What America's Users Spend on Illegal Drugs 1988-1998

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Table of Contents

List of Tables

List of Figures

Executive Summary

Since 1991, the Office of National Drug Control Policy has published a biennial report on expenditures by Americans on illegal drugs and on legal drugs used illegally. This version of that biennial report provides estimates of cocaine, heroin and marijuana consumption from 1988 through 1998 and projects estimates for 1999 through 2000. For the first time, it provides comparable estimates for methamphetamine. This version improves and updates estimates of the supply of cocaine to the United States, and for the first time, provides estimates of the supply of heroin to American consumers. Finally, this version reports improved and updated estimates of trends in the domestic price of cocaine, heroin, methamphetamine and marijuana.

Using a consumption-based approach, we investigated the dollar expenditures by Americans on illicit drugs. We estimated that:

$ In 1998, Americans spent $66 billion on these drugs (Table 1):[1]

        $ $39 billion on cocaine
        $ $12 billion on heroin
        $ $$2.2 billion on methamphetamine
        $ $11 billion on marijuana
        $ $2.3 billion on other illegal drugs

$ Between 1988 and 1998, expenditures on cocaine appear to have fallen. This trend results partly from a decrease in the number of users, but mostly from a decrease in cocaine=s street price.

$ Heroin expenditures fell from 1988 to the middle of the 1990s. Heroin expenditures appear to have increased since then.

$ Trends in methamphetamine purchases are imprecise because of significant measurement problems. While expenditures may have fallen due to changes in the consumer price index, consumption levels have remained about the same over the last decade.

$ Between 1989 and 1998, expenditure on marijuana increased slightly (as marijuana prices increased) then decreased slightly (as marijuana prices fell).

$ Between 1989 and 1998, expenditures on other illicit drugs, and on legal drugs used illicitly, remained fairly constant.

Figures developed in estimating the retail sales value of illicit drugs consumed in the United States were compared to estimates of the amounts supplied to the domestic market. To investigate the reasonableness

of our approximations of cocaine consumption in the U.S., we compared our consumption estimates with two estimates of cocaine supplied to the domestic market. The first comparison was an extrapolation of coca cultivation estimates (calculated by the Sequential Transition and Reduction (STAR) Model). The second comparison was an extrapolation of cocaine departing South America developed by the U.S. intelligence community, based on quantifying the density and loading of cocaine traffickers departing South America. See Table 4 for the results.

> $ The cultivation-based consumption estimates are high relative to our consumption estimates. Also, they decrease from 411-559 metric tons (1996) to 176-324 metric tons (1999), and that trend is not reflected in other measures of cocaine use.

> $ After 1996, the event-based consumption estimates are smaller than the Abt consumption estimates: 154 metric tons in 1997, 212 in 1998, and 191 metric tons in 1999. Moreover, their variability is not reflected in other data about cocaine use.

> $ Roughly 12 to 13 metric tons of pure heroin entered the United States between 1995 and 1998. Because heroin is roughly 80 percent pure when imported into the U.S., the 12 to 13 pure tons represents 15 to 16 bulk tons.

> $ It was not practical to develop supply-based estimates for methamphetamine and marijuana.

Consumption-based and supply-based estimates do not always agree about the amount of cocaine shipped into the United States. According to consumption-based estimates, Americans used 291 metric tons in 1998; according to the cultivation-based estimates, 204-352 metric tons could have entered the States in 1998. Cultivation-based estimates should be higher than consumption estimates because the former do not fully account for consumption outside the U.S., for quantities seized by State and local authorities, and for amounts otherwise lost in South America. Therefore the cultivation-based estimates should exceed the consumption-based estimates, but that is not always the case.

In contrast, after 1996, the event-based consumption estimates are lower than our consumption estimates. This relationship was expected, because the events understate the flow of cocaine into the United States. Thus, the event-based consumption estimates should provide a lower limit on U.S. consumption.

