilograms in 1990 to 8,903 kilograms in 2006 (p = 0.430), the last year for which this data is available. By contrast, seizures of heroin decreased by more than half, from 1,337 kilograms in 1990, to 569 kilograms in 2006 (p = 0.339). In Afghanistan, which is believed to supply over 90% of the world's opium,[26] seizures of opium increased by close to 9,000%, from 453 kilograms in 1990 to 40,959 kilograms in 2006, and seizures of heroin increased by approximately 220%, from 1,256 kilograms in 1990 to 4,053 kilograms in 2006 (Note: missing data prevented a trend test for annual opium and heroin seizures in Afghanistan).

With respect to cocaine seizures, according to the UNODC, Latin America's Andean region, which includes Peru, Bolivia, and Colombia, is the

primary global supplier of this drug, as coca leaf is grown exclusively in this region.[27] While seizures of cocaine in the Andean region decreased 81%, from 97,437 kilograms in 1990 to 17,835 kilograms in 2007 (p = 0.028), seizures of coca leaf increased 188% from 601,038 kilograms in 1990 to 1.73 million kilograms (p = 0.004).

Finally, according to the UNODC, cannabis is produced in all global regions, though major areas of cannabis cultivation exist in North Africa, Afghanistan, and North America. These areas are net exporters of cannabis, though most cannabis-producing countries also produce the drug for internal consumption.[17] In North Africa (i.e., Algeria, Morocco, and Tunisia), seizures of cannabis herb increased by 208% from 67,930 kilograms in 1990 to 209,445 kilograms in 2007 (p = 0.015). In North America (i.e., Canada, the United States, and Mexico), seizures of cannabis herb increased by 288% from 782,607 kilograms in 1990 to 3.05 million kilograms in 2007 (p < 0.001). In Afghanistan, while data on cannabis herb seizures are not available, seizures of cannabis resin increased 630% from 5,068 kilograms in 1990 to 36,972 kilograms in 2006 (p = 0.061).

CONCLUSIONS

Longitudinal data from government surveillance systems demonstrate that over the past two decades there has been a general pattern of increased illegal drug supply as defined through lower price and higher purity of heroin, cocaine and cannabis. During the same period, patterns of drug seizures either increased or remained stable, though the trends detected in some of these indicators did not reach statistical significance.

As noted elsewhere,[28, 29] there are limitations of ecologic analyses based on international surveillance systems. First, some states collect little or no data on indicators of illegal drug supply, whereas other states spend significant energy on monitoring drug availability. Second, even in states that closely track indicators of supply, the degree to which seized samples of illegal drugs reflect purity of retail drugs sold on the street is subject to variation, though where possible we presented purity-adjusted prices to address this limitation.[20] Nevertheless, the long-term trends in increasing purity and decreasing price presented here likely reflect overall trends in many regions, though some exceptions were observed. Australia for instance, while experiencing a significant decrease in the prices of both heroin and cannabis, did not experience a significant decrease in the price of cocaine, which may reflect the geographic isolation of the region or other market factors. Third, limitations in longitudinal data collection precluded our ability to include amphetamine-type stimulants and other emerging synthetic substances. It is noteworthy in this regard that the production of synthetic substances present particular challenges for supply reduction strategies, given that these drugs can be mass produced in clandestine locations regardless of climate or other factors that limit traditional drug production.[17, 30] Finally, while this review focused on the impact of enforcement-based supply reductions on price and purity of selected illegal drugs, these measures are only a marker of drug supply, and do not measure other factors determining availability and concomitant rates of drug use. It is noteworthy in this regard that a recent World Health Organization report that assessed data from a combined sample of over 85,000 participants in 17 countries found no

association between the intensity of national drug law enforcement and rates of drug use.[31]

In summary, longitudinal illegal drug surveillance systems demonstrate a general global pattern of falling drug prices and increasing drug purity and potency, alongside a relatively consistent pattern of increasing seizures of illegal drugs. Although source data have limitations and there are some exceptions to these trends, these findings highlight the need to re-examine the effectiveness of national and international drug strategies that place a disproportionate emphasis on supply reduction at the expense of prevention and treatment of illegal drug use.

Acknowledgments:

The authors would like to thank Deborah Graham, Peter Vann, Katherine Quayle, Samantha MacLean, and Kevin Lutz for their administrative assistance. Dan Werb is supported by the Canadian Institutes of Health Research. Thomas Kerr is supported by the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

Competing interests:

All authors declare that (1) DW, TK, BN, JM and EW have support from the BC Centre for Excellence in HIV/AIDS for their submitted work; SS has support from the Division of Global Public Health, Department of Medicine, University of California, San Diego; (2) DW, TK, BN, SS, and EW have no relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) DW, TK, BN, SS and EW have no non-financial interests that may be relevant to the submitted work. JM has received grants from, served as an ad hoc adviser to, or spoken at events sponsored by Abbott, Argos Therapeutics, Bioject Inc., Boehringer Ingelheim, BMS, Gilead Sciences, GlaxoSmithKline, Hoffmann-La Roche, Janssen-Ortho, Merck Frosst, Panacos, Pfizer Ltd., Schering, Serono Inc., TheraTechnologies, Tibotec (J&J), and Trimeris.

Contributorship

All authors contributed substantially to the design and drafting of the manuscript. DW and EW designed the initial methodological approach and drafted the manuscript; TK, BN, SS, and JM provided substantial revisions to the manuscript.

Data sharing

This study employed publicly available data, as described in the methods section.

Funding

None

References:

1. Pietschmann T, Walker J. Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes. Vienna: UNODC Studies and Threat Analysis Section, Division for Policy Analysis and Public Affairs; 2011.
2. Jurgens R, Ball A, Verster A. Interventions to reduce HIV transmission related to injecting drug use in prison. Lancet Infect Dis. 2009; **9**(1): 57-66.
3. Beyrer C, Malinowska-Sempruch K, Kamarulzaman A, Kazatchkine M, Sidibe M, Strathdee SA. Time to act: A call for comprehensive responses to HIV in people who use drugs. Lancet. 2010; **376**(9740): 551-63.
4. Coffin PO, Galea S, Ahern J, Leon AC, Vlahov D, Tardiff K. Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City, 1990-98. Addiction. 2003; **98**(6): 739.
5. Garfield J, Drucker E. Fatal overdose trends in major US cities: 1990 - 1997. Addict Res Theory. 2001; **9**(5): 425.
6. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. Lancet. 2008; **372**(9651): 1733-45.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis. 2005; **5**(9): 558-67.
8. Werb D, Rowell G, Guyatt G, Kerr T, Montaner J, Wood E. Effect of drug law enforcement on drug market violence: A systematic review. Int J Drug Pol. 2011; **22**(2): 8.
9. ECOSOC. Convention on Psychotropic Substances, 1971. Vienna: international; 1971.
10. ECOSOC. The Single Convention on Narcotic Drugs, 1961. As amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs, 1961. Vienna: international; 1972.
11. ECOSOC. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. Vienna: United Nations Economic and Social Council; 1988.

12. Travis A. Home Office rejects decriminalising possession of drugs for personal use. The Guardian. 2011 October 14.
13. Hoeffel J. Federal crackdown on medical pot sales reflects a shift in policy. Los Angeles Times. 2011 October 7.
14. Warren J, Gelb A, Horowitz J, Riordan J. One in 100: Behind bars in America 2008. Washington, D.C.: The Pew Center on the States 2008.
15. Farrell G, Clark, K. What does the world spend on criminal justice? Helsinki: The European Institute for Criminal Prevention and Control, affiliated with the United Nations; 2004.
16. Walmsley R. World prison population list. Report. London: International Centre for Prison Studies; 2007.
17. UNODC. World Drug Report 2011. Vienna: United Nations Office on Drugs and Crime; 2011.
18. Roberts M, Bewley-Taylor DR, Trace M. Monitoring drug policy outcomes: the measurement of drug-related harm: Beckley Foundation Drug Policy Programme; 2006.
19. Lenke L. An analysis of the significance of supply and market factors for variations in European cannabis use. EMCDDA Monographs. 2008: 293.
20. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alc Depend. 2007; **90**: S61-S8.
21. Hartnoll R. Drug epidemiology in the European institutions: Historical background and key indicators. Bulletin on Narcotics. 2003; **55**(1): 53-72.
22. Fries A, Anthony RW, Cseko Jr. A, Gaither CC, Schulman E. The price and purity of illicit drugs: 1981 - 2007. Alexandria, VA: Institute for Defense Analyses; 2008.
23. UNODC. World Drug Report 2010: Statistical Annex. Vienna: United Nations Office on Drugs and Crime; 2010.
24. Stafford J, Burns L. Australian drug trends 2010: Findings from the Illicit Drug Reporting System (IDRS). Sydney: National Drug and Alcohol Research Centre; 2011.
25. DEA. STRIDE surveillance system. New York: United States Drug Enforcement Administration; 2011.

26. UNODC. World Drug Report 2010. Vienna: United Nations Office on Drugs and Crime; 2010.
27. ONDCP. Coca in the Andes. Washington, D.C.: Office of National Drug Control Policy; 2011.
28. Caulkins JP. Comment: Should the DEA's STRIDE data be used for economic analyses of markets for illegal drugs? J Am Statistical Assoc. 2001; **96**(456): 1263-4.
29. Manski CF, Pepper J, Petrie C. Informing America's policy on illegal drugs: What we don't know keeps hurting us: National Academies Press; 2001.
30. EMCDDA. Europol 2010 annual report on the implementation of council decision 2005/387/JHA. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2010.
31. Degenhardt L, Chiu W-T, Sampson N, Kessler RC, Anthony JC, Angermeyer M, et al. Toward a global view of alcohol, tobacco, cannabis, and cocaine use: Findings from the WHO World Mental Health Surveys. PLOS Medicine. 2008; **5**(7): 1053-67.

Table 1: Major Illegal Drug Data Surveillance Systems

Surveillance system	Country/ Region	Inception Date	Illegal drugs considered			Outcomes considered				Summary of findings
			cannabis	cocaine	heroin	Price	Purity	Use	Seizures	
University of Mississippi Marijuana Project	USA	1975 -	X				X			Cannabis potency increased between 1990 and 2009.
STRIDE Surveillance System	USA	1986-	X	X	X	X	X			Price decreased and purity/potency increased across all illegal drugs considered.
UNODC Drug Seizures Database	International	1980 -	X	X	X				X	Seizures of all drugs have increased between 1995 and 2006.
UNODC Annual Reports Questionnaire	International	1990 -	X	X	X	X	X	X		Prices of opiates, cocaine, and cannabis have generally decreased in Europe and the US while purity and potency have increased.
Reitox (EMCDDA database)	Europe	1993 -	X	X	X	X			X	Price of all illegal substances decreased in 2002 to 2007. Cocaine, cannabis, and heroin seizures increased between 2002 and 2007.
Illicit Drug Reporting System	Australia	2000 -	X	X	X	X	X		X	Between 2000 and 2010, the price of cocaine, cannabis and heroin decreased, while perceived purity remained stable.
National Drug Threat Assessment	USA	2001 -	X	X	X	X			X	Between 2005 and 2009, cocaine purity decreased whereas price increased.

Note: STRIDE: System To Retrieve Information from Drug Evidence, EU = European Union, EC = European Commission; EMCDDA = European Monitoring Centre For Drugs and Drug Addiction; UNODC = United Nations Office of Drug Control

British Columbia Centre *for* Excellence *in* HIV/AIDS

Providence Health Care, St. Paul's Hospital, The University of British Columbia and The Ministry of Health, British Columbia, Canada

April 17, 2013

Dr. Trish Groves
BMJ Open Editorial Office
BMA House
Tavistock Square
London, WC1H 9JR
UK

Dear Dr. Groves and Colleagues:

As you are surely aware, there has been an increasing focus by scientists and policymakers on evaluating the effectiveness of law enforcement-based interventions for controlling illicit drugs. However, despite a wealth of governmental surveillance data on indicators of drug supply (e.g., the price and purity of illicit drugs), few published studies subject these data to longitudinal analyses. As such, the enclosed manuscript presents analyses of international trends in the supply of major illicit drugs over the past two decades, as measured through governmental surveillance data on the price and purity of illicit drugs, as well as on levels of illicit drug seizures in major drug production zones and destination markets.

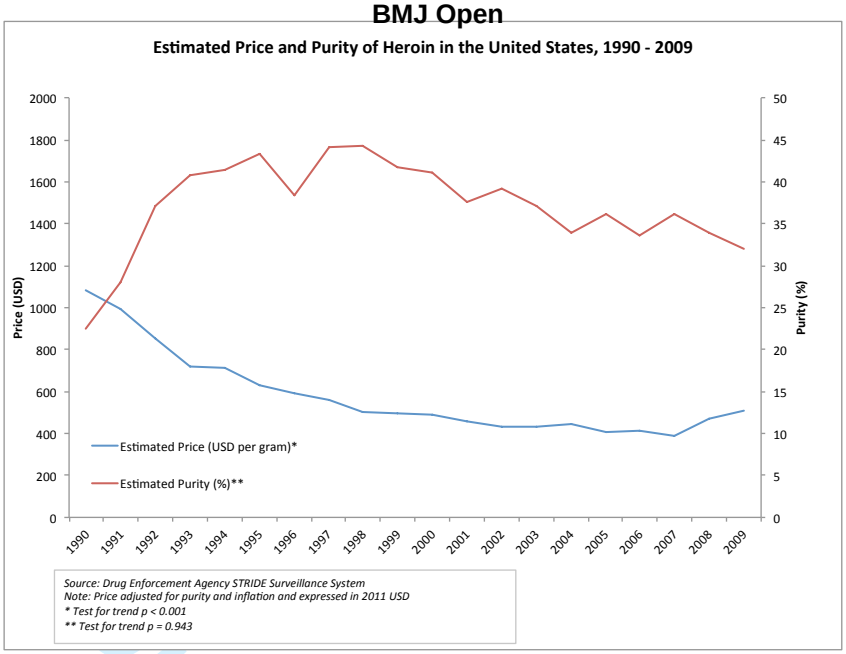
Given the current international debate regarding the effectiveness of current drug policy approaches, we believe that the publication of the enclosed manuscript will be of high interest to your readership. As is customary, this letter will certify that the enclosed article is not being considered for publication elsewhere. This letter also certifies if the enclosed manuscript is acceptable, we will turn copyright over to *BMJ Open*.

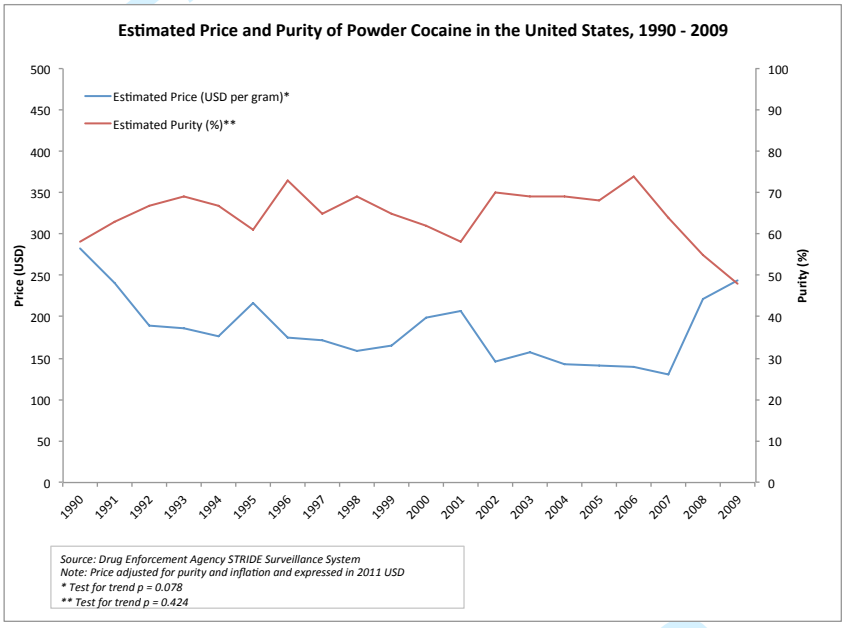
Thank you for your consideration.

Yours sincerely,

Evan Wood

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia
Director, Urban Health Research Initiative
BC Centre for Excellence in HIV/AIDS
CANADA





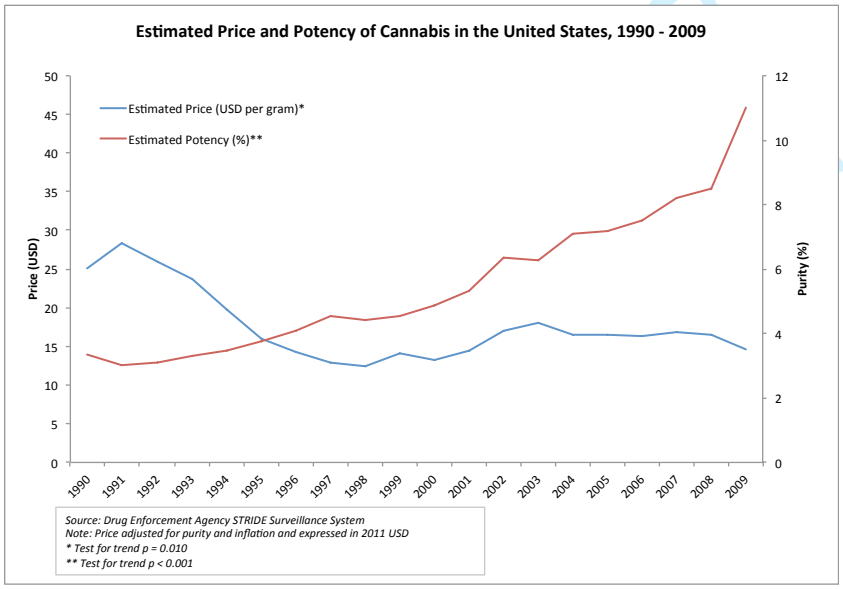
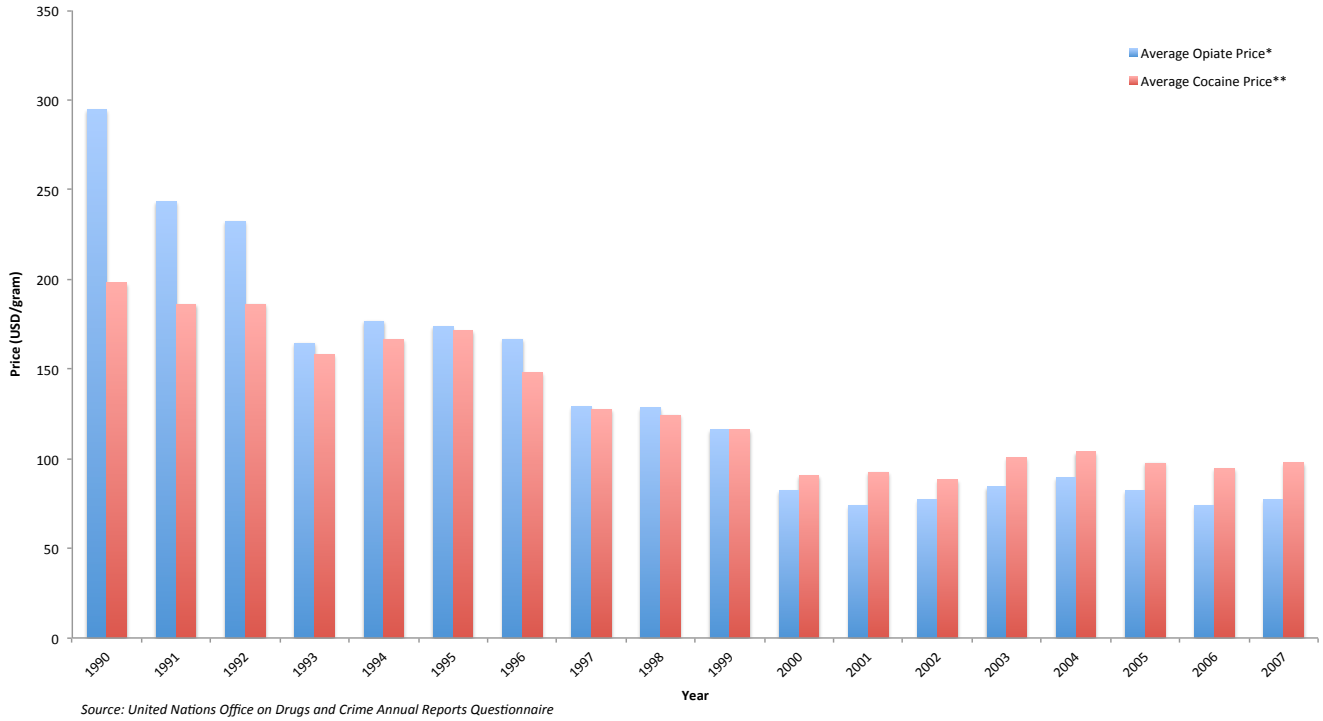


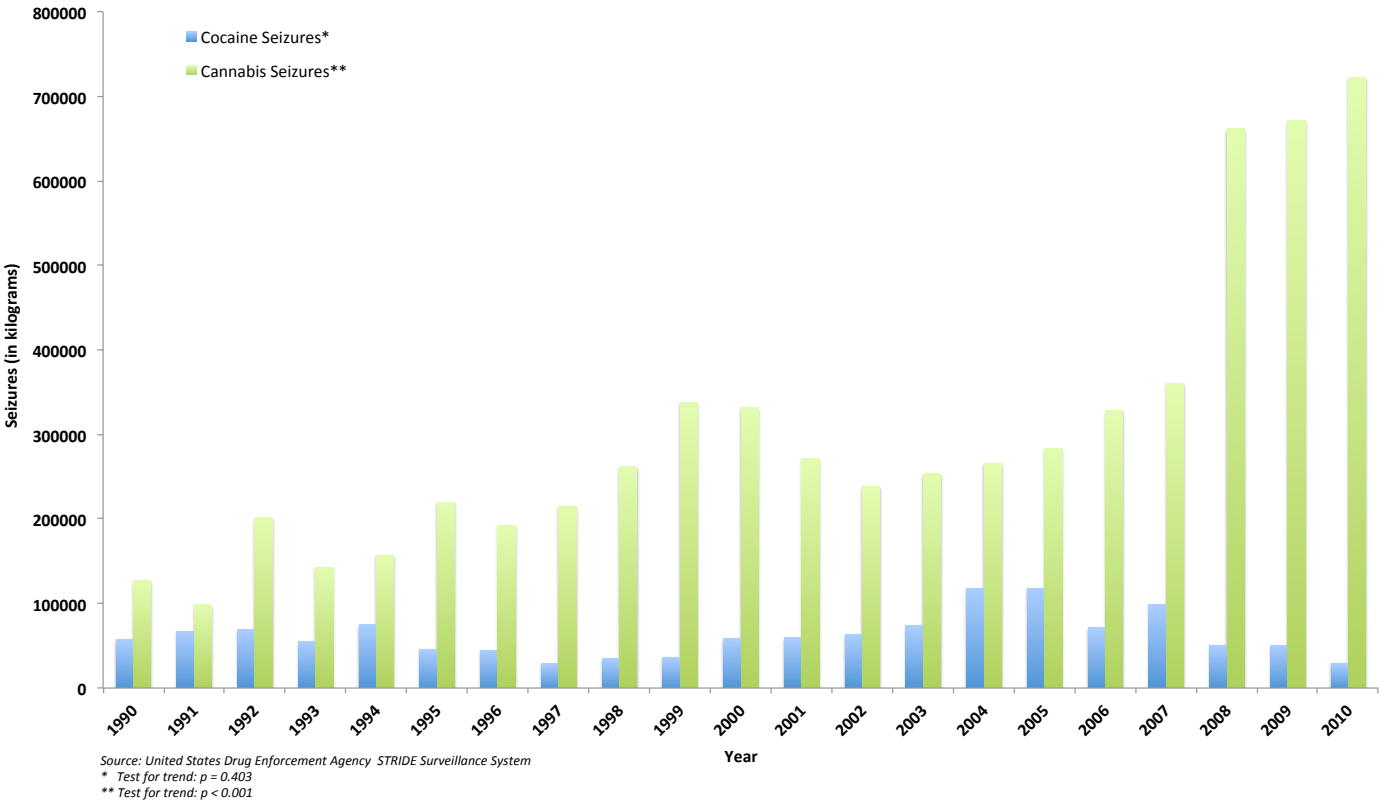
Figure 1. Estimated Price and Purity of Heroin, Cocaine and Cannabis in the United States, 1990 – 2009

Figure 2. Average Inflation-Adjusted Price of Opiates and Cocaine in Europe, 1990 - 2007



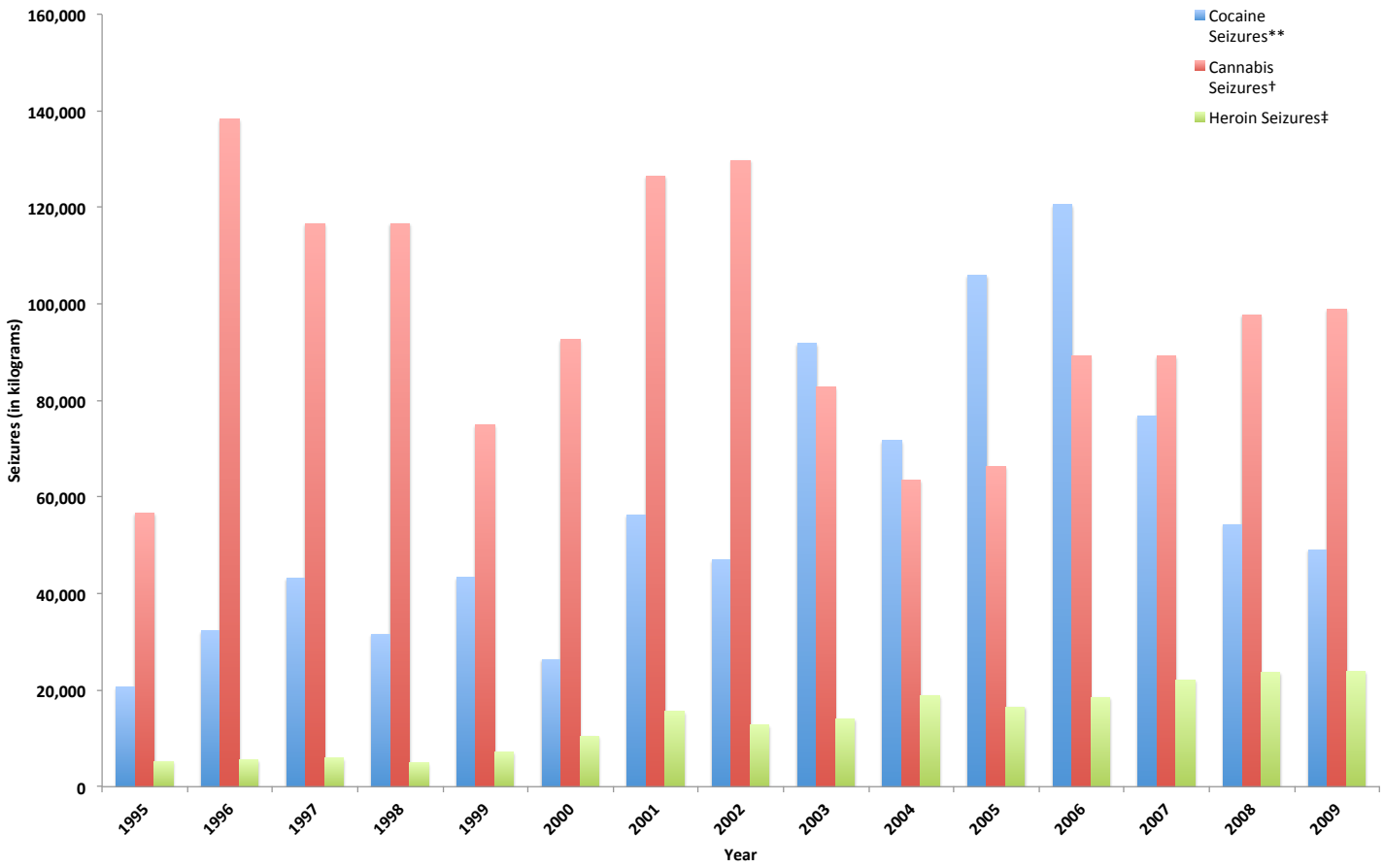
Source: United Nations Office on Drugs and Crime Annual Reports Questionnaire
Note: Price adjusted for CPI inflation
** Test for trend: p < 0.001*
*** Test for trend: p < 0.001*

Figure 3. Cocaine and Cannabis Seizures in the United States, 1990 - 2010



Source: United States Drug Enforcement Agency STRIDE Surveillance System
** Test for trend: p = 0.403*
*** Test for trend: p < 0.001*

Figure 4. Cocaine, Cannabis and Heroin Seizures in Europe*, 1990 - 2010



Source: European Monitoring Centre for Drugs and Drug Addiction REITOX Network
** Refers to European Union member countries, Croatia, Norway, and Turkey*
*** Test for trend: p = 0.018*
† Test for trend: p = 0.446
‡ Test for trend: p < 0.001

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-003077.R1
Article Type:	Research
Date Submitted by the Author:	07-Jun-2013
Complete List of Authors:	Werb, Dan; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Kerr, Thomas; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Nosyk, Bohdan; BC Centre for Excellence in HIV/AIDS, Strathdee, Steffanie; University of California San Diego, Medicine Montaner, Julio; BC Centre for Excellence in HIV/AIDS, Wood, Evan; BC Centre for Excellence in HIV/AIDS,
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health policy, Public health
Keywords:	AUDIT, Public health < INFECTIOUS DISEASES, PUBLIC HEALTH

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Dan Werb; Thomas Kerr; Bohdan Nosyk; Steffanie Strathdee; Julio Montaner; Evan Wood

Dan Werb, Senior Research Assistant, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Thomas Kerr, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Bohdan Nosyk, Research Scientist, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Steffanie Strathdee, Associate Dean of Global Health Sciences, University of California San Diego, Institute of the Americas, 10111 N. Torrey Rd., La Jolla, CA, USA, 92093-0507

Julio Montaner, Director, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Evan Wood, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Send correspondence to:

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia

BC Centre for Excellence in HIV/AIDS
608-1081 Burrard Street, Vancouver, B.C. V6Z 1Y6
CANADA

Tel: (604) 806-9116
Fax: (604) 806-9044
Email: uhri-ew@cfenet.ubc.ca

Word Count: 2,575
Tables: 1
Figures: 4

Revised: June 7, 2013
Printed: June 7, 2013

ABSTRACT

Objectives: Illegal drug use continues to be a major threat to community health and safety. We used international drug surveillance databases to assess the **relationship between multiple** long-term estimates of illegal drug price and purity.

Design: We systematically searched for longitudinal measures of illegal drug supply indicators to assess the long-term impact of enforcement-based supply reduction interventions.

Setting: Data from identified illegal drug surveillance systems were analysed using an *a priori* defined protocol in which we sought to present annual estimates beginning in 1990. Data were then subjected to trend analyses.

Main Outcome Measures: Data were obtained from government surveillance systems assessing price, purity, and/or seizure quantities of illegal drugs; systems with at least 10 years of longitudinal data assessing price, purity/potency, or seizures were included.

Results: We identified 7 regional/international meta-surveillance systems with longitudinal measures of price or purity/potency that met eligibility criteria. In the United States, the average inflation- and purity-adjusted prices of heroin, cocaine, and cannabis decreased by 81%, 80% and 86% respectively between 1990 and 2007, whereas average purity increased by 60%, 11%, and 161% respectively. Similar trends were observed in Europe, where during the same period the average inflation-adjusted price of opiates and cocaine decreased by 74% and 51% respectively. In Australia, the average inflation-adjusted price of cocaine decreased 14%, while the inflation-adjusted price of heroin and cannabis both decreased 49% between 2000 and 2010. During this time, seizures of these drugs in major production regions and major domestic markets generally increased.

Conclusions: With few exceptions and despite increasing investments in enforcement-based supply reduction efforts aimed at disrupting global drug supply, illegal drug prices have generally decreased while drug purity has generally increased since 1990. These findings suggest that expanding efforts at controlling the global illegal drug market through law enforcement are failing.

Word count: 300

Article Summary

Article focus

- Studies have demonstrated that illegal drug use remains a threat to community health and safety.
- However, less is known regarding the long-term impact of efforts to reduce the overall supply of illegal drugs.

Key messages

- Using longitudinal governmental surveillance data, this study demonstrates that over the past two decades, the supply of major illegal drugs has increased, as measured through a general decline in the price, and a general increase in the purity of illegal drugs in a variety of settings.

Strengths and limitations

- This study was limited by the quality and consistency of surveillance data on illegal drug supply
- This study presents data on trends in illegal drug supply in a variety of settings **over two decades**, including consumer and export drug markets

OBJECTIVES

The United Nations (UN) recently estimated that the global illegal drug trade is worth at least $350 billion USD annually,[1] and illegal drug use remains a major threat to community health and safety.[2, 3] In addition to the range of harms associated with the direct health effects of drugs, including fatal overdose,[4, 5] illegal drug use is also one of the key global drivers of blood borne disease transmission, in particular human immunodeficiency virus (HIV) infection.[6, 7] Illegal drug markets also contribute to community concerns such as high rates of violence in settings where the trade proliferates.[8]

In response to the health and social concerns associated with illegal drug use, several UN conventions were created to control the possession, consumption, and manufacture of illegal drugs.[9-11] As a result, over the last several decades, most national drug control strategies have prioritized drug law enforcement interventions to reduce drug supply, despite recent calls by experts to explore alternative models of drug control such as systems of drug decriminalization and legal regulation.[12-14] Some unintended consequences of this approach, such as record incarceration rates, have been well-documented.[15-18] Additionally, a small number of studies assessing aspects of drug supply, measured through indicators of drug price, purity/potency and seizures, have been undertaken to describe the global relationship between these indicators over the long-term.[19] However, systematic evaluation of these relationships is still needed to elucidate patterns of drug supply. The present study therefore sought to systematically identify international data from publicly available illegal drug surveillance systems to assess long-term estimates of illegal drug supply.

DESIGN

Outcomes of interest

The primary outcomes of interest were long-term patterns of illegal drug supply, measured through indicators of price and purity/potency for three major illegal drugs: cannabis, cocaine, and opiates (e.g., opium and heroin). While data on amphetamine-type stimulants exist in some specific countries (e.g., the United Kingdom), this class of drugs was not included given inconsistent data collection and classification, and fluctuating surveillance periods and overall data quality. A secondary outcome of interest was data on illegal drug seizures in a) major illegal drug source regions and, b) major destination markets, as identified by the United Nations Office on Drugs and Crime (UNODC).[20] These secondary outcome data were used as an additional proxy measure to assess the availability of illegal drugs in specific regions, as has been done previously.[21, 22] All outcomes were systematically identified through publicly available illegal drug surveillance systems. Linear by linear association trend tests were carried out on annualized estimates of all outcomes of interest. All price estimates are expressed in 2011 USD and are, where possible, adjusted for purity.[23]

Illegal drug surveillance systems

An online search of surveillance systems monitoring illegal drugs using two *a priori* defined inclusion criteria was carried out. First, because we specifically sought to assess the long-term impact of enforcement-based supply reduction strategies on illegal drug price and purity/potency, only surveillance systems that included continuous longitudinal assessments of these outcomes of interest for at least 10 years were prioritized for inclusion. Second, data

extraction was restricted to 1990 and onwards to focus on patterns of supply during recent decades.

Data were obtained through systematic searches of registries of surveillance systems (e.g., governmental websites, United Nations databases), governmental reports, and peer-reviewed publications, as well as through data requests to relevant organizations including the UNODC. All authors had complete access to all data and all had final responsibility to submit for publication. Ethics approval was not required given that we relied exclusively on publicly available data.

RESULTS

We identified 7 government surveillance systems that met inclusion criteria. Of these, 3 (43%) reported on international data, 3 (43%) reported on data from the United States (US), and 1 (14%) reported on data from Australia. One of the longest-running surveillance system identified, the US-based Marijuana Potency Monitoring Project, is funded by the U.S. National Institutes of Health and was established in 1975, while the most recent surveillance system was established in 2001 (e.g., the US-based *National Drug Threat Assessment*). With respect to international surveillance systems, the UNODC administers two separate surveillance systems that collect data from all participating United Nations member states: the Annual Reports Questionnaire surveillance system that collects price and purity/potency data, and the Drug Seizures Database that collects seizure data. Finally, the European Monitoring Centre for Drugs and Drug Addiction administers the Reitox drug surveillance system network, which

aggregates data from a number of country-level surveillance systems in Europe, as described below.[24]

Price and Purity/Potency

Table 1 presents surveillance systems that matched search criteria. An assessment of data provided by these surveillance systems demonstrated a number of broad trends. First, purity and/or potency of illegal drugs generally remained stable or increased overall during the study period. Second, the price of illegal drugs, with few exceptions, generally decreased. Third, seizures of cannabis, cocaine and opiates generally increased in major drug production regions and major domestic markets.

Figure 1 presents data from the US Drug Enforcement Administration's System To Retrieve Information from Drug Evidence (STRIDE). As can be seen, between 1990 and 2007 (the last year for which data are publicly available), the purity of heroin and cocaine, and the potency of cannabis herb in the US increased, while the inflation- and purity-adjusted retail street prices of these three drugs declined.[25] Specifically, heroin purity increased by 60% (p = 0.568), cocaine purity increased by 11% (p = 0.181), and cannabis herb potency increased by 161% (p < 0.001) during this time. During the same period, the prices of heroin, cocaine, and cannabis decreased 81% (p < 0.001), 80% (p < 0.001), and 86% (p < 0.001) respectively.

Figure 2 presents data collected by the UNODC on the street price of cocaine and opiates in participating European countries (i.e., Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Iceland, Portugal, Spain, Sweden, Switzerland, United Kingdom, and

Ireland).[26] In these countries, between 1990 and 2009, the aggregate average retail street price of cocaine decreased by 51%, from $198 USD per gram to $98 USD per gram ($p < 0.001$). Similarly, the aggregate average price of opiates in Europe decreased 74%, from a high of $295 USD per gram in 1990 to $77 USD per gram in 2009 ($p < 0.001$).

Data from the Australian Illicit Drug Reporting System (IDRS) were available from 2000 to 2010. IDRS data suggest that the price of illegal drugs in Australia fluctuated substantially during this period. Specifically, after adjustment, the price of heroin decreased by 49%, from approximately $460 USD per gram to approximately $235 per gram ($p < 0.001$), despite the well-described heroin 'drought' of 2001,[27] which saw a reduction in the supply and availability of heroin in Australia. Additionally, the price of cocaine decreased 14% from approximately $255 AUD per gram to $220 AUD per gram ($p = 0.477$), and the price of cannabis decreased 49% from approximately $25 AUD per gram to $13 AUD per gram ($p < 0.001$).[28]

Seizures

Domestic Markets

Figure 3 presents data on cannabis and cocaine seizures in the US between 1990 and 2010. As shown, data from the US Drug Enforcement Administration's STRIDE surveillance system demonstrate that the amount of cannabis herb seized by the Drug Enforcement Administration both in, and destined for, the US rose 465%, from approximately 130,000 kilograms in 1990 to approximately 720,000 kilograms in 2010 ($p < 0.001$). During this same period, despite fluctuations, the amount of cocaine seized by the US Drug Enforcement

Administration decreased 49%, from approximately 57,000 kilograms in 1990 to 29,000 in 2010 (p = 0.409), while the amount of heroin seized increased 29% from approximately 535 kilograms in 1990 to 690 kilograms (p = 0.979, heroin seizure data not shown).[29]

Figure 4 presents data on cannabis, cocaine and heroin seizures in countries participating in the European Monitoring Centre for Drugs and Drug Addiction's Reitox surveillance network (i.e., European Union member countries, as well as Croatia, Norway, and Turkey), between 1995 and 2009. As can be seen, annual estimates of the quantity of both cocaine and cannabis herb seized fluctuated throughout this period; however, the quantity of heroin seized increased relatively steadily. Specifically, the number of kilograms of cannabis herb seized was at a low of approximately 57,000 kilograms in 1995, and peaked one year later in 1996 at approximately 138,000 kilograms (p = 0.446). The number of cocaine seizures was at a low of approximately 21,000 kilograms in 1995, and peaked at approximately 121,000 kilograms in 2006 (p = 0.018). Finally, the number of kilograms of heroin seized increased 380% from a low of approximately 5,000 in 1995 to a high of approximately 24,000 in 2009 (p < 0.001).

Production Regions

With respect to opiate seizures, the Golden Triangle includes parts of Thailand, Lao, Viet Nam and Myanmar, and according to the UNODC, this region is the second largest supplier of heroin globally, though production has declined throughout the last decade, with opium production decreasing by approximately 60% and 90% in Myanmar and Lao, respectively.[30] In this region, trends in

seizures of opium have fluctuated; 3,198 kilograms of opium were seized in 1990, with a high of 12,462 kilograms seized in 2007 before a steep decline to 1,225 kilograms in 2010 (p = 0.856). Similarly, seizures of heroin fluctuated, with a decrease of more than half, from 1,337 kilograms in 1990, to 627 kilograms in 2010 (p = 0.085), and a peak of 1,565 kilograms seized in 2009. In Afghanistan, which is believed to supply over 90% of the world's opium,[30] seizures of raw and prepared opium increased by over 12,000%, from 453 kilograms in 1990 to 57,023 kilograms in 2010, and seizures of heroin increased by over 600%, from 1,256 kilograms in 1990 to 9,036 kilograms in 2010 (Note: missing data prevented a trend test for annual opium and heroin seizures in Afghanistan).