Consumption-based estimates do not fully agree with supply-based estimates for heroin, but the differences are not great. Colombia seems to produce somewhat less heroin, and Mexico seems to produce somewhat more heroin, than can be accounted for by the consumption-based estimates. This difference might be

2

explained by incorrect information about processing efficiencies in Colombia and Mexico, because estimates of processing efficiencies are based on Southwest and Southeast Asia studies.

Although these estimates are imprecise, they are sufficiently reliable to conclude that the trade in illicit substances was somewhat less than $70 billion per year during the latter part of the 1990s, according to consumption-based estimates (Table 1).[2] The costs to society from drug consumption, however, exceed the amounts spent on drug abuse. Drug use fosters crime; facilitates the spread of catastrophic health problems, such as hepatitis, endocarditis, and AIDS; and disrupts personal, familial, and legitimate economic relationships. The public bears much of the burden of these indirect costs because it finances the criminal justice response to drug-related crime, a public drug-treatment system, and anti-drug prevention programs.

Table 1 - Total U.S. Expenditures on Illicit Drugs, 1988-2000 ($ in billions, 1998 dollar equivalents)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine	$76.9	$70.8	$61.3	$55.0	$49.4	$45.9	$42.2	$43.0	$41.3	$41.8	$39.0	$37.1	$36.1
Heroin	$21.8	$20.9	$17.6	$13.8	$10.9	$10.2	$10.5	$11.2	$11.7	$12.2	$11.6	$12.0	$11.9
Methamp	$3.2	$3.2	$2.6	$2.2	$2.3	$2.7	$3.3	$2.8	$2.4	$2.0	$2.2	$2.2	$2.2
Marijuana	$11.3	$11.1	$13.5	$12.8	$12.5	$11.2	$11.4	$9.3	$9.0	$10.1	$10.7	$10.2	$10.4
Other Drugs	$3.3	$2.8	$2.2	$2.3	$1.5	$1.5	$2.6	$2.7	$2.7	$2.5	$2.3	$2.3	$2.3
Total	$116.5	$108.8	$97.3	$86.1	$76.5	$71.5	$70.0	$68.9	$67.2	$68.6	$65.8	$63.7	$62.9

…………….Columns may not add due to rounding. Estimates for 1999 and 2000 are projections.

Sources: See Tables 3 through 10.

Table 2 - Supply-Based Estimates of Cocaine and Heroin Available for Consumption
in the U.S. (pure metric tons)

Cocaine Consumption Estimates	1996	1997	1998	1999
Abt calculation	288	312	291	276
Event-based	307	154	212	191
Cultivation-based	411-559	309-457	204-352	176-324
Heroin	12.4	13.1	12.5	12.9

Source: Table 16

What America's Users Spend on Illegal Drugs

In 1997, the Office of National Drug Control Policy (ONDCP), working with Abt Associates Inc., reported that Americans spent an estimated $57 billion to $91 billion per year between 1988 and 1995 for illicit drugs and for licit drugs used illegally. New data and a revised methodology have enabled us to improve those estimates, extend them through 1998, and project them into the year 2000.

To estimate the retail sales value of illicit drugs consumed in the United States, we examined both the demand for and the supply of drugs. The demand, or *consumption approach*, estimates the number of drug users, how much they spend on drugs, and the amount of drugs they consume. The *supply* approach estimates the volume of drugs available for consumption. To determine the amount of drugs available in this country and the retail value of these drugs, we estimated the amount of base crop raised in producer countries, and

reduced it by the amounts lost, seized, or consumed in other countries and by the amount seized in the United States. We then multiplied the result by retail prices.

For a number of reasons, neither of these approaches yields precise estimates of the yearly retail value of the illegal drug trade. First, the secretive nature of drug crop production and manufacturing prevents accurate assessments of drug production. Second, with some exceptions, drug dealers and their customers transact business away from public view. Finally, drug users often misrepresent their drug use when interviewed. For these reasons, estimates of retail expenditures are based on the best available data, although those data are seldom as complete or accurate as we desire. Also, the data lack a probability-sampling basis, so we cannot provide probabilistic confidence intervals.

Because of these complexities in drug use monitoring, we encourage an evaluation of our findings in three ways. First, the reader can compare our estimates with those reported elsewhere. Second, the reader should consider whether or not the two independent approaches used in this report (supply-based and consumption-based) reach similar conclusions about the amount American drug users spend on drugs. Finally, our calculations can be replicated using alternative assumptions the reader finds more plausible than the ones we used. The report is divided into two sections. Section I reports estimates derived using the consumption approach. Section II reports estimates for cocaine and heroin derived from the supply approach, and it reconciles the differences between the two approaches. Technical material appears in appendices.

1 Consumption-based Estimate of Retail Expenditures

Cocaine and Heroin

Between 1989 and 1998, American users spent $39 billion to $77 billion yearly on cocaine and $10 billion to $22 billion yearly on heroin. To arrive at these estimates, we multiplied the number of users by their typical expenditures, and then converted the resulting estimates to 1998-dollar equivalents. Most of the downward trend results from changes in the consumer price index.

The Number of Cocaine and Heroin Users

The National Household Survey on Drug Abuse (NHSDA), the Nation=s most comprehensive survey of drug use, measures drug use among the American household population age 12 and older, as well as among people living in group quarters and the homeless.[3] The NHSDA misses a part of the population that may be a key to determining the extent of drug use: those hardcore drug users who, although not homeless, are too unstable to be considered as part of a household, or who, if part of the household, are unlikely to answer surveys.[4]

This less-stable population of hardcore drug users is, however, well-represented in data collected by the Drug Use Forecasting (DUF) program, which questions a sample of arrestees in 24 central city jails and lockups about their drug use.[5] DUF also asks arrestees to voluntarily produce specimens for urinalysis. This helps to confirm whether the interviewees have used any of up to 10 types of drugs during the two to three days before the interview. Although urinalysis is subject to error and tells us nothing about the frequency of drug use, it adds credence to estimates of drug use when self-reports are unreliable.

The *hardcore user* is identified in the NHSDA as one who used cocaine at least one or two days a week every week during the year before the survey, or one who used heroin on more than 10 days during the month before the survey. In this analysis, hardcore users in the DUF data are defined as those who admitted using cocaine or heroin on more than 10 days during the month before being arrested.[6] *Occasional users* are identified in the NHSDA as those whose drug use was less frequent than the hardcore drug use criteria described above. Occasional use cannot be estimated from DUF.[7]

Appendix A explains how we used data from the NHSDA and DUF, as well as other sources, to estimate the number of drug users in the United States. The rest of this section provides an overview and reports findings.

According to one estimate, hardcore drug users seem to account for about three-quarters[8] of all cocaine used in the United States, so understanding hardcore consumption patterns is crucial to estimating expenditures

6

on cocaine. The concentration of heroin consumption is probably similar. Thus, estimating hardcore drug use is especially important. The calculations start by estimating the number of hardcore users who are arrested during the year. This number is then divided by the average number of arrests that hardcore users generate during the year. For example, if hardcore users account for 2 million arrests per year, and if hardcore users are arrested an average of 0.5 times per year, then there must be 2 million divided by 0.5, or 4 million, hardcore users in the nation. We then subtract estimates of hardcore users in jails and prisons, because they are unlikely to use heroin or cocaine heavily while incarcerated. The trick, of course, is to obtain reasonable estimates of both the number of hardcore users who are arrested during each year and the average number of arrests that they generate during the year (see Appendix A).