With respect to cocaine seizures, according to the UNODC, Latin America's Andean region, which includes Peru, Bolivia, and Colombia, is the primary global supplier of this drug, as coca leaf is grown exclusively in this region.[31] While seizures of cocaine in the Andean region decreased 81%, from 97,437 kilograms in 1990 to 17,835 kilograms in 2007 (p = 0.028), seizures of coca leaf increased 188% from 601,038 kilograms in 1990 to 1.73 million kilograms in 2007 (p = 0.004). During the same period, the area of coca cultivation in this region declined slightly, from approximately 210,000 hectares to 180,000 hectares (p = 0.004).

Finally, according to the UNODC, major areas of cannabis cultivation exist in North Africa, Afghanistan, and North America. These areas are net exporters of cannabis, though most cannabis-producing countries also produce the drug for internal consumption.[20] In North Africa (i.e., Algeria, Morocco, and Tunisia), seizures of cannabis herb increased by 208% from 67,930 kilograms in 1990 to

209,445 kilograms in 2007 (p = 0.015). In North America (i.e., Canada, the United States, and Mexico), seizures of cannabis herb increased by 288% from 782,607 kilograms in 1990 to 3.05 million kilograms in 2007 (p < 0.001). In Afghanistan, while data on cannabis herb seizures are not available, seizures of cannabis resin increased 630% from 5,068 kilograms in 1990 to 36,972 kilograms in 2006 (p = 0.061).

CONCLUSIONS

Longitudinal data from government surveillance systems demonstrate that over the past two decades there has been a general pattern of increased illegal drug supply as defined through lower price and higher purity of heroin, cocaine and cannabis. During the same period, patterns of drug seizures either increased or remained stable, though the trends detected in some of these indicators did not reach statistical significance. As such, we conclude, consistent with previous studies,[19] that the global supply of illicit drugs has likely not been reduced in the previous two decades. In particular, the data presented in this study suggest that the supply of opiates and cannabis, in particular, have increased, given the increasing potency and decreasing prices of these illegal commodities. These results have implications for the development of evidence-based drug policies, particularly given the interest in novel drug policy approaches in a number of settings in Latin America, North America, and Europe.[32-34]

As noted elsewhere,[35, 36] there are limitations of ecologic analyses based on international surveillance systems. First, some states collect little or no data

on indicators of illegal drug supply, whereas other states spend significant energy on monitoring drug availability. Second, even in states that closely track indicators of supply, the degree to which seized samples of illegal drugs reflect purity of retail drugs sold on the street is subject to variation, though where possible we presented purity-adjusted prices to address this limitation.[23] Nevertheless, the long-term trends in increasing purity and decreasing price presented here likely reflect overall trends in many regions, though it should be noted that in some regions (e.g., Europe), indicators of price and purity may have been strongly influenced by a few countries such as the United Kingdom and Spain. Additionally, some exceptions in the trends were observed. Australia for instance, while experiencing a significant decrease in the prices of both heroin and cannabis, did not experience a significant decrease in the price of cocaine, which may reflect the geographic isolation of the region or other market factors. It is also of note that Australia's 'heroin drought',[37] which saw a sudden drop in measures of the supply and availability of heroin, appears to have had a limited long-term impact on supply, though some experts suggest that it may have resulted in higher levels of polysubstance use among Australian heroin injectors.[27] Third, limitations in longitudinal data collection precluded our ability to include amphetamine-type stimulants and other emerging synthetic substances, as this data is limited to certain countries and the focus of this study was on regional trends. It is noteworthy in this regard that the production of synthetic substances – as well as indoor cannabis cultivation – present particular challenges for supply reduction strategies, given that these drugs can be mass produced in clandestine locations regardless of climate or other factors that limit

traditional drug production.[20, 38] Finally, while this review focused on patterns of price and purity of selected illegal drugs, these measures are only a marker of drug supply, and do not measure other factors determining availability and concomitant rates of drug use. These limitations to assessing global drug supply using classic proxy measures such as price, purity, and, to a lesser extent, seizures, suggests that there may be a need to expand the range of measures systematically collected by governments and international bodies such as the UNODC and the European Monitoring Centre for Drugs and Drug Addiction. In particular, meaningfully incorporating measures derived from street-level questionnaires of people who use drugs may provide a more reliable metric of supply and availability. Indeed, some bodies, such as Australia's IDRS, collect such data,[28] and this methodological approach should be considered by those coordinating surveillance of illegal drugs. Other bodies have also prioritized emphasizing measures of community health including reduced HIV infections, reduced drug-related violence and reductions in numbers of individuals incarcerated.[39, 40]

In summary, longitudinal illegal drug surveillance systems demonstrate a general global pattern of falling drug prices and increasing drug purity and potency, alongside a relatively consistent pattern of increasing seizures of illegal drugs. Although source data have limitations and there are some exceptions to these trends, these findings should be useful given the current debates and drug policy experimentation under way in Latin America, North America, and Europe.[32-34] It is hoped that this study highlights the need to re-examine the effectiveness of national and international drug strategies that place a

disproportionate emphasis on supply reduction at the expense of evidence-based prevention and treatment of problematic illegal drug use.

Acknowledgments:

The authors would like to thank Deborah Graham, Peter Vann, Katherine Quayle, Samantha MacLean, and Kevin Lutz for their administrative assistance. Dan Werb is supported by the Canadian Institutes of Health Research. Thomas Kerr is supported by the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

Competing interests:

All authors declare that (1) DW, TK, BN, JM and EW have support from the BC Centre for Excellence in HIV/AIDS for their submitted work; SS has support from the Division of Global Public Health, Department of Medicine, University of California, San Diego; (2) DW, TK, BN, SS, and EW have no relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) DW, TK, BN, SS and EW have no non-financial interests that may be relevant to the submitted work. JM has received grants from, served as an ad hoc adviser to, or spoken at events sponsored by Abbott, Argos Therapeutics, Bioject Inc., Boehringer Ingelheim, BMS, Gilead Sciences, GlaxoSmithKline, Hoffmann-La Roche, Janssen-Ortho, Merck Frosst, Panacos, Pfizer Ltd., Schering, Serono Inc., TheraTechnologies, Tibotec (J&J), and Trimeris.

References:

1. Pietschmann T, Walker J. Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes. Vienna: UNODC Studies and Threat Analysis Section, Division for Policy Analysis and Public Affairs; 2011.
2. Jurgens R, Ball A, Verster A. Interventions to reduce HIV transmission related to injecting drug use in prison. Lancet Infect Dis. 2009; **9**(1): 57-66.
3. Beyrer C, Malinowska-Sempruch K, Kamarulzaman A, Kazatchkine M, Sidibe M, Strathdee SA. Time to act: A call for comprehensive responses to HIV in people who use drugsThe Lancet. 2010; **376**(9740): 551-63.
4. Coffin PO, Galea S, Ahern J, Leon AC, Vlahov D, Tardiff K. Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City, 1990-98. Addiction. 2003; **98**(6): 739.
5. Garfield J, Drucker E. Fatal overdose trends in major US cities: 1990 - 1997. Addictions Research and Theory. 2001; **9**(5): 425.
6. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. Lancet. 2008; **372**(9651): 1733-45.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis. 2005; **5**(9): 558-67.
8. Werb D, Rowell G, Guyatt G, Kerr T, Montaner J, Wood E. Effect of drug law enforcement on drug market violence: A systematic review. Int J Drug Pol. 2011; **22**(2): 8.
9. ECOSOC. Convention on Psychotropic Substances, 1971. Vienna: United Nations Economic and Social Council; 1971.
10. ECOSOC. The Single Convention on Narcotic Drugs, 1961. As amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs, 1961. Vienna: United Nations Economic and Social Council; 1972.
11. ECOSOC. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. Vienna: United Nations Economic and Social Council; 1988.

12. Travis A. Home Office rejects decriminalising possession of drugs for personal use. The Guardian. 2011 October 14.
13. Hoeffel J. Federal crackdown on medical pot sales reflects a shift in policy. Los Angeles Times. 2011 October 7.
14. Greenwald G. Drug decriminalization in Portugal: Lessons for creating fair and successful drug policies. Washington, D.C.: Cato Institute; 2009.
15. Warren J, Gelb A, Horowitz J, Riordan J. One in 100: Behind bars in America 2008. Washington, D.C.: The Pew Center on the States; 2008.
16. Farrell G, Clark, K. What does the world spend on criminal justice? Helsinki: The European Institute for Criminal Prevention and Control, affiliated with the United Nations; 2004.
17. Walmsley R. World prison population list. Report. London: International Centre for Prison Studies; 2007.
18. UNODC. World Drug Report 2008. Vienna: United Nations Office on Drugs and Crime; 2008.
19. A report on global illicit drug markets, 1998-2007. Netherlands: European Commission Directorate-General on Justice, Freedom and Security; 2009.
20. UNODC. World Drug Report 2011. Vienna: United Nations Office on Drugs and Crime; 2011.
21. Roberts M, Bewley-Taylor DR, Trace M. Monitoring drug policy outcomes: the measurement of drug-related harm: Beckley Foundation Drug Policy Programme; 2006.
22. Lenke L. An analysis of the significance of supply and market factors for variations in European cannabis use. EMCDDA Monographs. 2008: 293.
23. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alc Depend. 2007; **90**: S61-S8.
24. Hartnoll R. Drug epidemiology in the European institutions: Historical background and key indicators. Bulletin on Narcotics. 2003; **55**(1): 53-72.
25. Fries A, Anthony RW, Cseko Jr. A, Gaither CC, Schulman E. The price and purity of illicit drugs: 1981 - 2007. Alexandria, VA: Institute for Defense Analyses; 2008.

26. UNODC. World Drug Report 2010: Statistical Annex. Vienna: United Nations Office on Drugs and Crime; 2010.
27. Weatherburn D, Jones C, Freeman K, Makkai T. Supply control and harm reduction: lessons from the Australian heroin drought. Addiction. 2003; **98**: 83.
28. Stafford J, Burns L. Australian drug trends 2010: Findings from the Illicit Drug Reporting System (IDRS). Sydney: National Drug and Alcohol Research Centre; 2011.
29. DEA. STRIDE surveillance system. New York: United States Drug Enforcement Administration; 2011.
30. UNODC. World Drug Report 2010. Vienna: United Nations Office on Drugs and Crime; 2010.
31. ONDCP. Coca in the Andes. Washington, D.C.: Office of National Drug Control Policy; 2011.
32. Insulza JM. The drug problem in the Americas. Washington, DC: Organization of American States General Secretariat; 2013.
33. Harkinson J. Marijuana legalization may be unstoppable. Mother Jones. 2013 February 28.
34. EMCDDA. Drug Policy profiles: Portugal. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2011.
35. Caulkins JP. Comment: Should the DEA's STRIDE data be used for economic analyses of markets for illegal drugs? Journal of the American Statistical Association. 2001; **96**(456): 1263-4.
36. Manski CF, Pepper J, Petrie C. Informing America's policy on illegal drugs: What we don't know keeps hurting us: National Academies Press; 2001.
37. Longo MC, Henry-Edwards SM, Humeniuk RE, Christie P, Ali RL. Impact of the heroin'drought'on patterns of drug use and drug-related harms. Drug Alc Rev. 2004; **23**(2): 143-50.
38. EMCDDA. Europol 2010 annual report on the implementation of council decision 2005/387/JHA. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2010.

39. Global Commission on Drug Policy. The War on Drugs and HIV/AIDS: How the criminalization of drug use fuels the global pandemic. Rio de Janeiro: Global Commission on Drug Policy; 2012.

40. Global Commission on Drug Policy. Report of the Global Commission on Drug Policy. Rio de Janeiro: Global Commission on Drug Policy; 2010.

Table 1: Major Illegal Drug Data Surveillance Systems

Surveillance system	Country/ Region	Inception Date	Illegal drugs considered			Outcomes considered				Summary of findings
			cannabis	cocaine	heroin	Price	Purity	Use	Seizures	
University of Mississippi Marijuana Project	USA	1975 -	X				X			Cannabis potency increased between 1990 and 2009.
STRIDE Surveillance System	USA	1986-	X	X	X	X	X			Price decreased and purity/potency increased across all illegal drugs considered.
UNODC Drug Seizures Database	International	1980 -	X	X	X				X	Seizures of all drugs have increased between 1995 and 2006.
UNODC Annual Reports Questionnaire	International	1990 -	X	X	X	X	X	X		Prices of opiates, cocaine, and cannabis have generally decreased in Europe and the US while purity and potency have increased.
Reitox (EMCDDA database)	Europe	1993 -	X	X	X	X			X	Price of all illegal substances decreased in 2002 to 2007. Cocaine, cannabis, and heroin seizures increased between 2002 and 2007.
Illicit Drug Reporting System	Australia	2000 -	X	X	X	X	X		X	Between 2000 and 2010, the price of cocaine, cannabis and heroin decreased, while perceived purity remained stable.
National Drug Threat Assessment	USA	2001 -	X	X	X	X			X	Between 2005 and 2009, cocaine purity decreased whereas price increased.

Note: STRIDE: System To Retrieve Information from Drug Evidence, EU = European Union, EC = European Commission; *EMCDDA = European Monitoring Centre For Drugs and Drug Addiction; UNODC = United Nations Office of Drug Control*

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Dan Werb; Thomas Kerr; Bohdan Nosyk; Steffanie Strathdee; Julio Montaner; Evan Wood

Dan Werb, Senior Research Assistant, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Thomas Kerr, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Bohdan Nosyk, Research Scientist, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Steffanie Strathdee, Associate Dean of Global Health Sciences, University of California San Diego, Institute of the Americas, 10111 N. Torrey Rd., La Jolla, CA, USA, 92093-0507

Julio Montaner, Director, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Evan Wood, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Send correspondence to:

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia

BC Centre for Excellence in HIV/AIDS
608-1081 Burrard Street, Vancouver, B.C. V6Z 1Y6
CANADA

Tel: (604) 806-9116
Fax: (604) 806-9044
Email: uhri-ew@cfenet.ubc.ca

Word Count: 2,575
Tables: 1
Figures: 4

Revised: June 7, 2013
Printed: June 7, 2013

ABSTRACT

Objectives: Illegal drug use continues to be a major threat to community health and safety. We used international drug surveillance databases to assess the **relationship between multiple** long-term estimates of illegal drug price and purity.

Design: We systematically searched for longitudinal measures of illegal drug supply indicators to assess the long-term impact of enforcement-based supply reduction interventions.

Setting: Data from identified illegal drug surveillance systems were analysed using an *a priori* defined protocol in which we sought to present annual estimates beginning in 1990. Data were then subjected to trend analyses.

Main Outcome Measures: Data were obtained from government surveillance systems assessing price, purity, and/or seizure **quantities** of illegal drugs; systems with at least 10 years of longitudinal data assessing price, purity/potency, or seizures were included.

Results: We identified 7 **regional/international meta-**surveillance systems with longitudinal measures of price or purity/potency that met eligibility criteria. In the United States, the average inflation- and purity-adjusted prices of heroin, cocaine, and cannabis decreased by 81%, 80% and 86% respectively between 1990 and 2007, whereas average purity increased by 60%, 11%, and 161% respectively. Similar trends were observed in Europe, where during the same period the average inflation-adjusted price of opiates and cocaine decreased by 74% and 51% respectively. In Australia, the average inflation-adjusted price of cocaine decreased 14%, while the inflation-adjusted price of heroin and cannabis both decreased 49% between 2000 and 2010. During this time, seizures of these drugs in major production regions and major domestic markets generally increased.

Conclusions: With few exceptions and despite increasing investments in enforcement-based supply reduction efforts aimed at disrupting global drug supply, illegal drug prices have generally decreased while drug purity has generally increased since 1990. These findings suggest that expanding efforts at controlling the global illegal drug market through law enforcement are failing.

Word count: 300

Article Summary

Article focus

- Studies have demonstrated that illegal drug use remains a threat to community health and safety.
- However, less is known regarding the long-term impact of efforts to reduce the overall supply of illegal drugs.

Key messages

- Using longitudinal governmental surveillance data, this study demonstrates that over the past two decades, the supply of major illegal drugs has increased, as measured through a general decline in the price, and a general increase in the purity of illegal drugs in a variety of settings.

Strengths and limitations

- This study was limited by the quality and consistency of surveillance data on illegal drug supply
- This study presents data on trends in illegal drug supply in a variety of settings **over two decades**, including consumer and export drug markets

OBJECTIVES

The United Nations (UN) recently estimated that the global illegal drug trade is worth at least $350 billion USD annually,[1] and illegal drug use remains a major threat to community health and safety.[2, 3] In addition to the range of harms associated with the direct health effects of drugs, including fatal overdose,[4, 5] illegal drug use is also one of the key global drivers of blood borne disease transmission, in particular human immunodeficiency virus (HIV) infection.[6, 7] Illegal drug markets also contribute to community concerns such as high rates of violence in settings where the trade proliferates.[8]

In response to the health and social concerns associated with illegal drug use, several UN conventions were created to **control** the possession, consumption, and manufacture of illegal drugs.[9-11] **As a result**, over the last several decades, most national drug control strategies have prioritized drug law enforcement interventions to reduce drug supply, despite recent calls by experts to explore alternative models of drug control **such as systems of drug decriminalization and legal regulation.**[12-14] Some unintended consequences of this approach, such as record incarceration rates, have been well-documented.[15-18] **Additionally, a small number of studies assessing aspects of** drug supply, measured through indicators of drug price, purity/potency and seizures, **have been undertaken to describe the global relationship between these indicators over the long-term.[19] However, systematic evaluation of these relationships is still needed to elucidate patterns of drug supply.** The present study therefore sought to systematically identify international data from

publicly available illegal drug surveillance systems to assess long-term estimates of illegal drug supply.

DESIGN

Outcomes of interest

The primary outcomes of interest were long-term patterns of illegal drug supply, measured through indicators of price and purity/potency for three major illegal drugs: cannabis, cocaine, and opiates (e.g., opium and heroin). **While data on amphetamine-type stimulants exist in some specific countries (e.g., the United Kingdom), this class of drugs was not included given inconsistent data collection and classification**, **and fluctuating surveillance periods and overall data quality**. A secondary outcome of interest was **data on** illegal drug seizures in a) major illegal drug source regions and, b) major destination markets, as identified by the United Nations Office on Drugs and Crime (UNODC).[20] These secondary outcome data were used as an additional proxy measure to assess the availability of illegal drugs in specific regions, as has been done previously.[21, 22] All outcomes were systematically identified through publicly available illegal drug surveillance systems. Linear by linear association trend tests were carried out on annualized estimates of all outcomes of interest. All price estimates are expressed in 2011 USD and are, where possible, adjusted for purity.[23]

Illegal drug surveillance systems

An online search of surveillance systems monitoring illegal drugs using two *a priori* defined inclusion criteria was carried out. First, because we specifically sought to assess the long-term impact of enforcement-based

supply reduction strategies on illegal drug price and purity/potency, only surveillance systems that included continuous longitudinal assessments of these outcomes of interest for at least 10 years were prioritized for inclusion. Second, data extraction was restricted to 1990 and onwards to focus on patterns of supply during recent decades.

Data were obtained through systematic searches of registries of surveillance systems (e.g., governmental websites, United Nations databases), governmental reports, and peer-reviewed publications, as well as through data requests to relevant organizations including the UNODC. All authors had complete access to all data and all had final responsibility to submit for publication. Ethics approval was not required given that we relied exclusively on publicly available data.

RESULTS

We identified 7 government surveillance systems that met inclusion criteria. Of these, 3 (43%) reported on international data, 3 (43%) reported on data from the United States (US), and 1 (14%) reported on data from Australia. **One of the** longest-running surveillance system identified, the US-based Marijuana Potency Monitoring Project, is funded by the U.S. National Institutes of Health and was established in 1975, while the most recent surveillance system was established in 2001 (e.g., the US-based *National Drug Threat Assessment*). With respect to international surveillance systems, the UNODC administers two separate surveillance systems that collect data from all participating United Nations member states: the Annual Reports Questionnaire surveillance system that collects price and purity/potency data, and the Drug Seizures Database that

collects seizure data. Finally, the European Monitoring Centre for Drugs and Drug Addiction administers the Reitox drug surveillance system network, which aggregates data from a number of country-level surveillance systems in Europe, as described below.[24]

Price and Purity/Potency

Table 1 presents surveillance systems that matched search criteria. An assessment of data provided by these surveillance systems demonstrated a number of broad trends. First, purity and/or potency of illegal drugs generally remained stable or increased overall during the study period. Second, the price of illegal drugs, with few exceptions, generally decreased. Third, seizures of cannabis, cocaine and opiates generally increased in major drug production regions and major domestic markets.