Once estimates of the number of hardcore users are available, the next step is to estimate how much they spend on cocaine and heroin. The best way to learn this information is to ask the users, and studies sponsored by ONDCP, the National Institute on Drug Abuse, and the National Institute of Justice provide data (see Appendix B). An estimate of the retail sales value of illicit drugs consumed by heavy users follows from multiplying estimates of typical expenditures by estimates of the number of hardcore users.

Estimates of expenditures by hardcore users are then converted to units measured in kilograms of heroin and cocaine, so that amount consumed can be compared with the amount of drugs trafficked into the country. This requires an estimate of the prevailing retail prices for illicit substances. Here, too, ONDCP and other agencies have sponsored research leading to estimates of what substance abusers pay for drugs on the streets (see Appendix C). Dividing the estimate of retail sales value by the prevailing price paid by users gives an estimate of the total amount of drugs purchased, and this amount can be converted readily into metric ton units.[9]

This explains the derivation of estimates of drugs used by hardcore users, but while hardcore users probably account for at least three-quarters of the cocaine and heroin used in this country, they do not account for all illicit drug consumption. One view is that the National Household Survey on Drug Abuse understates the number of hardcore drug users and the amount that they spend, but that the NHSDA provides a reasonably accurate estimate of the amount of more casual drug use. Thus, this report complements expenditures by hardcore users on cocaine and heroin based on DUF data with expenditures on these substances by more casual users based on the NHSDA.

This report provides preliminary estimates of methamphetamine use, based mostly on DUF data, and using estimation procedures similar to those used to estimate cocaine and heroin use. Finally, estimates for marijuana use and for other illicit drugs (excluding cocaine, heroin, marijuana, and methamphetamine) come from the NHSDA, with some adjustments for under reporting.

Table 3 provides estimates of the number of hardcore and occasional cocaine and heroin users derived from the NHSDA and the DUF data. (Users of other drugs will be discussed later.) Because the NHSDA was not administered in 1989, the 1989 NHSDA estimates used in this report are the average of 1988 and 1990 data; also, SAMHSA changed the survey in 1994, and statistics from earlier years were adjusted by SAMHSA to take these changes into account. Estimates for 1998 through 2000 are projections based on trends observed in earlier years.[10]

Excluding persons in custody, between 1988 and 1998, about 3.2 million to 3.9 million Americans were hardcore users of cocaine and approximately 2.9 million to 6.0 million were occasional users. Another 630,000 to 980,000 Americans were hardcore users of heroin, and 140,000 to 600,000 were occasional users. Considering the overlap between hardcore cocaine users and hardcore heroin users, the estimates suggest that there were about 3.3 million hardcore users of heroin or cocaine in 1998.[11] Although imprecise, these estimates are consistent with reported estimates derived by others using different methodologies and data.

For example, Rhodes, Langenbahn, Kling and Scheiman[12] provided one national estimate of 508,000 hardcore heroin users, and a second national estimate of 582,000 hardcore heroin users. The authors explain why both estimates probably understate the true number. We are aware of only one other national estimate of heroin addicts, by Hamill and Cooley,[13] who concluded there were 640,000 to 1.1 million heroin addicts in 1987. These estimates are roughly consistent with our 1988 estimate of 920,000 hardcore heroin users.

Simeone, Rhodes and Hunt[14] estimated that there were about 300,000 hardcore cocaine/heroin users in Cook County in 1995. Assuming a constant proportionality between the number of hardcore users in a population and the number of emergency room admissions attributed to them, an extension of the Simeone, Rhodes and Hunt estimates suggest there are about 4.0 to 4.5 million hardcore users in the nation. Although such an assumption of proportionality rests on shaky grounds, it nevertheless leads to estimates of a magnitude remarkably close to the 3.3 million estimate used in retail sales calculations.

The Substance Abuse Mental Health Services Administration estimated that about 3.6 million Americans have a severe need for substance abuse treatment exclusive of treatment for alcohol abuse.[15] SAMHSA derived this estimate by identifying someone as needing treatment if he met one of four criteria and then inflating the estimates to account for undercounting in the NHSDA.[16] Because the inflation factor is only 20 to 30 percent, it seems likely that SAMHSA=s estimates of the number of cocaine and heroin users who need treatment would be smaller than the estimates given here for weekly heroin and cocaine users. SAMHSA does not report the need for treatment by type of drug, but we applied the SAMHSA algorithm to the NHSDA data as best we could and inflated the resulting estimate by 25 percent.[17] The result was that 920 thousand cocaine users needed treatment, as did 130 thousand heroin users and 59 thousand people who used both heroin and cocaine. Thus, SAMHSA estimated that almost 1.2 million people need treatment for cocaine abuse, and almost 190,000 need treatment for heroin addiction.

Not all weekly users of cocaine need treatment, so an estimate of 3.4 million weekly users (1996) may conceivably be consistent with SAMHSA=s estimate of 1.2 million who need treatment. Similarly, weekly heroin use may not indicate a need for treatment, so an estimate of 190 thousand heroin addicts could conceivably be consistent with our estimate of 900 thousand weekly heroin users. Although conceivable, these differences are so large that they tax credulity. There are three problems. The first is that, from the view of our calculations, a 20 to 30 percent inflation factor is insufficient to approximate the number of hardcore users *not* represented by the NHSDA. A second problem is that the SAMHSA estimates suggest that at a maximum, about 25 percent of all people who need treatment for substance abuse are current users of heroin or cocaine. In fact, all 17 CEWG (Community Epidemiological Work Group) sites[18] report more than 25 percent of their treatment admissions are for cocaine or heroin, and 11 of 17 report that more than half their admissions are for cocaine or heroin. Although not all people who need treatment actually receive treatment, we would expect a closer correspondence between those who need treatment for cocaine and heroin, and those who receive treatment for those substances. Third, according to the Treatment Episode Data Sets (TEDS), roughly 200,000 heroin users and another 250,000 cocaine users received treatment per year between 1993 and 1997.[19] SAMHSA=s estimates are inconsistent with TEDS. Thus, even after attempts to inflate estimates based on the NHSDA, the estimates seem to understate the number of hardcore heroin and cocaine users, and consequently, the SAMHSA estimates cannot be reconciled with our estimates.

Table 3 - Estimated Number of Hardcore and Occasional Users of Cocaine and Heroin (Thousands), 1988-2000

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
NHSDA [1]													
Cocaine Hardcore	1,100	980	850	806	829	615	734	582	608	682	595	490	445
Cocaine Occasional	6,000	5,300	4,600	4,478	3,503	3,332	2,930	3,082	3,425	3,487	3,216	2,411	2,155
Heroin Occasional	170	150	140	359	304	230	281	428	455	597	253	484	514
DUF [2]													
Cocaine Hardcore	3,323	3,025	2,761	2,767	2,844	3,042	3,000	3,264	3,106	3,162	3,045	3,103	3,103
Heroin Hardcore	923	886	797	681	630	694	795	855	917	935	980	977	977
Composite													
Cocaine Occasional	6,000	5,300	4,600	4,478	3,503	3,332	2,930	3,082	3,425	3,487	3,216	2,411	2,155
Heroin Occasional	170	150	140	395	304	230	281	428	455	597	253	484	514
Cocaine Hardcore [2]	3,873	3,515	3,186	3,170	3,259	3,350	3,367	3,555	3,410	3,503	3,343	3,348	3,325
Heroin Hardcore	923	886	797	681	630	694	795	855	917	935	980	977	977

Columns may not add due to rounding
Sources: NHSDA 1988, 1990 through 1998; DUF 1988 through 1998; Uniform Crime Reports (UCR) 1988 through 1997.

[1]   The NHSDA was not administered in 1989. Estimates are the averages for 1988 and 1990.
[2]   Due to sample overlap, the estimated number of composite hardcore cocaine users is derived from the sum of DUF hardcore cocaine users and one half of NHSDA hardcore cocaine users.