Figure 1 presents data from the US Drug Enforcement Administration's System To Retrieve Information from Drug Evidence (STRIDE). As can be seen, between 1990 and 2007 (the last year for which data are publicly available), the purity of heroin and cocaine, and the potency of cannabis **herb** in the US increased, while the inflation- and purity-adjusted **retail street** prices of these three drugs declined.[25] Specifically, heroin purity increased by 60% ($p = 0.568$), cocaine purity increased by 11% ($p = 0.181$), and cannabis **herb** potency increased by 161% ($p < 0.001$) during this time. During the same period, the prices of heroin, cocaine, and cannabis decreased 81% ($p < 0.001$), 80% ($p < 0.001$), and 86% ($p < 0.001$) respectively.

Figure 2 presents data collected by the UNODC on the street price of cocaine and opiates in participating European countries (i.e., Austria, Belgium,

Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Iceland, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Ireland).[26] In these countries, between 1990 and 2009, the aggregate average retail street price of cocaine decreased by 51%, from $198 USD per gram to $98 USD per gram ($p < 0.001$). Similarly, the aggregate average price of opiates in Europe decreased 74%, from a high of $295 USD per gram in 1990 to $77 USD per gram in 2009 ($p < 0.001$).

Data from the Australian Illicit Drug Reporting System (IDRS) were available from 2000 to 2010. IDRS data suggest that the price of illegal drugs in Australia fluctuated substantially during this period. Specifically, after adjustment, the price of heroin decreased by 49%, from approximately $460 USD per gram to approximately $235 per gram ($p < 0.001$)**, despite the well-described heroin 'drought' of 2001,[27] which saw a reduction in the supply and availability of heroin in Australia. Additionally,** the price of cocaine decreased 14% from approximately $255 AUD per gram to $220 AUD per gram ($p = 0.477$), and the price of cannabis decreased 49% from approximately $25 AUD per gram to $13 AUD per gram ($p < 0.001$).[28]

Seizures

Domestic Markets

Figure 3 presents data on cannabis and cocaine seizures in the US between 1990 and 2010. As shown, data from the US Drug Enforcement Administration's STRIDE surveillance system demonstrate that the amount of cannabis herb seized by the Drug Enforcement Administration both in, and destined for, the US rose 465%, from approximately 130,000 kilograms in 1990

to approximately 720,000 kilograms in 2010 ($p < 0.001$). During this same period, despite fluctuations, the amount of cocaine seized by the US Drug Enforcement Administration decreased 49%, from approximately 57,000 kilograms in 1990 to 29,000 in 2010 ($p = 0.409$), while the amount of heroin seized increased 29% from approximately 535 kilograms in 1990 to 690 kilograms ($p = 0.979$, heroin seizure data not shown).[29]

Figure 4 presents data on cannabis, cocaine and heroin seizures in countries participating in the European Monitoring Centre for Drugs and Drug Addiction's Reitox surveillance network (i.e., European Union member countries, as well as Croatia, Norway, and Turkey), between 1995 and 2009. As can be seen, annual estimates of the quantity of both cocaine and cannabis **herb** seized fluctuated throughout this period; however, the quantity of heroin seized increased relatively steadily. Specifically, the number of kilograms of cannabis herb seized was at a low of approximately 57,000 kilograms in 1995, and peaked one year later in 1996 at approximately 138,000 kilograms ($p = 0.446$). The number of cocaine seizures was at a low of approximately 21,000 kilograms in 1995, and peaked at approximately 121,000 kilograms in 2006 ($p = 0.018$). Finally, the number of kilograms of heroin seized increased 380% from a low of approximately 5,000 in 1995 to a high of approximately 24,000 in 2009 ($p < 0.001$).

Production Regions

With respect to opiate seizures, the Golden Triangle includes parts of Thailand, Lao, Viet Nam and Myanmar, and according to the UNODC, this region is the second largest supplier of heroin globally, though production

has declined throughout the last decade, with opium production decreasing by approximately 60% and 90% in Myanmar and Lao, respectively.[30] In this region, trends in seizures of opium have fluctuated; 3,198 kilograms of opium were seized in 1990, with a high of 12,462 kilograms seized in 2007 before a steep decline to 1,225 kilograms in 2010 (*p* = 0.856). Similarly, seizures of heroin fluctuated, with a decrease of more than half, from 1,337 kilograms in 1990, to 627 kilograms in 2010 (*p* = 0.085), and a peak of 1,565 kilograms seized in 2009. In Afghanistan, which is believed to supply over 90% of the world's opium,[30] seizures of raw and prepared opium increased by over 12,000%, from 453 kilograms in 1990 to 57,023 kilograms in 2010, and seizures of heroin increased by over 600%, from 1,256 kilograms in 1990 to 9,036 kilograms in 2010 (Note: missing data prevented a trend test for annual opium and heroin seizures in Afghanistan).

With respect to cocaine seizures, according to the UNODC, Latin America's Andean region, which includes Peru, Bolivia, and Colombia, is the primary global supplier of this drug, as coca leaf is grown exclusively in this region.[31] While seizures of cocaine in the Andean region decreased 81%, from 97,437 kilograms in 1990 to 17,835 kilograms in 2007 (*p* = 0.028), seizures of coca leaf increased 188% from 601,038 kilograms in 1990 to 1.73 million kilograms in 2007 (*p* = 0.004)**. During the same period, the area of coca cultivation in this region declined slightly, from approximately 210,000 hectares to 180,000 hectares (*p* = 0.004).**

Finally, according to the UNODC, major areas of cannabis cultivation exist in North Africa, Afghanistan, and North America. These areas are net exporters of cannabis, though most cannabis-producing countries also produce the drug for internal consumption.[20] In North Africa (i.e., Algeria, Morocco, and Tunisia), seizures of cannabis herb increased by 208% from 67,930 kilograms in 1990 to 209,445 kilograms in 2007 (p = 0.015). In North America (i.e., Canada, the United States, and Mexico), seizures of cannabis herb increased by 288% from 782,607 kilograms in 1990 to 3.05 million kilograms in 2007 (p < 0.001). In Afghanistan, while data on cannabis herb seizures are not available, seizures of cannabis resin increased 630% from 5,068 kilograms in 1990 to 36,972 kilograms in 2006 (p = 0.061).

CONCLUSIONS

Longitudinal data from government surveillance systems demonstrate that over the past two decades there has been a general pattern of increased illegal drug supply as defined through lower price and higher purity of heroin, cocaine and cannabis. During the same period, patterns of drug seizures either increased or remained stable, though the trends detected in some of these indicators did not reach statistical significance. **As such, we conclude, consistent with previous studies,[19] that the global supply of illicit drugs has likely not been reduced in the previous two decades. In particular, the data presented in this study suggest that the supply of opiates and cannabis, in particular, have increased, given the increasing potency and decreasing prices of these illegal commodities. These results have implications for the development of evidence-based drug policies, particularly given the**

interest in novel drug policy approaches in a number of settings in Latin America, North America, and Europe.[32-34]

As noted elsewhere,[35, 36] there are limitations of ecologic analyses based on international surveillance systems. First, some states collect little or no data on indicators of illegal drug supply, whereas other states spend significant energy on monitoring drug availability. Second, even in states that closely track indicators of supply, the degree to which seized samples of illegal drugs reflect purity of retail drugs sold on the street is subject to variation, though where possible we presented purity-adjusted prices to address this limitation.[23] Nevertheless, the long-term trends in increasing purity and decreasing price presented here likely reflect overall trends in many regions, **though it should be noted that in some regions (e.g., Europe), indicators of price and purity may have been strongly influenced by a few countries such as the United Kingdom and Spain. Additionally, some exceptions in the trends were observed.** Australia for instance, while experiencing a significant decrease in the prices of both heroin and cannabis, did not experience a significant decrease in the price of cocaine, which may reflect the geographic isolation of the region or other market factors**. It is also of note that Australia's 'heroin drought',[37] which saw a sudden drop in measures of the supply and availability of heroin, appears to have had a limited long-term impact on supply, though some experts suggest that it may have resulted in higher levels of polysubstance use among Australian heroin injectors.[27] Third, limitations in longitudinal data collection precluded our ability to include amphetamine-type stimulants and other emerging synthetic substances, as this data is**

limited to certain countries and the focus of this study was on regional trends. It is noteworthy in this regard that the production of synthetic substances – as well as indoor cannabis cultivation – present particular challenges for supply reduction strategies, given that these drugs can be mass produced in clandestine locations regardless of climate or other factors that limit traditional drug production.[20, 38] Finally, while this review focused on **patterns of** price and purity of selected illegal drugs, these measures are only a marker of drug supply, and do not measure other factors determining availability and concomitant rates of drug use. **These limitations to assessing global drug supply using classic proxy measures such as price, purity, and, to a lesser extent, seizures, suggests that there may be a need to expand the range of measures systematically collected by governments and international bodies such as the UNODC and the European Monitoring Centre for Drugs and Drug Addiction. In particular, meaningfully incorporating measures derived from street-level questionnaires of people who use drugs may provide a more reliable metric of supply and availability. Indeed, some bodies, such as Australia's IDRS, collect such data,[28] and this methodological approach should be considered by those coordinating surveillance of illegal drugs. Other bodies have also prioritized emphasizing measures of community health including reduced HIV infections, reduced drug-related violence and reductions in numbers of individuals incarcerated.[39, 40]**

In summary, longitudinal illegal drug surveillance systems demonstrate a general global pattern of falling drug prices and increasing drug purity and

potency, alongside a relatively consistent pattern of increasing seizures of illegal drugs. **Although source data have limitations and there are some exceptions to these trends, these findings should be useful given the current debates and drug policy experimentation under way in Latin America, North America, and Europe.[32-34] It is hoped that this study highlights the need to re-examine the effectiveness of national and international drug strategies that place a disproportionate emphasis on supply reduction at the expense of evidence-based prevention and treatment of problematic illegal drug use.**

Acknowledgments:

The authors would like to thank Deborah Graham, Peter Vann, Katherine Quayle, Samantha MacLean, and Kevin Lutz for their administrative assistance. Dan Werb is supported by the Canadian Institutes of Health Research. Thomas Kerr is supported by the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

Competing interests:

All authors declare that (1) DW, TK, BN, JM and EW have support from the BC Centre for Excellence in HIV/AIDS for their submitted work; SS has support from the Division of Global Public Health, Department of Medicine, University of California, San Diego; (2) DW, TK, BN, SS, and EW have no relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) DW, TK, BN, SS and EW have no non-financial interests that may be relevant to the submitted work. JM has received grants from, served as an ad hoc adviser to, or spoken at events sponsored by Abbott, Argos Therapeutics, Bioject Inc., Boehringer Ingelheim, BMS, Gilead Sciences, GlaxoSmithKline, Hoffmann-La Roche, Janssen-Ortho, Merck Frosst, Panacos, Pfizer Ltd., Schering, Serono Inc., TheraTechnologies, Tibotec (J&J), and Trimeris.

References:

1. Pietschmann T, Walker J. Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes. Vienna: UNODC Studies and Threat Analysis Section, Division for Policy Analysis and Public Affairs; 2011.
2. Jurgens R, Ball A, Verster A. Interventions to reduce HIV transmission related to injecting drug use in prison. Lancet Infect Dis. 2009; **9**(1): 57-66.
3. Beyrer C, Malinowska-Sempruch K, Kamarulzaman A, Kazatchkine M, Sidibe M, Strathdee SA. Time to act: A call for comprehensive responses to HIV in people who use drugsThe Lancet. 2010; **376**(9740): 551-63.
4. Coffin PO, Galea S, Ahern J, Leon AC, Vlahov D, Tardiff K. Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City, 1990-98. Addiction. 2003; **98**(6): 739.
5. Garfield J, Drucker E. Fatal overdose trends in major US cities: 1990 - 1997. Addictions Research and Theory. 2001; **9**(5): 425.
6. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. Lancet. 2008; **372**(9651): 1733-45.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis. 2005; **5**(9): 558-67.
8. Werb D, Rowell G, Guyatt G, Kerr T, Montaner J, Wood E. Effect of drug law enforcement on drug market violence: A systematic review. Int J Drug Pol. 2011; **22**(2): 8.
9. ECOSOC. Convention on Psychotropic Substances, 1971. Vienna: United Nations Economic and Social Council; 1971.
10. ECOSOC. The Single Convention on Narcotic Drugs, 1961. As amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs, 1961. Vienna: United Nations Economic and Social Council; 1972.
11. ECOSOC. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. Vienna: United Nations Economic and Social Council; 1988.

12. Travis A. Home Office rejects decriminalising possession of drugs for personal use. The Guardian. 2011 October 14.
13. Hoeffel J. Federal crackdown on medical pot sales reflects a shift in policy. Los Angeles Times. 2011 October 7.
14. Greenwald G. Drug decriminalization in Portugal: Lessons for creating fair and successful drug policies. Washington, D.C.: Cato Institute; 2009.
15. Warren J, Gelb A, Horowitz J, Riordan J. One in 100: Behind bars in America 2008. Washington, D.C.: The Pew Center on the States; 2008.
16. Farrell G, Clark, K. What does the world spend on criminal justice? Helsinki: The European Institute for Criminal Prevention and Control, affiliated with the United Nations; 2004.
17. Walmsley R. World prison population list. Report. London: International Centre for Prison Studies; 2007.
18. UNODC. World Drug Report 2008. Vienna: United Nations Office on Drugs and Crime; 2008.
19. A report on global illicit drug markets, 1998-2007. Netherlands: European Commission Directorate-General on Justice, Freedom and Security; 2009.
20. UNODC. World Drug Report 2011. Vienna: United Nations Office on Drugs and Crime; 2011.
21. Roberts M, Bewley-Taylor DR, Trace M. Monitoring drug policy outcomes: the measurement of drug-related harm: Beckley Foundation Drug Policy Programme; 2006.
22. Lenke L. An analysis of the significance of supply and market factors for variations in European cannabis use. EMCDDA Monographs. 2008: 293.
23. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alc Depend. 2007; **90**: S61-S8.
24. Hartnoll R. Drug epidemiology in the European institutions: Historical background and key indicators. Bulletin on Narcotics. 2003; **55**(1): 53-72.
25. Fries A, Anthony RW, Cseko Jr. A, Gaither CC, Schulman E. The price and purity of illicit drugs: 1981 - 2007. Alexandria, VA: Institute for Defense Analyses; 2008.

26. UNODC. World Drug Report 2010: Statistical Annex. Vienna: United Nations Office on Drugs and Crime; 2010.
27. Weatherburn D, Jones C, Freeman K, Makkai T. Supply control and harm reduction: lessons from the Australian heroin drought. Addiction. 2003; **98**: 83.
28. Stafford J, Burns L. Australian drug trends 2010: Findings from the Illicit Drug Reporting System (IDRS). Sydney: National Drug and Alcohol Research Centre; 2011.
29. DEA. STRIDE surveillance system. New York: United States Drug Enforcement Administration; 2011.
30. UNODC. World Drug Report 2010. Vienna: United Nations Office on Drugs and Crime; 2010.
31. ONDCP. Coca in the Andes. Washington, D.C.: Office of National Drug Control Policy; 2011.
32. Insulza JM. The drug problem in the Americas. Washington, DC: Organization of American States General Secretariat; 2013.
33. Harkinson J. Marijuana legalization may be unstoppable. Mother Jones. 2013 February 28.
34. EMCDDA. Drug Policy profiles: Portugal. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2011.
35. Caulkins JP. Comment: Should the DEA's STRIDE data be used for economic analyses of markets for illegal drugs? Journal of the American Statistical Association. 2001; **96**(456): 1263-4.
36. Manski CF, Pepper J, Petrie C. Informing America's policy on illegal drugs: What we don't know keeps hurting us: National Academies Press; 2001.
37. Longo MC, Henry-Edwards SM, Humeniuk RE, Christie P, Ali RL. Impact of the heroin'drought'on patterns of drug use and drug-related harms. Drug Alc Rev. 2004; **23**(2): 143-50.
38. EMCDDA. Europol 2010 annual report on the implementation of council decision 2005/387/JHA. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2010.

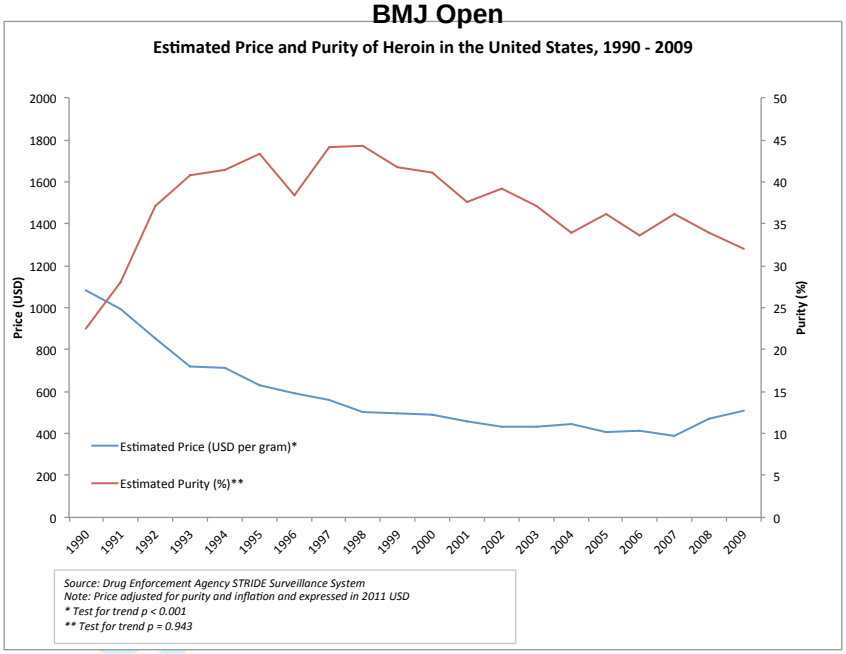
39. Global Commission on Drug Policy. The War on Drugs and HIV/AIDS: How the criminalization of drug use fuels the global pandemic. Rio de Janeiro: Global Commission on Drug Policy; 2012.

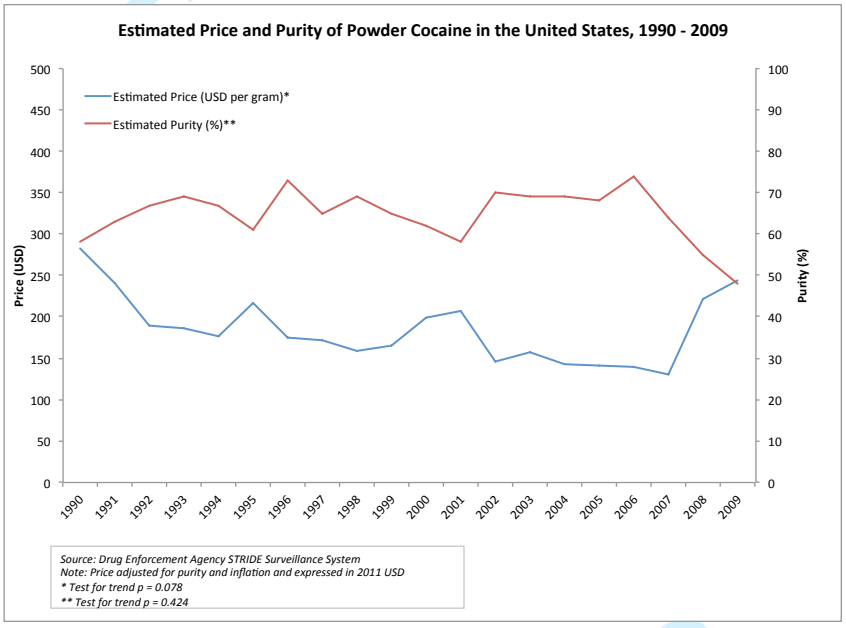
40. Global Commission on Drug Policy. Report of the Global Commission on Drug Policy. Rio de Janeiro: Global Commission on Drug Policy; 2010.

Table 1: Major Illegal Drug Data Surveillance Systems

Surveillance system	Country/ Region	Inception Date	Illegal drugs considered			Outcomes considered				Summary of findings
			cannabis	cocaine	heroin	Price	Purity	Use	Seizures	
University of Mississippi Marijuana Project	USA	1975 -	X				X			Cannabis potency increased between 1990 and 2009.
STRIDE Surveillance System	USA	1986-	X	X	X	X	X			Price decreased and purity/potency increased across all illegal drugs considered.
UNODC Drug Seizures Database	International	1980 -	X	X	X				X	Seizures of all drugs have increased between 1995 and 2006.
UNODC Annual Reports Questionnaire	International	1990 -	X	X	X	X	X	X		Prices of opiates, cocaine, and cannabis have generally decreased in Europe and the US while purity and potency have increased.
Reitox (EMCDDA database)	Europe	1993 -	X	X	X	X			X	Price of all illegal substances decreased in 2002 to 2007. Cocaine, cannabis, and heroin seizures increased between 2002 and 2007.
Illicit Drug Reporting System	Australia	2000 -	X	X	X	X	X		X	Between 2000 and 2010, the price of cocaine, cannabis and heroin decreased, while perceived purity remained stable.
National Drug Threat Assessment	USA	2001 -	X	X	X	X			X	Between 2005 and 2009, cocaine purity decreased whereas price increased.

Note: STRIDE: System To Retrieve Information from Drug Evidence, EU = European Union, EC = European Commission; *EMCDDA = European Monitoring Centre For Drugs and Drug Addiction; UNODC = United Nations Office of Drug Control*





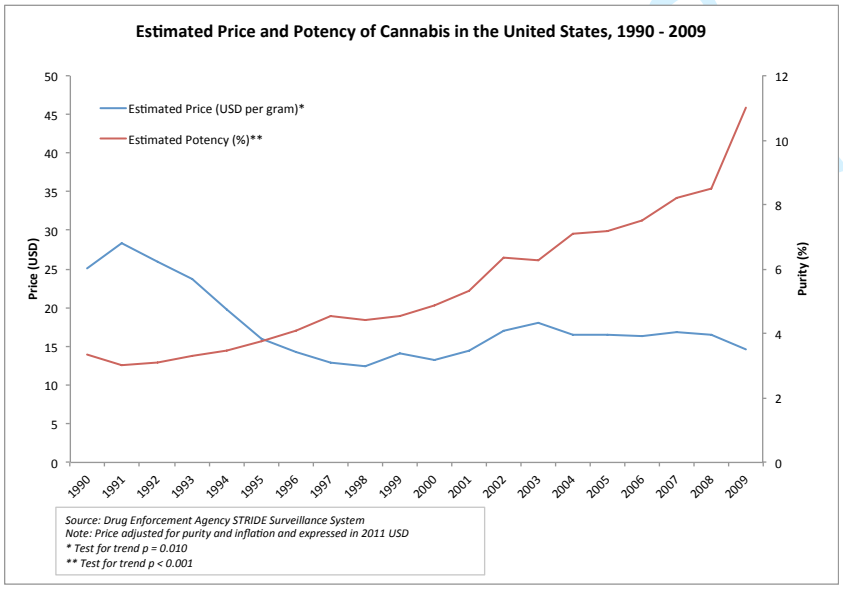
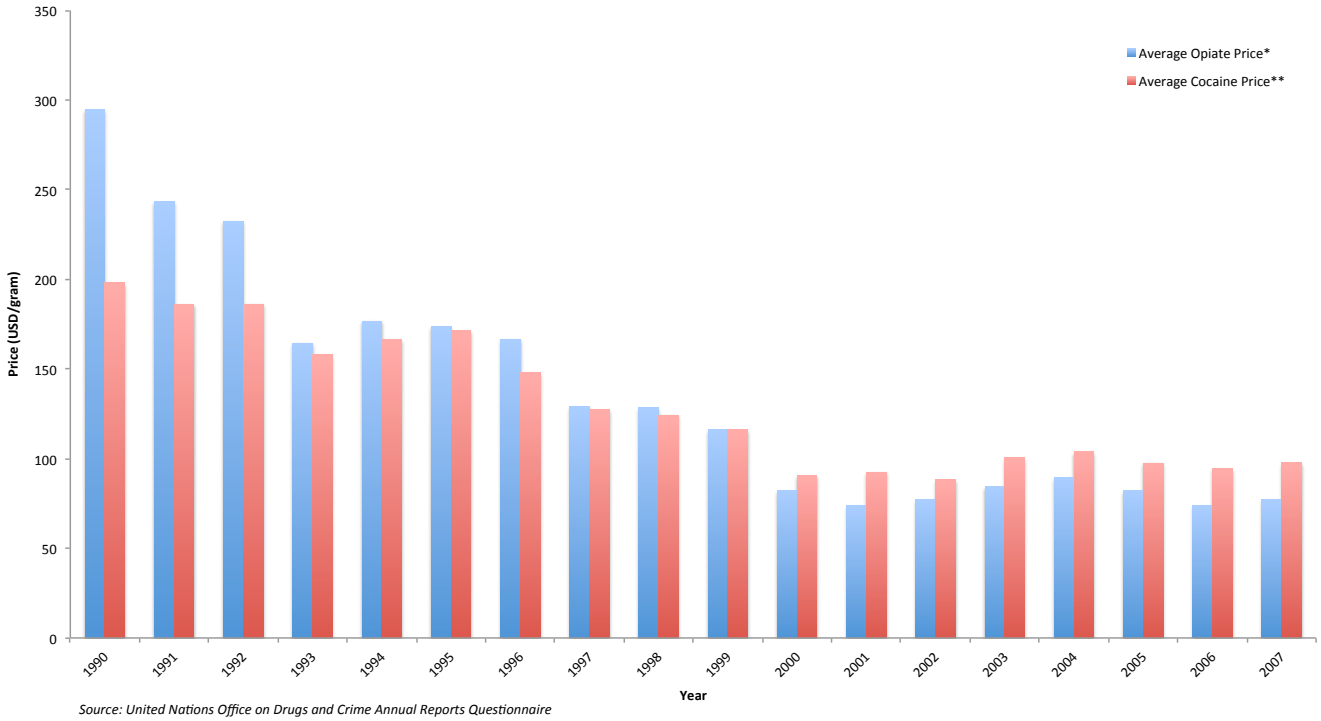


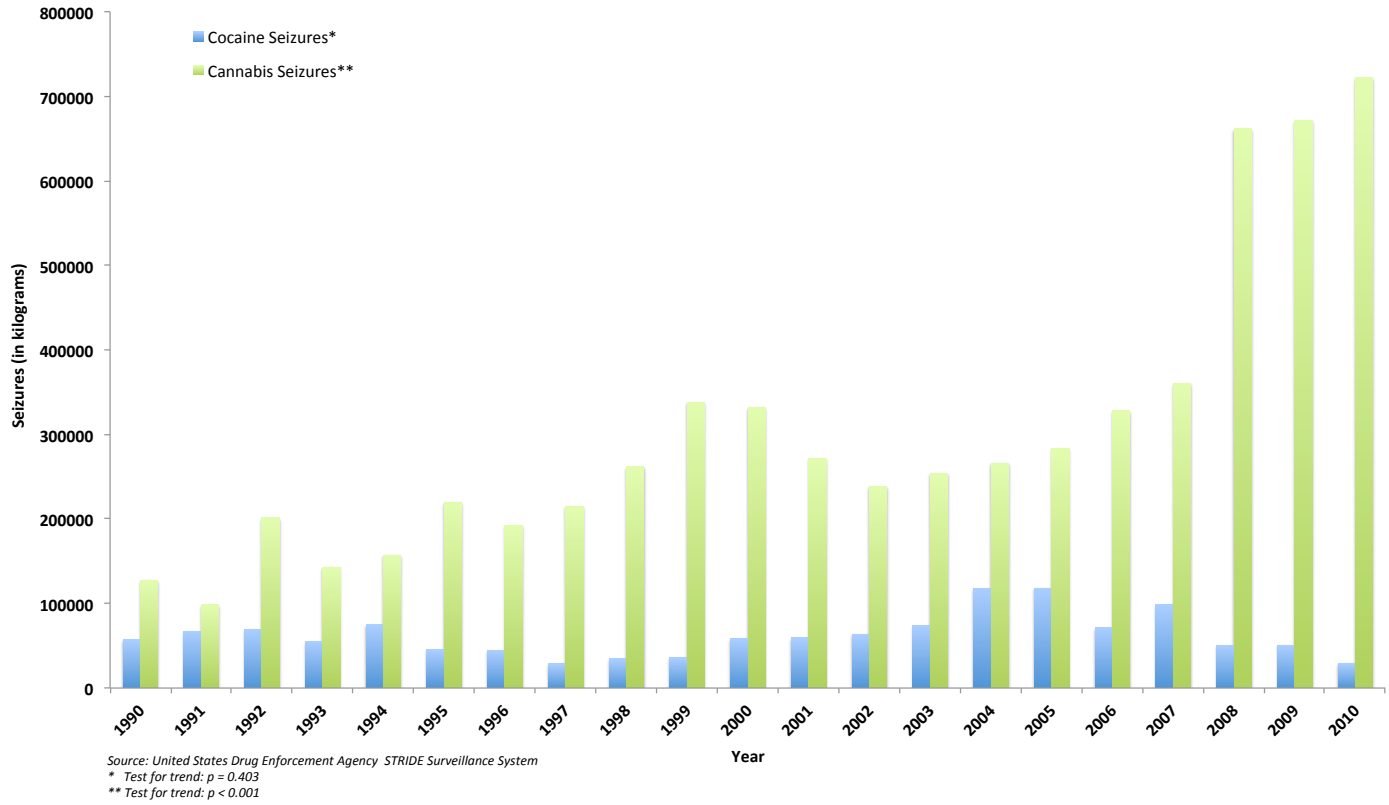
Figure 1. Estimated Price and Purity of Heroin, Cocaine and Cannabis in the United States, 1990 – 2009

Figure 2. Average Inflation-Adjusted Price of Opiates and Cocaine in Europe, 1990 - 2007



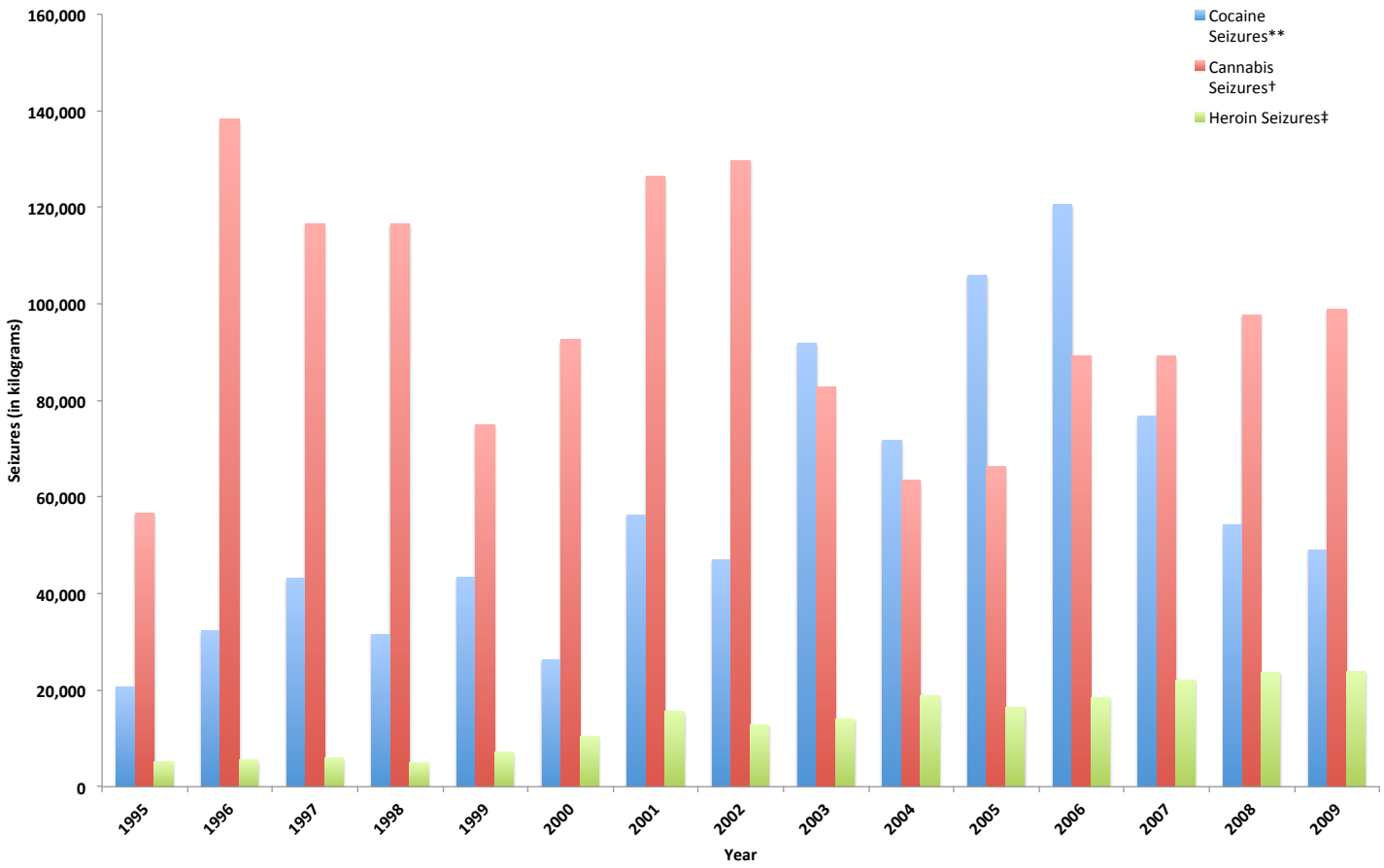
Source: United Nations Office on Drugs and Crime Annual Reports Questionnaire
Note: Price adjusted for CPI inflation
** Test for trend: p < 0.001*
*** Test for trend: p < 0.001*

Figure 3. Cocaine and Cannabis Seizures in the United States, 1990 - 2010



Source: United States Drug Enforcement Agency STRIDE Surveillance System
** Test for trend: p = 0.403*
*** Test for trend: p < 0.001*

Figure 4. Cocaine, Cannabis and Heroin Seizures in Europe*, 1990 - 2010



Source: European Monitoring Centre for Drugs and Drug Addiction REITOX Network
** Refers to European Union member countries, Croatia, Norway, and Turkey*
*** Test for trend: p = 0.018*
† Test for trend: p = 0.446
‡ Test for trend: p < 0.001

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-003077.R2
Article Type:	Research
Date Submitted by the Author:	16-Jul-2013
Complete List of Authors:	Werb, Dan; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Kerr, Thomas; BC Centre for Excellence in HIV/AIDS, Urban Health Research Initiative Nosyk, Bohdan; BC Centre for Excellence in HIV/AIDS, Strathdee, Steffanie; University of California San Diego, Medicine Montaner, Julio; BC Centre for Excellence in HIV/AIDS, Wood, Evan; BC Centre for Excellence in HIV/AIDS,
Primary Subject Heading:	Public health
Secondary Subject Heading:	Health policy, Public health
Keywords:	AUDIT, Public health < INFECTIOUS DISEASES, PUBLIC HEALTH

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Dan Werb; Thomas Kerr; Bohdan Nosyk; Steffanie Strathdee; Julio Montaner; Evan Wood

Dan Werb, Senior Research Assistant, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Thomas Kerr, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Bohdan Nosyk, Research Scientist, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Steffanie Strathdee, Associate Dean of Global Health Sciences, University of California San Diego, Institute of the Americas, 10111 N. Torrey Rd., La Jolla, CA, USA, 92093-0507

Julio Montaner, Director, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Evan Wood, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Send correspondence to:

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia

BC Centre for Excellence in HIV/AIDS
608-1081 Burrard Street, Vancouver, B.C. V6Z 1Y6
CANADA

Tel: (604) 806-9116
Fax: (604) 806-9044
Email: uhri-ew@cfenet.ubc.ca

Word Count: 2,575
Tables: 1
Figures: 4

Revised: July 17, 2013
Printed: July 17, 2013

ABSTRACT

Objectives: Illegal drug use continues to be a major threat to community health and safety. We used international drug surveillance databases to assess the relationship between multiple long-term estimates of illegal drug price and purity.

Design: We systematically searched for longitudinal measures of illegal drug supply indicators to assess the long-term impact of enforcement-based supply reduction interventions.

Setting: Data from identified illegal drug surveillance systems were analysed using an *a priori* defined protocol in which we sought to present annual estimates beginning in 1990. Data were then subjected to trend analyses.

Main Outcome Measures: Data were obtained from government surveillance systems assessing price, purity, and/or seizure quantities of illegal drugs; systems with at least 10 years of longitudinal data assessing price, purity/potency, or seizures were included.

Results: We identified 7 regional/international meta-surveillance systems with longitudinal measures of price or purity/potency that met eligibility criteria. In the United States, the average inflation- and purity-adjusted prices of heroin, cocaine, and cannabis decreased by 81%, 80% and 86% respectively between 1990 and 2007, whereas average purity increased by 60%, 11%, and 161% respectively. Similar trends were observed in Europe, where during the same period the average inflation-adjusted price of opiates and cocaine decreased by 74% and 51% respectively. In Australia, the average inflation-adjusted price of cocaine decreased 14%, while the inflation-adjusted price of heroin and cannabis both decreased 49% between 2000 and 2010. During this time, seizures of these drugs in major production regions and major domestic markets generally increased.

Conclusions: With few exceptions and despite increasing investments in enforcement-based supply reduction efforts aimed at disrupting global drug supply, illegal drug prices have generally decreased while drug purity has generally increased since 1990. These findings suggest that expanding efforts at controlling the global illegal drug market through law enforcement are failing.

Word count: 298

Article Summary

Article focus

- Studies have demonstrated that illegal drug use remains a threat to community health and safety.
- However, less is known regarding the long-term impact of efforts to reduce the overall supply of illegal drugs.

Key messages

- Using longitudinal governmental surveillance data, this study demonstrates that over the past two decades, the supply of major illegal drugs has increased, as measured through a general decline in the price, and a general increase in the purity of illegal drugs in a variety of settings.

Strengths and limitations

- This study was limited by the quality and consistency of surveillance data on illegal drug supply
- This study presents data on trends in illegal drug supply in a variety of settings over two decades, including consumer and export drug markets

OBJECTIVES

The United Nations (UN) recently estimated that the global illegal drug trade is worth at least $350 billion USD annually,[1] and illegal drug use remains a major threat to community health and safety.[2, 3] In addition to the range of harms associated with the direct health effects of drugs, including fatal overdose,[4, 5] illegal drug use is also one of the key global drivers of blood borne disease transmission, in particular human immunodeficiency virus (HIV) infection.[6, 7] Illegal drug markets also contribute to community concerns such as high rates of violence in settings where the trade proliferates.[8]

In response to the health and social concerns associated with illegal drug use, several UN conventions were created to control the possession, consumption, and manufacture of illegal drugs.[9-11] As a result, over the last several decades, most national drug control strategies have prioritized drug law enforcement interventions to reduce drug supply, despite recent calls by experts to explore alternative models of drug control such as systems of drug decriminalization and legal regulation.[12-14] Some unintended consequences of this approach, such as record incarceration rates, have been well-documented.[15-18] Additionally, a small number of studies assessing aspects of drug supply, measured through indicators of drug price, purity/potency and seizures, have been undertaken to describe the global relationship between these indicators over the long-term.[19] However, systematic evaluation of these relationships is still needed to elucidate patterns of drug supply. The present study therefore sought to systematically identify international data from publicly available illegal drug surveillance systems to assess long-term estimates of illegal drug supply.

DESIGN

Outcomes of interest

The primary outcomes of interest were long-term patterns of illegal drug supply, measured through indicators of price and purity/potency for three major illegal drugs: cannabis, cocaine, and opiates (e.g., opium and heroin). While data on amphetamine-type stimulants exist in some specific countries (e.g., the United Kingdom), this class of drugs was not included given inconsistent data collection and classification, and fluctuating surveillance periods and overall data quality. A secondary outcome of interest was data on illegal drug seizures in a) major illegal drug source regions and, b) major destination markets, as identified by the United Nations Office on Drugs and Crime (UNODC).[20] These secondary outcome data were used as an additional proxy measure to assess the availability of illegal drugs in specific regions, as has been done previously.[21, 22] All outcomes were systematically identified through publicly available illegal drug surveillance systems. Linear by linear association trend tests were carried out on **annual** estimates of all outcomes of interest. Price and purity estimates represent median values for each year, while estimates for seizures represent crude totals of quantity seized. All price estimates are expressed in 2011 USD and are, where possible, adjusted for purity.[23]

Illegal drug surveillance systems

An online search of surveillance systems monitoring illegal drugs using two *a priori* defined inclusion criteria was carried out. Search terms included: drugs, illicit, illegal, price, purity, potency, surveillance system, government data, longitudinal, annual, estimate. Inclusion/exclusion criteria were as follows: only

surveillance systems that included continuous longitudinal assessments of these outcomes of interest for at least 10 years were included because we specifically sought to assess the long-term impact of enforcement-based supply reduction strategies on illegal drug price and purity/potency. Finally, data extraction was restricted to 1990 and onwards to focus on patterns of supply during recent decades.

Data were obtained through online searches of registries of surveillance systems (e.g., governmental websites, United Nations databases), governmental reports, and peer-reviewed publications, through referrals from experts in the field, and through data requests to relevant organizations including the UNODC. All authors had complete access to all data and all had final responsibility to submit for publication. Ethics approval was not required given that we relied exclusively on publicly available data.

RESULTS

We identified 7 government surveillance systems that met inclusion criteria. Of these, 3 (43%) reported on international data, 3 (43%) reported on data from the United States (US), and 1 (14%) reported on data from Australia. One of the longest-running surveillance system identified, the US-based Marijuana Potency Monitoring Project, is funded by the U.S. National Institutes of Health and was established in 1975, while the most recent surveillance system was established in 2001 (e.g., the US-based *National Drug Threat Assessment*). With respect to international surveillance systems, the UNODC administers two separate surveillance systems that collect data from all participating United Nations member states: the Annual Reports Questionnaire surveillance system

that collects price and purity/potency data, and the Drug Seizures Database that collects seizure data. Finally, the European Monitoring Centre for Drugs and Drug Addiction administers the Reitox drug surveillance system network, which aggregates data from a number of country-level surveillance systems in Europe, as described below.[24]

Price and Purity/Potency

Table 1 presents surveillance systems that matched search criteria. An assessment of data provided by these surveillance systems demonstrated a number of broad trends. First, purity and/or potency of illegal drugs generally remained stable or increased overall during the study period. Second, the price of illegal drugs, with few exceptions, generally decreased. Third, seizures of cannabis, cocaine and opiates generally increased in major drug production regions and major domestic markets.

Figure 1 presents data from the US Drug Enforcement Administration's System To Retrieve Information from Drug Evidence (STRIDE). As can be seen, between 1990 and 2007 (the last year for which data are publicly available), the purity of heroin and cocaine, and the potency of cannabis herb in the US increased, while the inflation- and purity-adjusted retail street prices of these three drugs declined.[25] Specifically, heroin purity increased by 60% ($p = 0.568$), cocaine purity increased by 11% ($p = 0.181$), and cannabis herb potency increased by 161% ($p < 0.001$) during this time. During the same period, the prices of heroin, cocaine, and cannabis decreased 81% ($p < 0.001$), 80% ($p < 0.001$), and 86% ($p < 0.001$) respectively.

Figure 2 presents data collected by the UNODC on the street price of cocaine and opiates in participating European countries (i.e., Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Iceland, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Ireland).[26] In these countries, between 1990 and 2009, the aggregate average retail street price of cocaine decreased by 51%, from $198 USD per gram to $98 USD per gram ($p < 0.001$). Similarly, the aggregate average price of opiates in Europe decreased 74%, from a high of $295 USD per gram in 1990 to $77 USD per gram in 2009 ($p < 0.001$).

Data from the Australian Illicit Drug Reporting System (IDRS) were available from 2000 to 2010. IDRS data suggest that the price of illegal drugs in Australia fluctuated substantially during this period. Specifically, after adjustment, the price of heroin decreased by 49%, from approximately $460 USD per gram to approximately $235 per gram ($p < 0.001$), despite the well-described heroin 'drought' of 2001,[27] which saw a reduction in the supply and availability of heroin in Australia. Additionally, the price of cocaine decreased 14% from approximately $255 AUD per gram to $220 AUD per gram ($p = 0.477$), and the price of cannabis decreased 49% from approximately $25 AUD per gram to $13 AUD per gram ($p < 0.001$).[28]

Seizures

Domestic Markets

Figure 3 presents data on cannabis and cocaine seizures in the US between 1990 and 2010. As shown, data from the US Drug Enforcement Administration's STRIDE surveillance system demonstrate that the amount of

cannabis herb seized by the Drug Enforcement Administration both in, and destined for, the US rose 465%, from approximately 130,000 kilograms in 1990 to approximately 720,000 kilograms in 2010 ($p < 0.001$). During this same period, despite fluctuations, the amount of cocaine seized by the US Drug Enforcement Administration decreased 49%, from approximately 57,000 kilograms in 1990 to 29,000 in 2010 ($p = 0.409$), while the amount of heroin seized increased 29% from approximately 535 kilograms in 1990 to 690 kilograms ($p = 0.979$, heroin seizure data not shown).[29]

Figure 4 presents data on cannabis, cocaine and heroin seizures in countries participating in the European Monitoring Centre for Drugs and Drug Addiction's Reitox surveillance network (i.e., European Union member countries, as well as Croatia, Norway, and Turkey), between 1995 and 2009. As can be seen, annual estimates of the quantity of both cocaine and cannabis herb seized fluctuated throughout this period; however, the quantity of heroin seized increased relatively steadily. Specifically, the number of kilograms of cannabis herb seized was at a low of approximately 57,000 kilograms in 1995, and peaked one year later in 1996 at approximately 138,000 kilograms ($p = 0.446$). The number of cocaine seizures was at a low of approximately 21,000 kilograms in 1995, and peaked at approximately 121,000 kilograms in 2006 ($p = 0.018$). Finally, the number of kilograms of heroin seized increased 380% from a low of approximately 5,000 in 1995 to a high of approximately 24,000 in 2009 ($p < 0.001$).

Production Regions

With respect to opiate seizures, the Golden Triangle includes parts of Thailand, Lao, Viet Nam and Myanmar, and according to the UNODC, this region is the second largest supplier of heroin globally, though production has declined throughout the last decade, with opium production decreasing by approximately 60% and 90% in Myanmar and Lao, respectively.[30] In this region, trends in seizures of opium have fluctuated; 3,198 kilograms of opium were seized in 1990, with a high of 12,462 kilograms seized in 2007 before a steep decline to 1,225 kilograms in 2010 (p = 0.856). Similarly, seizures of heroin fluctuated, with a decrease of more than half, from 1,337 kilograms in 1990, to 627 kilograms in 2010 (p = 0.085), and a peak of 1,565 kilograms seized in 2009. In Afghanistan, which is believed to supply over 90% of the world's opium,[30] seizures of raw and prepared opium increased by over 12,000%, from 453 kilograms in 1990 to 57,023 kilograms in 2010, and seizures of heroin increased by over 600%, from 1,256 kilograms in 1990 to 9,036 kilograms in 2010 (Note: missing data prevented a trend test for annual opium and heroin seizures in Afghanistan).

With respect to cocaine seizures, according to the UNODC, Latin America's Andean region, which includes Peru, Bolivia, and Colombia, is the primary global supplier of this drug, as coca leaf is grown exclusively in this region.[31] While seizures of cocaine in the Andean region decreased 81%, from 97,437 kilograms in 1990 to 17,835 kilograms in 2007 (p = 0.028), seizures of coca leaf increased 188% from 601,038 kilograms in 1990 to 1.73 million kilograms in 2007 (p = 0.004). During the same period, the area of coca cultivation in this region declined slightly, from approximately 210,000 hectares to 180,000 hectares (p = 0.004).

Finally, according to the UNODC, major areas of cannabis cultivation exist in North Africa, Afghanistan, and North America. These areas are net exporters of cannabis, though most cannabis-producing countries also produce the drug for internal consumption.[20] In North Africa (i.e., Algeria, Morocco, and Tunisia), seizures of cannabis herb increased by 208% from 67,930 kilograms in 1990 to 209,445 kilograms in 2007 (p = 0.015). In North America (i.e., Canada, the United States, and Mexico), seizures of cannabis herb increased by 288% from 782,607 kilograms in 1990 to 3.05 million kilograms in 2007 (p < 0.001). In Afghanistan, while data on cannabis herb seizures are not available, seizures of cannabis resin increased 630% from 5,068 kilograms in 1990 to 36,972 kilograms in 2006 (p = 0.061).

CONCLUSIONS

Longitudinal data from government surveillance systems demonstrate that over the past two decades there has been a general pattern of increased illegal drug supply as defined through lower price and higher purity of heroin, cocaine and cannabis. During the same period, patterns of drug seizures either increased or remained stable, though the trends detected in some of these indicators did not reach statistical significance. As such, we conclude, consistent with previous studies,[19] that the global supply of illicit drugs has likely not been reduced in the previous two decades. In particular, the data presented in this study suggest that the supply of opiates and cannabis, in particular, have increased, given the increasing potency and decreasing prices of these illegal commodities. These results have implications for the development of evidence-based drug policies,

particularly given the interest in novel drug policy approaches in a number of settings in Latin America, North America, and Europe.[32-34]

As noted elsewhere,[35, 36] there are limitations of ecologic analyses based on international surveillance systems. First, some states collect little or no data on indicators of illegal drug supply, whereas other states spend significant energy on monitoring drug availability. Second, even in states that closely track indicators of supply, the degree to which seized samples of illegal drugs reflect purity of retail drugs sold on the street is subject to variation, though where possible we presented purity-adjusted prices to address this limitation.[23] Nevertheless, the long-term trends in increasing purity and decreasing price presented here likely reflect overall trends in many regions, though it should be noted that in some regions (e.g., Europe), indicators of price and purity may have been strongly influenced by a few countries such as the United Kingdom and Spain. Additionally, some exceptions in the trends were observed. Australia for instance, while experiencing a significant decrease in the prices of both heroin and cannabis, did not experience a significant decrease in the price of cocaine, which may reflect the geographic isolation of the region or other market factors. It is also of note that Australia's 'heroin drought',[37] which saw a sudden drop in measures of the supply and availability of heroin, appears to have had a limited long-term impact on supply, though some experts suggest that it may have resulted in higher levels of polysubstance use among Australian heroin injectors.[27] Third, limitations in longitudinal data collection precluded our ability to include amphetamine-type stimulants and other emerging synthetic substances, as this data is limited to certain countries and the focus of this study was on

regional trends. It is noteworthy in this regard that the production of synthetic substances – as well as indoor cannabis cultivation – present particular challenges for supply reduction strategies, given that these drugs can be mass produced in clandestine locations regardless of climate or other factors that limit traditional drug production.[20, 38] Finally, while this review focused on patterns of price and purity of selected illegal drugs, these measures are only a marker of drug supply, and do not measure other factors determining availability and concomitant rates of drug use. These limitations to assessing global drug supply using classic proxy measures such as price, purity, and, to a lesser extent, seizures, suggests that there may be a need to expand the range of measures systematically collected by governments and international bodies such as the UNODC and the European Monitoring Centre for Drugs and Drug Addiction. In particular, meaningfully incorporating measures derived from street-level questionnaires of people who use drugs may provide a more reliable metric of supply and availability. Indeed, some bodies, such as Australia's IDRS, collect such data,[28] and this methodological approach should be considered by those coordinating surveillance of illegal drugs. Other bodies have also prioritized emphasizing measures of community health including reduced HIV infections, reduced drug-related violence and reductions in numbers of individuals incarcerated.[39, 40]

In summary, longitudinal illegal drug surveillance systems demonstrate a general global pattern of falling drug prices and increasing drug purity and potency, alongside a relatively consistent pattern of increasing seizures of illegal drugs. Although source data have limitations and there are some exceptions to

these trends, these findings should be useful given the current debates and drug policy experimentation under way in Latin America, North America, and Europe.[32-34] It is hoped that this study highlights the need to re-examine the effectiveness of national and international drug strategies that place a disproportionate emphasis on supply reduction at the expense of evidence-based prevention and treatment of problematic illegal drug use.

Acknowledgments:

The authors would like to thank Deborah Graham, Peter Vann, Katherine Quayle, Samantha MacLean, and Kevin Lutz for their administrative assistance. Dan Werb is supported by the Canadian Institutes of Health Research. Thomas Kerr is supported by the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

Competing interests:

All authors declare that (1) DW, TK, BN, JM and EW have support from the BC Centre for Excellence in HIV/AIDS for their submitted work; SS has support from the Division of Global Public Health, Department of Medicine, University of California, San Diego; (2) DW, TK, BN, SS, and EW have no relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) DW, TK, BN, SS and EW have no non-financial interests that may be relevant to the submitted work. JM has received grants from, served as an ad hoc adviser to, or spoken at events sponsored by Abbott, Argos Therapeutics, Bioject Inc., Boehringer Ingelheim, BMS, Gilead Sciences, GlaxoSmithKline, Hoffmann-La Roche, Janssen-Ortho, Merck Frosst, Panacos, Pfizer Ltd., Schering, Serono Inc., TheraTechnologies, Tibotec (J&J), and Trimeris.

Contributorship

All authors contributed substantially to the design and drafting of the manuscript. DW and EW designed the initial methodological approach and drafted the manuscript; TK, BN, SS, and JM provided substantial revisions to the manuscript.

Data sharing

This study employed publicly available data, as described in the methods section.

Funding

None

References:

1. Pietschmann T, Walker J. Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes. Vienna: UNODC Studies and Threat Analysis Section, Division for Policy Analysis and Public Affairs; 2011.
2. Jurgens R, Ball A, Verster A. Interventions to reduce HIV transmission related to injecting drug use in prison. Lancet Infect Dis. 2009; **9**(1): 57-66.
3. Beyrer C, Malinowska-Sempruch K, Kamarulzaman A, Kazatchkine M, Sidibe M, Strathdee SA. Time to act: A call for comprehensive responses to HIV in people who use drugsThe Lancet. 2010; **376**(9740): 551-63.
4. Coffin PO, Galea S, Ahern J, Leon AC, Vlahov D, Tardiff K. Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City, 1990-98. Addiction. 2003; **98**(6): 739.
5. Garfield J, Drucker E. Fatal overdose trends in major US cities: 1990 - 1997. Addictions Research and Theory. 2001; **9**(5): 425.
6. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. Lancet. 2008; **372**(9651): 1733-45.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis. 2005; **5**(9): 558-67.
8. Werb D, Rowell G, Guyatt G, Kerr T, Montaner J, Wood E. Effect of drug law enforcement on drug market violence: A systematic review. Int J Drug Pol. 2011; **22**(2): 8.

9. ECOSOC. Convention on Psychotropic Substances, 1971. Vienna: United Nations Economic and Social Council; 1971.
10. ECOSOC. The Single Convention on Narcotic Drugs, 1961. As amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs, 1961. Vienna: United Nations Economic and Social Council; 1972.
11. ECOSOC. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. Vienna: United Nations Economic and Social Council; 1988.
12. Travis A. Home Office rejects decriminalising possession of drugs for personal use. The Guardian. 2011 October 14.
13. Hoeffel J. Federal crackdown on medical pot sales reflects a shift in policy. Los Angeles Times. 2011 October 7.
14. Greenwald G. Drug decriminalization in Portugal: Lessons for creating fair and successful drug policies. Washington, D.C.: Cato Institute; 2009.
15. Warren J, Gelb A, Horowitz J, Riordan J. One in 100: Behind bars in America 2008. Washington, D.C.: The Pew Center on the States; 2008.
16. Farrell G, Clark, K. What does the world spend on criminal justice? Helsinki: The European Institute for Criminal Prevention and Control, affiliated with the United Nations; 2004.
17. Walmsley R. World prison population list. Report. London: International Centre for Prison Studies; 2007.
18. UNODC. World Drug Report 2008. Vienna: United Nations Office on Drugs and Crime; 2008.
19. A report on global illicit drug markets, 1998-2007. Netherlands: European Commission Directorate-General on Justice, Freedom and Security; 2009.
20. UNODC. World Drug Report 2011. Vienna: United Nations Office on Drugs and Crime; 2011.
21. Roberts M, Bewley-Taylor DR, Trace M. Monitoring drug policy outcomes: the measurement of drug-related harm: Beckley Foundation Drug Policy Programme; 2006.

22. Lenke L. An analysis of the significance of supply and market factors for variations in European cannabis use. EMCDDA Monographs. 2008: 293.
23. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alc Depend. 2007; **90**: S61-S8.
24. Hartnoll R. Drug epidemiology in the European institutions: Historical background and key indicators. Bulletin on Narcotics. 2003; **55**(1): 53-72.
25. Fries A, Anthony RW, Cseko Jr. A, Gaither CC, Schulman E. The price and purity of illicit drugs: 1981 - 2007. Alexandria, VA: Institute for Defense Analyses; 2008.
26. UNODC. World Drug Report 2010: Statistical Annex. Vienna: United Nations Office on Drugs and Crime; 2010.
27. Weatherburn D, Jones C, Freeman K, Makkai T. Supply control and harm reduction: lessons from the Australian heroin drought. Addiction. 2003; **98**: 83.
28. Stafford J, Burns L. Australian drug trends 2010: Findings from the Illicit Drug Reporting System (IDRS). Sydney: National Drug and Alcohol Research Centre; 2011.
29. DEA. STRIDE surveillance system. New York: United States Drug Enforcement Administration; 2011.
30. UNODC. World Drug Report 2010. Vienna: United Nations Office on Drugs and Crime; 2010.
31. ONDCP. Coca in the Andes. Washington, D.C.: Office of National Drug Control Policy; 2011.
32. Insulza JM. The drug problem in the Americas. Washington, DC: Organization of American States General Secretariat; 2013.
33. Harkinson J. Marijuana legalization may be unstoppable. Mother Jones. 2013 February 28.
34. EMCDDA. Drug Policy profiles: Portugal. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2011.

35. Caulkins JP. Comment: Should the DEA's STRIDE data be used for economic analyses of markets for illegal drugs? Journal of the American Statistical Association. 2001; **96**(456): 1263-4.

36. Manski CF, Pepper J, Petrie C. Informing America's policy on illegal drugs: What we don't know keeps hurting us: National Academies Press; 2001.

37. Longo MC, Henry-Edwards SM, Humeniuk RE, Christie P, Ali RL. Impact of the heroin'drought'on patterns of drug use and drug-related harms. Drug Alc Rev. 2004; **23**(2): 143-50.

38. EMCDDA. Europol 2010 annual report on the implementation of council decision 2005/387/JHA. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2010.

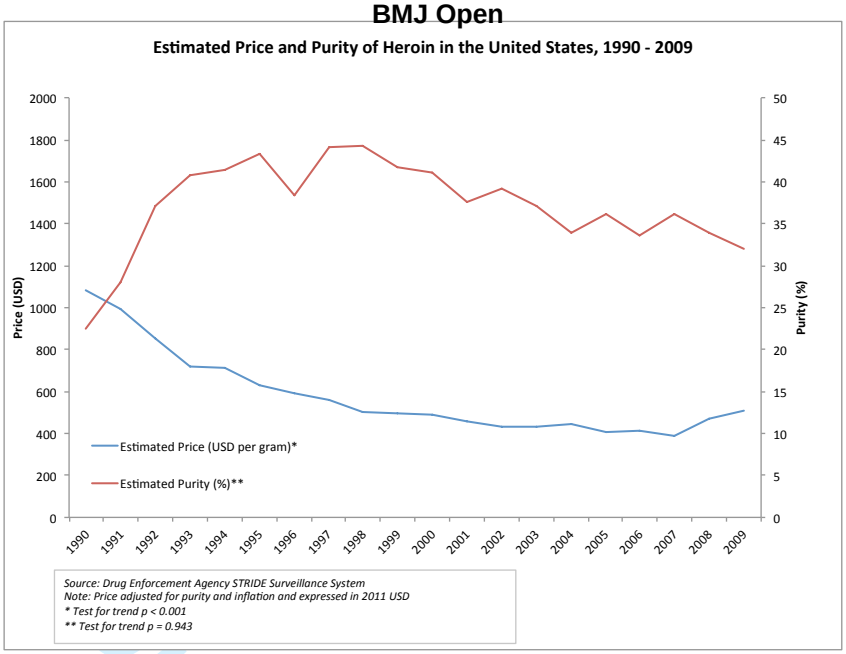
39. Global Commission on Drug Policy. The War on Drugs and HIV/AIDS: How the criminalization of drug use fuels the global pandemic. Rio de Janeiro: Global Commission on Drug Policy; 2012.

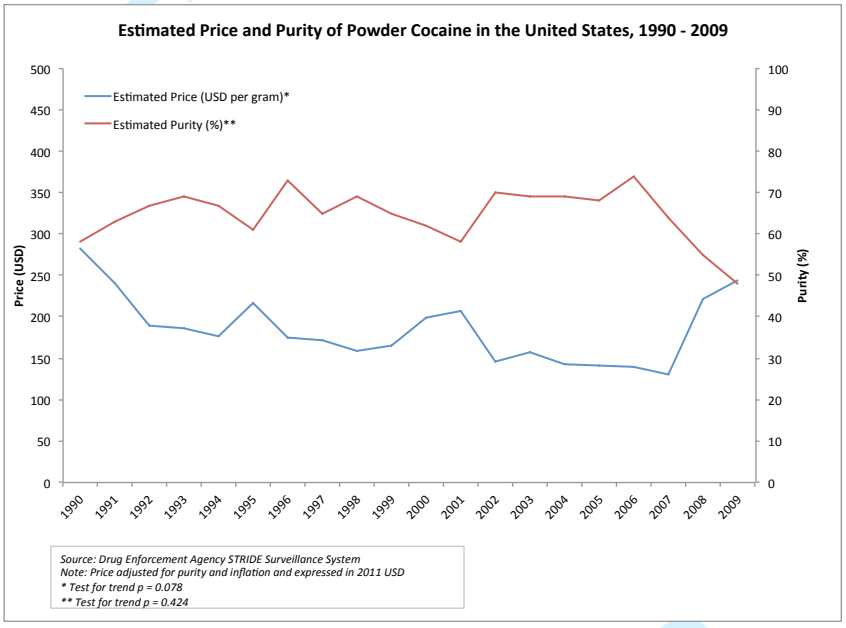
40. Global Commission on Drug Policy. Report of the Global Commission on Drug Policy. Rio de Janeiro: Global Commission on Drug Policy; 2010.

Table 1: Major Illegal Drug Data Surveillance Systems

Surveillance system	Country/ Region	Inception Date	Illegal drugs considered			Outcomes considered				Summary of findings
			cannabis	cocaine	heroin	Price	Purity	Use	Seizures	
University of Mississippi Marijuana Project	USA	1975 -	X				X			Cannabis potency increased between 1990 and 2009.
STRIDE Surveillance System	USA	1986-	X	X	X	X	X			Price decreased and purity/potency increased across all illegal drugs considered.
UNODC Drug Seizures Database	International	1980 -	X	X	X				X	Seizures of all drugs have increased between 1995 and 2006.
UNODC Annual Reports Questionnaire	International	1990 -	X	X	X	X	X	X		Prices of opiates, cocaine, and cannabis have generally decreased in Europe and the US while purity and potency have increased.
Reitox (EMCDDA database)	Europe	1993 -	X	X	X	X			X	Price of all illegal substances decreased in 2002 to 2007. Cocaine, cannabis, and heroin seizures increased between 2002 and 2007.
Illicit Drug Reporting System	Australia	2000 -	X	X	X	X	X		X	Between 2000 and 2010, the price of cocaine, cannabis and heroin decreased, while perceived purity remained stable.
National Drug Threat Assessment	USA	2001 -	X	X	X	X			X	Between 2005 and 2009, cocaine purity decreased whereas price increased.

Note: STRIDE: System To Retrieve Information from Drug Evidence, EU = European Union, EC = European Commission; EMCDDA = European Monitoring Centre For Drugs and Drug Addiction; UNODC = United Nations Office of Drug Control





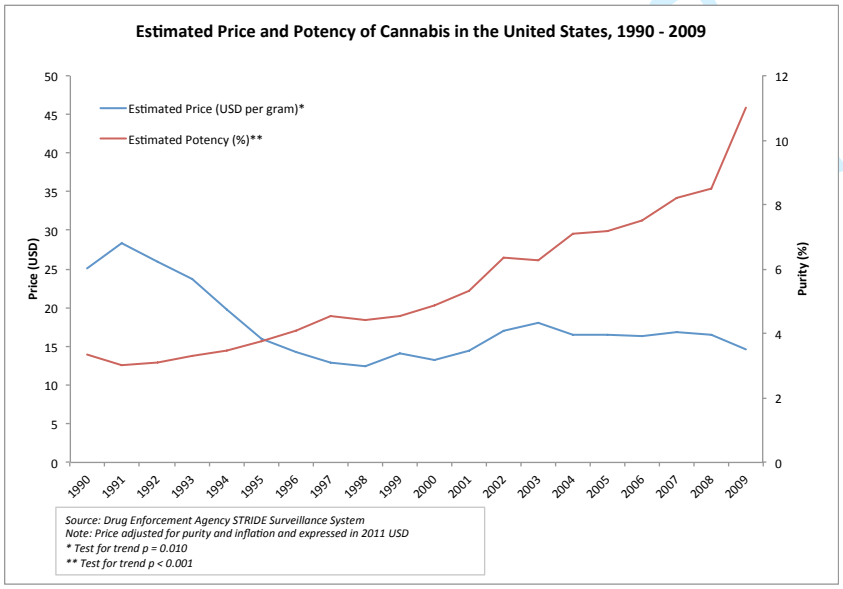


Figure 1. Estimated Price and Purity of Heroin, Cocaine and Cannabis in the United States, 1990 – 2009

The temporal relationship between drug supply indicators: An audit of international government surveillance systems

Dan Werb; Thomas Kerr; Bohdan Nosyk; Steffanie Strathdee; Julio Montaner; Evan Wood

Dan Werb, Senior Research Assistant, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Thomas Kerr, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Bohdan Nosyk, Research Scientist, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Steffanie Strathdee, Associate Dean of Global Health Sciences, University of California San Diego, Institute of the Americas, 10111 N. Torrey Rd., La Jolla, CA, USA, 92093-0507

Julio Montaner, Director, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Evan Wood, Director, Urban Health Research Initiative, BC Centre for Excellence in HIV/AIDS, Vancouver, Canada, 608 – 1081 Burrard Street, Vancouver, B.C., Canada, V6Z 1Y6

Send correspondence to:

Evan Wood, MD, PhD ABIM FRCPC
Professor of Medicine, University of British Columbia

BC Centre for Excellence in HIV/AIDS
608-1081 Burrard Street, Vancouver, B.C. V6Z 1Y6
CANADA

Tel: (604) 806-9116
Fax: (604) 806-9044
Email: uhri-ew@cfenet.ubc.ca

Word Count: 2,575

Tables: 1
Figures: 4
Revised: July 17, 2013
Printed: July 17, 2013

ABSTRACT

Objectives: Illegal drug use continues to be a major threat to community health and safety. We used international drug surveillance databases to assess the relationship between multiple long-term estimates of illegal drug price and purity.

Design: We systematically searched for longitudinal measures of illegal drug supply indicators to assess the long-term impact of enforcement-based supply reduction interventions.

Setting: Data from identified illegal drug surveillance systems were analysed using an *a priori* defined protocol in which we sought to present annual estimates beginning in 1990. Data were then subjected to trend analyses.

Main Outcome Measures: Data were obtained from government surveillance systems assessing price, purity, and/or seizure quantities of illegal drugs; systems with at least 10 years of longitudinal data assessing price, purity/potency, or seizures were included.

Results: We identified 7 regional/international meta-surveillance systems with longitudinal measures of price or purity/potency that met eligibility criteria. In the United States, the average inflation- and purity-adjusted prices of heroin, cocaine, and cannabis decreased by 81%, 80% and 86% respectively between 1990 and 2007, whereas average purity increased by 60%, 11%, and 161% respectively. Similar trends were observed in Europe, where during the same period the average inflation-adjusted price of opiates and cocaine decreased by 74% and 51% respectively. In Australia, the average inflation-adjusted price of cocaine decreased 14%, while the inflation-adjusted price of heroin and cannabis both decreased 49% between 2000 and 2010. During this time, seizures of these drugs in major production regions and major domestic markets generally increased.

Conclusions: With few exceptions and despite increasing investments in enforcement-based supply reduction efforts aimed at disrupting global drug supply, illegal drug prices have generally decreased while drug purity has generally increased since 1990. These findings suggest that expanding efforts at controlling the global illegal drug market through law enforcement are failing.

Word count: 298

Article Summary

Article focus

- Studies have demonstrated that illegal drug use remains a threat to community health and safety.
- However, less is known regarding the long-term impact of efforts to reduce the overall supply of illegal drugs.

Key messages

- Using longitudinal governmental surveillance data, this study demonstrates that over the past two decades, the supply of major illegal drugs has increased, as measured through a general decline in the price, and a general increase in the purity of illegal drugs in a variety of settings.

Strengths and limitations

- This study was limited by the quality and consistency of surveillance data on illegal drug supply
- This study presents data on trends in illegal drug supply in a variety of settings over two decades, including consumer and export drug markets

OBJECTIVES

The United Nations (UN) recently estimated that the global illegal drug trade is worth at least $350 billion USD annually,[1] and illegal drug use remains a major threat to community health and safety.[2, 3] In addition to the range of harms associated with the direct health effects of drugs, including fatal overdose,[4, 5] illegal drug use is also one of the key global drivers of blood borne disease transmission, in particular human immunodeficiency virus (HIV) infection.[6, 7] Illegal drug markets also contribute to community concerns such as high rates of violence in settings where the trade proliferates.[8]

In response to the health and social concerns associated with illegal drug use, several UN conventions were created to control the possession, consumption, and manufacture of illegal drugs.[9-11] As a result, over the last several decades, most national drug control strategies have prioritized drug law enforcement interventions to reduce drug supply, despite recent calls by experts to explore alternative models of drug control such as systems of drug decriminalization and legal regulation.[12-14] Some unintended consequences of this approach, such as record incarceration rates, have been well-documented.[15-18] Additionally, a small number of studies assessing aspects of drug supply, measured through indicators of drug price, purity/potency and seizures, have been undertaken to describe the global relationship between these indicators over the long-term.[19] However, systematic evaluation of these relationships is still needed to elucidate patterns of drug supply. The present study therefore sought

to systematically identify international data from publicly available illegal drug surveillance systems to assess long-term estimates of illegal drug supply.

DESIGN

Outcomes of interest

The primary outcomes of interest were long-term patterns of illegal drug supply, measured through indicators of price and purity/potency for three major illegal drugs: cannabis, cocaine, and opiates (e.g., opium and heroin). While data on amphetamine-type stimulants exist in some specific countries (e.g., the United Kingdom), this class of drugs was not included given inconsistent data collection and classification, and fluctuating surveillance periods and overall data quality. A secondary outcome of interest was data on illegal drug seizures in a) major illegal drug source regions and, b) major destination markets, as identified by the United Nations Office on Drugs and Crime (UNODC).[20] These secondary outcome data were used as an additional proxy measure to assess the availability of illegal drugs in specific regions, as has been done previously.[21, 22] All outcomes were systematically identified through publicly available illegal drug surveillance systems. Linear by linear association trend tests were carried out on **annual** estimates of all outcomes of interest. **Price and purity estimates represent median values for each year, while estimates for seizures represent crude totals of quantity seized**. All price estimates are expressed in 2011 USD and are, where possible, adjusted for purity.[23]

Illegal drug surveillance systems

An online search of surveillance systems monitoring illegal drugs using two *a priori* defined inclusion criteria was carried out. **Search terms included: drugs, illicit, illegal, price, purity, potency, surveillance system, government data, longitudinal, annual, estimate. Inclusion/exclusion criteria were as follows: only surveillance systems that included continuous longitudinal assessments of these outcomes of interest for at least 10 years were included because we specifically sought to assess the long-term impact of enforcement-based supply reduction strategies on illegal drug price and purity/potency. Finally, data extraction was restricted to 1990 and onwards to focus on patterns of supply during recent decades.**

Data were obtained through online searches of registries of surveillance systems (e.g., governmental websites, United Nations databases), governmental reports, and peer-reviewed publications, through referrals from experts in the field, and through data requests to relevant organizations including the UNODC. All authors had complete access to all data and all had final responsibility to submit for publication. Ethics approval was not required given that we relied exclusively on publicly available data.

RESULTS

We identified 7 government surveillance systems that met inclusion criteria. Of these, 3 (43%) reported on international data, 3 (43%) reported on data from the United States (US), and 1 (14%) reported on data from Australia. One of the longest-running surveillance system identified, the US-based Marijuana Potency Monitoring Project, is funded by the U.S. National Institutes of Health

and was established in 1975, while the most recent surveillance system was established in 2001 (e.g., the US-based *National Drug Threat Assessment*). With respect to international surveillance systems, the UNODC administers two separate surveillance systems that collect data from all participating United Nations member states: the Annual Reports Questionnaire surveillance system that collects price and purity/potency data, and the Drug Seizures Database that collects seizure data. Finally, the European Monitoring Centre for Drugs and Drug Addiction administers the Reitox drug surveillance system network, which aggregates data from a number of country-level surveillance systems in Europe, as described below.[24]

Price and Purity/Potency

Table 1 presents surveillance systems that matched search criteria. An assessment of data provided by these surveillance systems demonstrated a number of broad trends. First, purity and/or potency of illegal drugs generally remained stable or increased overall during the study period. Second, the price of illegal drugs, with few exceptions, generally decreased. Third, seizures of cannabis, cocaine and opiates generally increased in major drug production regions and major domestic markets.

Figure 1 presents data from the US Drug Enforcement Administration's System To Retrieve Information from Drug Evidence (STRIDE). As can be seen, between 1990 and 2007 (the last year for which data are publicly available), the purity of heroin and cocaine, and the potency of cannabis herb in the US increased, while the inflation- and purity-adjusted retail street prices of these

three drugs declined.[25] Specifically, heroin purity increased by 60% (p = 0.568), cocaine purity increased by 11% (p = 0.181), and cannabis herb potency increased by 161% (p < 0.001) during this time. During the same period, the prices of heroin, cocaine, and cannabis decreased 81% (p < 0.001), 80% (p < 0.001), and 86% (p < 0.001) respectively.

Figure 2 presents data collected by the UNODC on the street price of cocaine and opiates in participating European countries (i.e., Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Iceland, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Ireland).[26] In these countries, between 1990 and 2009, the aggregate average retail street price of cocaine decreased by 51%, from $198 USD per gram to $98 USD per gram ($p$ < 0.001). Similarly, the aggregate average price of opiates in Europe decreased 74%, from a high of $295 USD per gram in 1990 to $77 USD per gram in 2009 (p < 0.001).

Data from the Australian Illicit Drug Reporting System (IDRS) were available from 2000 to 2010. IDRS data suggest that the price of illegal drugs in Australia fluctuated substantially during this period. Specifically, after adjustment, the price of heroin decreased by 49%, from approximately $460 USD per gram to approximately $235 per gram ($p$ < 0.001), despite the well-described heroin 'drought' of 2001,[27] which saw a reduction in the supply and availability of heroin in Australia. Additionally, the price of cocaine decreased 14% from approximately $255 AUD per gram to $220 AUD per gram ($p$ = 0.477), and the

price of cannabis decreased 49% from approximately $25 AUD per gram to $13 AUD per gram ($p < 0.001$).[28]

Seizures

Domestic Markets

Figure 3 presents data on cannabis and cocaine seizures in the US between 1990 and 2010. As shown, data from the US Drug Enforcement Administration's STRIDE surveillance system demonstrate that the amount of cannabis herb seized by the Drug Enforcement Administration both in, and destined for, the US rose 465%, from approximately 130,000 kilograms in 1990 to approximately 720,000 kilograms in 2010 ($p < 0.001$). During this same period, despite fluctuations, the amount of cocaine seized by the US Drug Enforcement Administration decreased 49%, from approximately 57,000 kilograms in 1990 to 29,000 in 2010 ($p = 0.409$), while the amount of heroin seized increased 29% from approximately 535 kilograms in 1990 to 690 kilograms ($p = 0.979$, heroin seizure data not shown).[29]

Figure 4 presents data on cannabis, cocaine and heroin seizures in countries participating in the European Monitoring Centre for Drugs and Drug Addiction's Reitox surveillance network (i.e., European Union member countries, as well as Croatia, Norway, and Turkey), between 1995 and 2009. As can be seen, annual estimates of the quantity of both cocaine and cannabis herb seized fluctuated throughout this period; however, the quantity of heroin seized increased relatively steadily. Specifically, the number of kilograms of cannabis herb seized was at a low of approximately 57,000 kilograms in 1995, and peaked

one year later in 1996 at approximately 138,000 kilograms (p = 0.446). The number of cocaine seizures was at a low of approximately 21,000 kilograms in 1995, and peaked at approximately 121,000 kilograms in 2006 (p = 0.018). Finally, the number of kilograms of heroin seized increased 380% from a low of approximately 5,000 in 1995 to a high of approximately 24,000 in 2009 (p < 0.001).

Production Regions

With respect to opiate seizures, the Golden Triangle includes parts of Thailand, Lao, Viet Nam and Myanmar, and according to the UNODC, this region is the second largest supplier of heroin globally, though production has declined throughout the last decade, with opium production decreasing by approximately 60% and 90% in Myanmar and Lao, respectively.[30] In this region, trends in seizures of opium have fluctuated; 3,198 kilograms of opium were seized in 1990, with a high of 12,462 kilograms seized in 2007 before a steep decline to 1,225 kilograms in 2010 (p = 0.856). Similarly, seizures of heroin fluctuated, with a decrease of more than half, from 1,337 kilograms in 1990, to 627 kilograms in 2010 (p = 0.085), and a peak of 1,565 kilograms seized in 2009. In Afghanistan, which is believed to supply over 90% of the world's opium,[30] seizures of raw and prepared opium increased by over 12,000%, from 453 kilograms in 1990 to 57,023 kilograms in 2010, and seizures of heroin increased by over 600%, from 1,256 kilograms in 1990 to 9,036 kilograms in 2010 (Note: missing data prevented a trend test for annual opium and heroin seizures in Afghanistan).

With respect to cocaine seizures, according to the UNODC, Latin America's Andean region, which includes Peru, Bolivia, and Colombia, is the primary global supplier of this drug, as coca leaf is grown exclusively in this region.[31] While seizures of cocaine in the Andean region decreased 81%, from 97,437 kilograms in 1990 to 17,835 kilograms in 2007 (p = 0.028), seizures of coca leaf increased 188% from 601,038 kilograms in 1990 to 1.73 million kilograms in 2007 (p = 0.004). During the same period, the area of coca cultivation in this region declined slightly, from approximately 210,000 hectares to 180,000 hectares (p = 0.004).

Finally, according to the UNODC, major areas of cannabis cultivation exist in North Africa, Afghanistan, and North America. These areas are net exporters of cannabis, though most cannabis-producing countries also produce the drug for internal consumption.[20] In North Africa (i.e., Algeria, Morocco, and Tunisia), seizures of cannabis herb increased by 208% from 67,930 kilograms in 1990 to 209,445 kilograms in 2007 (p = 0.015). In North America (i.e., Canada, the United States, and Mexico), seizures of cannabis herb increased by 288% from 782,607 kilograms in 1990 to 3.05 million kilograms in 2007 (p < 0.001). In Afghanistan, while data on cannabis herb seizures are not available, seizures of cannabis resin increased 630% from 5,068 kilograms in 1990 to 36,972 kilograms in 2006 (p = 0.061).

CONCLUSIONS

Longitudinal data from government surveillance systems demonstrate that over the past two decades there has been a general pattern of increased

illegal drug supply as defined through lower price and higher purity of heroin, cocaine and cannabis. During the same period, patterns of drug seizures either increased or remained stable, though the trends detected in some of these indicators did not reach statistical significance. As such, we conclude, consistent with previous studies,[19] that the global supply of illicit drugs has likely not been reduced in the previous two decades. In particular, the data presented in this study suggest that the supply of opiates and cannabis, in particular, have increased, given the increasing potency and decreasing prices of these illegal commodities. These results have implications for the development of evidence-based drug policies, particularly given the interest in novel drug policy approaches in a number of settings in Latin America, North America, and Europe.[32-34]

As noted elsewhere,[35, 36] there are limitations of ecologic analyses based on international surveillance systems. First, some states collect little or no data on indicators of illegal drug supply, whereas other states spend significant energy on monitoring drug availability. Second, even in states that closely track indicators of supply, the degree to which seized samples of illegal drugs reflect purity of retail drugs sold on the street is subject to variation, though where possible we presented purity-adjusted prices to address this limitation.[23] Nevertheless, the long-term trends in increasing purity and decreasing price presented here likely reflect overall trends in many regions, though it should be noted that in some regions (e.g., Europe), indicators of price and purity may have been strongly influenced by a few countries such as the United Kingdom and

Spain. Additionally, some exceptions in the trends were observed. Australia for instance, while experiencing a significant decrease in the prices of both heroin and cannabis, did not experience a significant decrease in the price of cocaine, which may reflect the geographic isolation of the region or other market factors. It is also of note that Australia's 'heroin drought',[37] which saw a sudden drop in measures of the supply and availability of heroin, appears to have had a limited long-term impact on supply, though some experts suggest that it may have resulted in higher levels of polysubstance use among Australian heroin injectors.[27] Third, limitations in longitudinal data collection precluded our ability to include amphetamine-type stimulants and other emerging synthetic substances, as this data is limited to certain countries and the focus of this study was on regional trends. It is noteworthy in this regard that the production of synthetic substances – as well as indoor cannabis cultivation – present particular challenges for supply reduction strategies, given that these drugs can be mass produced in clandestine locations regardless of climate or other factors that limit traditional drug production.[20, 38] Finally, while this review focused on patterns of price and purity of selected illegal drugs, these measures are only a marker of drug supply, and do not measure other factors determining availability and concomitant rates of drug use. These limitations to assessing global drug supply using classic proxy measures such as price, purity, and, to a lesser extent, seizures, suggests that there may be a need to expand the range of measures systematically collected by governments and international bodies such as the UNODC and the European Monitoring Centre for Drugs and Drug Addiction. In

particular, meaningfully incorporating measures derived from street-level questionnaires of people who use drugs may provide a more reliable metric of supply and availability. Indeed, some bodies, such as Australia's IDRS, collect such data,[28] and this methodological approach should be considered by those coordinating surveillance of illegal drugs. Other bodies have also prioritized emphasizing measures of community health including reduced HIV infections, reduced drug-related violence and reductions in numbers of individuals incarcerated.[39, 40]

In summary, longitudinal illegal drug surveillance systems demonstrate a general global pattern of falling drug prices and increasing drug purity and potency, alongside a relatively consistent pattern of increasing seizures of illegal drugs. Although source data have limitations and there are some exceptions to these trends, these findings should be useful given the current debates and drug policy experimentation under way in Latin America, North America, and Europe.[32-34] It is hoped that this study highlights the need to re-examine the effectiveness of national and international drug strategies that place a disproportionate emphasis on supply reduction at the expense of evidence-based prevention and treatment of problematic illegal drug use.

Acknowledgments:

The authors would like to thank Deborah Graham, Peter Vann, Katherine Quayle, Samantha MacLean, and Kevin Lutz for their administrative assistance. Dan Werb is supported by the Canadian Institutes of Health Research. Thomas Kerr is supported by the Canadian Institutes of Health Research and the Michael Smith Foundation for Health Research.

Competing interests:

All authors declare that (1) DW, TK, BN, JM and EW have support from the BC Centre for Excellence in HIV/AIDS for their submitted work; SS has support from the Division of Global Public Health, Department of Medicine, University of California, San Diego; (2) DW, TK, BN, SS, and EW have no relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) DW, TK, BN, SS and EW have no non-financial interests that may be relevant to the submitted work. JM has received grants from, served as an ad hoc adviser to, or spoken at events sponsored by Abbott, Argos Therapeutics, Bioject Inc., Boehringer Ingelheim, BMS, Gilead Sciences, GlaxoSmithKline, Hoffmann-La Roche, Janssen-Ortho, Merck Frosst, Panacos, Pfizer Ltd., Schering, Serono Inc., TheraTechnologies, Tibotec (J&J), and Trimeris.

References:

1. Pietschmann T, Walker J. Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes. Vienna: UNODC Studies and Threat Analysis Section, Division for Policy Analysis and Public Affairs; 2011.
2. Jurgens R, Ball A, Verster A. Interventions to reduce HIV transmission related to injecting drug use in prison. Lancet Infect Dis. 2009; **9**(1): 57-66.
3. Beyrer C, Malinowska-Sempruch K, Kamarulzaman A, Kazatchkine M, Sidibe M, Strathdee SA. Time to act: A call for comprehensive responses to HIV in people who use drugsThe Lancet. 2010; **376**(9740): 551-63.
4. Coffin PO, Galea S, Ahern J, Leon AC, Vlahov D, Tardiff K. Opiates, cocaine, and alcohol combinations in accidental drug overdose deaths in New York City, 1990-98. Addiction. 2003; **98**(6): 739.
5. Garfield J, Drucker E. Fatal overdose trends in major US cities: 1990 - 1997. Addictions Research and Theory. 2001; **9**(5): 425.
6. Mathers BM, Degenhardt L, Phillips B, Wiessing L, Hickman M, Strathdee SA, et al. Global epidemiology of injecting drug use and HIV among people who inject drugs: A systematic review. Lancet. 2008; **372**(9651): 1733-45.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis. 2005; **5**(9): 558-67.
8. Werb D, Rowell G, Guyatt G, Kerr T, Montaner J, Wood E. Effect of drug law enforcement on drug market violence: A systematic review. Int J Drug Pol. 2011; **22**(2): 8.
9. ECOSOC. Convention on Psychotropic Substances, 1971. Vienna: United Nations Economic and Social Council; 1971.
10. ECOSOC. The Single Convention on Narcotic Drugs, 1961. As amended by the 1972 Protocol amending the Single Convention on Narcotic Drugs, 1961. Vienna: United Nations Economic and Social Council; 1972.
11. ECOSOC. United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. Vienna: United Nations Economic and Social Council; 1988.

12. Travis A. Home Office rejects decriminalising possession of drugs for personal use. The Guardian. 2011 October 14.
13. Hoeffel J. Federal crackdown on medical pot sales reflects a shift in policy. Los Angeles Times. 2011 October 7.
14. Greenwald G. Drug decriminalization in Portugal: Lessons for creating fair and successful drug policies. Washington, D.C.: Cato Institute; 2009.
15. Warren J, Gelb A, Horowitz J, Riordan J. One in 100: Behind bars in America 2008. Washington, D.C.: The Pew Center on the States; 2008.
16. Farrell G, Clark, K. What does the world spend on criminal justice? Helsinki: The European Institute for Criminal Prevention and Control, affiliated with the United Nations; 2004.
17. Walmsley R. World prison population list. Report. London: International Centre for Prison Studies; 2007.
18. UNODC. World Drug Report 2008. Vienna: United Nations Office on Drugs and Crime; 2008.
19. A report on global illicit drug markets, 1998-2007. Netherlands: European Commission Directorate-General on Justice, Freedom and Security; 2009.
20. UNODC. World Drug Report 2011. Vienna: United Nations Office on Drugs and Crime; 2011.
21. Roberts M, Bewley-Taylor DR, Trace M. Monitoring drug policy outcomes: the measurement of drug-related harm: Beckley Foundation Drug Policy Programme; 2006.
22. Lenke L. An analysis of the significance of supply and market factors for variations in European cannabis use. EMCDDA Monographs. 2008: 293.
23. Caulkins JP. Price and purity analysis for illicit drug: Data and conceptual issues. Drug Alc Depend. 2007; **90**: S61-S8.
24. Hartnoll R. Drug epidemiology in the European institutions: Historical background and key indicators. Bulletin on Narcotics. 2003; **55**(1): 53-72.
25. Fries A, Anthony RW, Cseko Jr. A, Gaither CC, Schulman E. The price and purity of illicit drugs: 1981 - 2007. Alexandria, VA: Institute for Defense Analyses; 2008.

26. UNODC. World Drug Report 2010: Statistical Annex. Vienna: United Nations Office on Drugs and Crime; 2010.
27. Weatherburn D, Jones C, Freeman K, Makkai T. Supply control and harm reduction: lessons from the Australian heroin drought. Addiction. 2003; **98**: 83.
28. Stafford J, Burns L. Australian drug trends 2010: Findings from the Illicit Drug Reporting System (IDRS). Sydney: National Drug and Alcohol Research Centre; 2011.
29. DEA. STRIDE surveillance system. New York: United States Drug Enforcement Administration; 2011.
30. UNODC. World Drug Report 2010. Vienna: United Nations Office on Drugs and Crime; 2010.
31. ONDCP. Coca in the Andes. Washington, D.C.: Office of National Drug Control Policy; 2011.
32. Insulza JM. The drug problem in the Americas. Washington, DC: Organization of American States General Secretariat; 2013.
33. Harkinson J. Marijuana legalization may be unstoppable. Mother Jones. 2013 February 28.
34. EMCDDA. Drug Policy profiles: Portugal. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2011.
35. Caulkins JP. Comment: Should the DEA's STRIDE data be used for economic analyses of markets for illegal drugs? Journal of the American Statistical Association. 2001; **96**(456): 1263-4.
36. Manski CF, Pepper J, Petrie C. Informing America's policy on illegal drugs: What we don't know keeps hurting us: National Academies Press; 2001.
37. Longo MC, Henry-Edwards SM, Humeniuk RE, Christie P, Ali RL. Impact of the heroin'drought'on patterns of drug use and drug-related harms. Drug Alc Rev. 2004; **23**(2): 143-50.
38. EMCDDA. Europol 2010 annual report on the implementation of council decision 2005/387/JHA. Lisbon: European Monitoring Centre for Drugs and Drug Addiction; 2010.

39. Global Commission on Drug Policy. The War on Drugs and HIV/AIDS: How the criminalization of drug use fuels the global pandemic. Rio de Janeiro: Global Commission on Drug Policy; 2012.

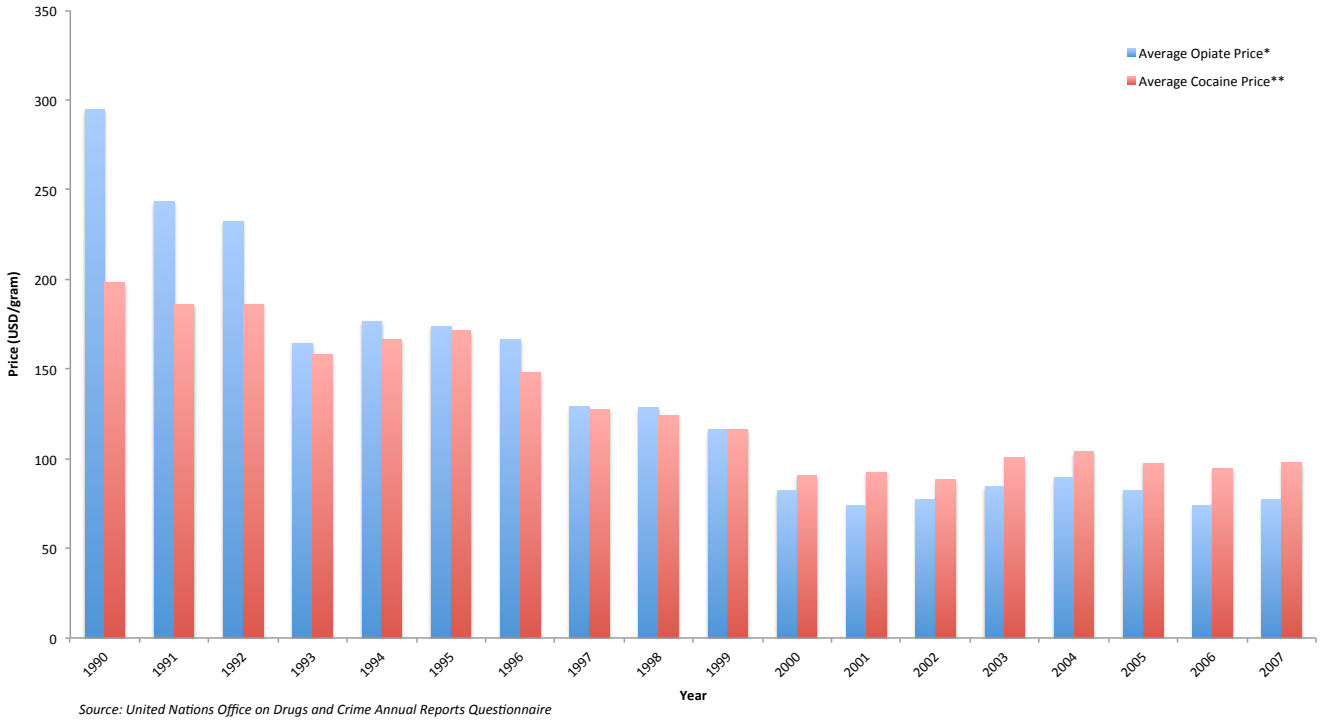
40. Global Commission on Drug Policy. Report of the Global Commission on Drug Policy. Rio de Janeiro: Global Commission on Drug Policy; 2010.

Table 1: Major Illegal Drug Data Surveillance Systems

Surveillance system	Country/ Region	Inception Date	Illegal drugs considered			Outcomes considered				Summary of findings
			cannabis	cocaine	heroin	Price	Purity	Use	Seizures	
University of Mississippi Marijuana Project	USA	1975 -	X				X			Cannabis potency increased between 1990 and 2009.
STRIDE Surveillance System	USA	1986-	X	X	X	X	X			Price decreased and purity/potency increased across all illegal drugs considered.
UNODC Drug Seizures Database	International	1980 -	X	X	X				X	Seizures of all drugs have increased between 1995 and 2006.
UNODC Annual Reports Questionnaire	International	1990 -	X	X	X	X	X	X		Prices of opiates, cocaine, and cannabis have generally decreased in Europe and the US while purity and potency have increased.
Reitox (EMCDDA database)	Europe	1993 -	X	X	X	X			X	Price of all illegal substances decreased in 2002 to 2007. Cocaine, cannabis, and heroin seizures increased between 2002 and 2007.
Illicit Drug Reporting System	Australia	2000 -	X	X	X	X	X		X	Between 2000 and 2010, the price of cocaine, cannabis and heroin decreased, while perceived purity remained stable.
National Drug Threat Assessment	USA	2001 -	X	X	X	X			X	Between 2005 and 2009, cocaine purity decreased whereas price increased.

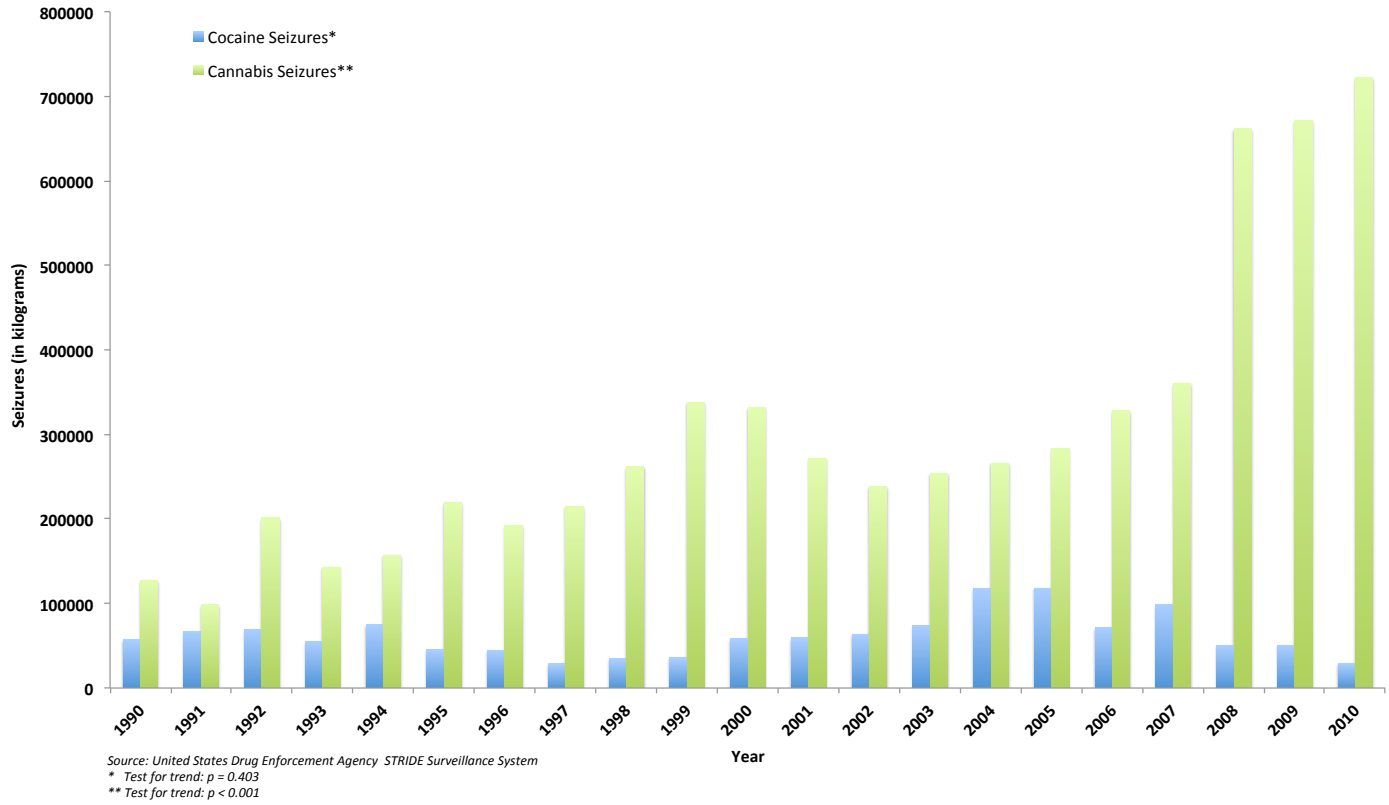
Note: STRIDE: System To Retrieve Information from Drug Evidence, EU = European Union, EC = European Commission; *EMCDDA = European Monitoring Centre For Drugs and Drug Addiction; UNODC = United Nations Office of Drug Control*

Figure 2. Average Inflation-Adjusted Price of Opiates and Cocaine in Europe, 1990 - 2007



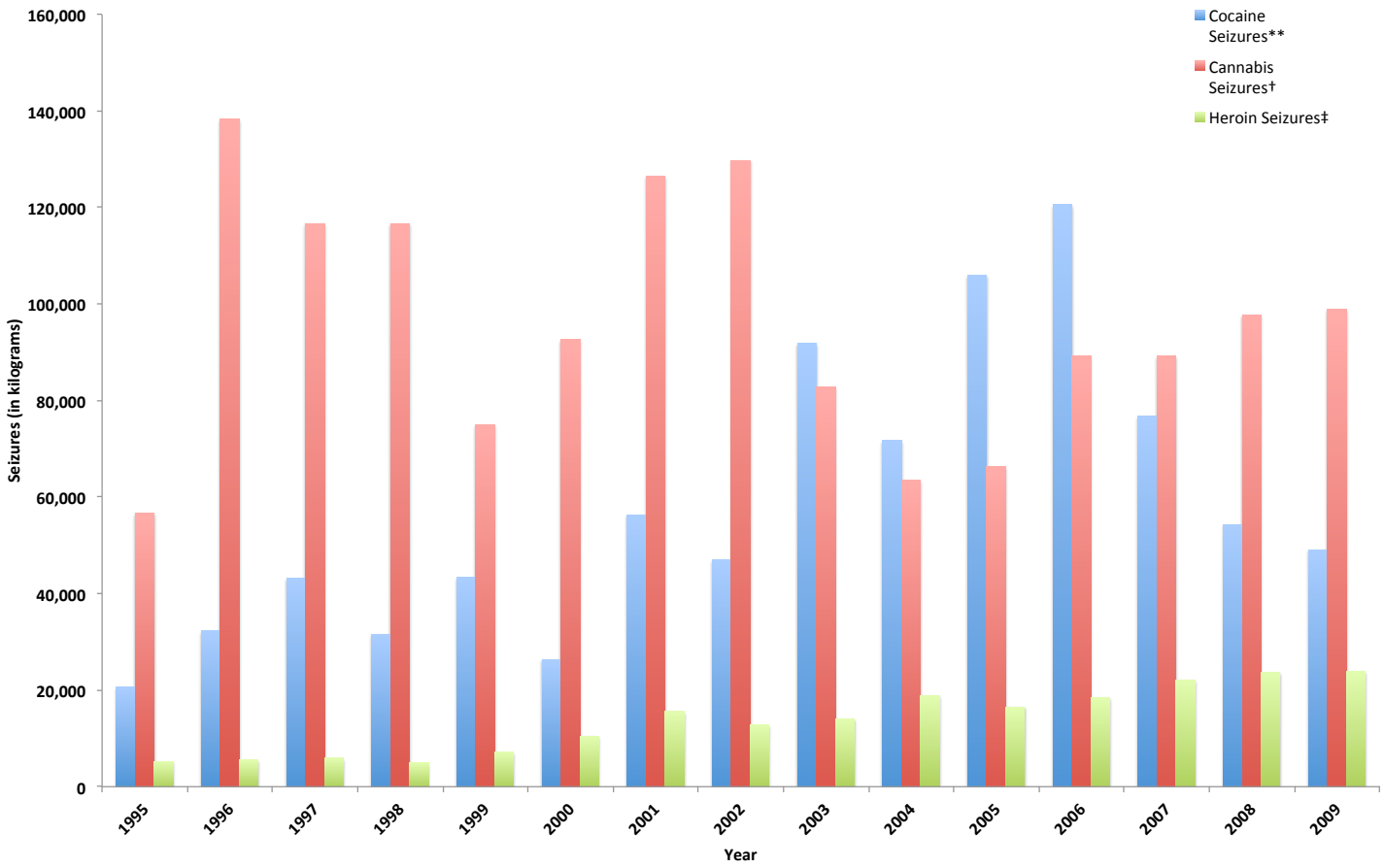
Source: United Nations Office on Drugs and Crime Annual Reports Questionnaire
Note: Price adjusted for CPI inflation
** Test for trend: p < 0.001*
*** Test for trend: p < 0.001*

Figure 3. Cocaine and Cannabis Seizures in the United States, 1990 - 2010



Source: United States Drug Enforcement Agency STRIDE Surveillance System
** Test for trend: p = 0.403*
*** Test for trend: p < 0.001*

Figure 4. Cocaine, Cannabis and Heroin Seizures in Europe*, 1990 - 2010



Source: European Monitoring Centre for Drugs and Drug Addiction REITOX Network
** Refers to European Union member countries, Croatia, Norway, and Turkey*
*** Test for trend: p = 0.018*
† Test for trend: p = 0.446
‡ Test for trend: p < 0.001