Trends in Drug Use

If the prevalence estimates have some justification, what can be said about trends? Because the estimates presented in Table 3 are based on a consistent methodology from 1988 through 1997, they can be compared meaningfully from year to year. We do not know the standard errors for these estimates, however, so we lack a probability basis for judging whether or not changes are statistically significant. Our estimates seem to show a decrease in the number of hardcore cocaine users from 1988 to 1991. Thereafter, the estimated number of hardcore cocaine users fluctuates from year to year but follows no strong trend. Estimates of

occasional use from the NHSDA show a consistent downward trend. Table 3 shows a decrease and then an increase in hardcore heroin use. This recent increase in hardcore heroin use has a counterpart in the NHSDA, which also reports a recent increase in heroin use among household members.

Because trends in drug use are often disputed, it may be helpful to discuss whether or not other evidence is consistent with our findings. Hardcore drug users are frequently in trouble with the law, so a temporal change in incarceration practices will necessarily have a large effect on them. Based on estimates explained in Appendix A, the increase in prison populations between 1988 and 1998 would have incapacitated an additional 200,000 hardcore cocaine users and an additional 72,000 hardcore heroin users. These are sizable yet conservative numbers, because they do not take into account inmates and detainees under the supervision of local correctional authorities.

The AIDS epidemic provides another reason for expecting a decrease in heavy drug use, especially by heroin users, but also for others who inject drugs. According to the Centers for Disease Control[20] 217,000 injection drug users had been diagnosed with AIDS as of 1998, and 87,000 had died of the disease. Having AIDS does not preclude substance abuse, of course, but advanced AIDS must make it all but impossible to support heavy use of heroin. Adding together hardcore heroin users who are incarcerated and hardcore heroin users who have died implies about 150,000 fewer hardcore heroin users at the end of the decade than at the beginning of the decade. The figure may be closer to 200,000 when we consider heroin users with advanced AIDS.

If no other factors affected hardcore drug use, we would expect a decline in hardcore cocaine users and, especially, hardcore heroin users, from 1988 to 1998. Offsetting these trends toward less use, however, is an apparent recent increase in heroin use by people who do not inject. This might result from the increased availability of higher purity heroin. Trends reported by SAMHSA in the 1998 Treatment Episode Data Set (Table 5.3) are consistent. Between 1993 and 1998, the proportion of admissions for heroin inhalation increased from 23 percent to 28 percent. Moreover, those admitted for heroin inhalation tend to be younger than those admitted for heroin injection; they are more likely to be experiencing a first treatment episode; and among heroin abusers experiencing a first treatment episode, those who inhale have typically used for a shorter time. Recent tabulations based on the National Household Survey on Drug Abuse and the Monitoring the Future Survey have suggested renewed drug use by youths.[21] Nevertheless, this increase is a relatively recent phenomenon, and it followed a decrease in earlier years. It is difficult to believe that these youth could

11

have progressed to heavy use as of 1998, and certainly they could not account for much of the increase in treatment episodes for heroin **B** where fewer than 5 percent of patients are under twenty years old.[22] Finally, according to the Substance Abuse and Mental Health Services Administration, emergency room mentions for cocaine use have increased from about 80,000 in 1990 to about 161,000 in 1997. Emergency room mentions for heroin grew from about 34,000 in 1990 to 72,000 in 1997. A naïve observer might infer that cocaine and heroin use doubled between 1990 and 1997, but this is almost certainly wrong.

Little is known about the dynamics of emergency room use by hardcore cocaine and heroin users, but some speculation might be helpful. According to the 1997 DAWN (Drug Awareness Warning Network) report, dependence is the dominant drug use motive for heroin and cocaine users seeking emergency room assistance **B** 86 percent for heroin mentions and 68 percent for cocaine mentions. Either chronic effects, withdrawal or seeking detoxification are the typical reasons for going to the emergency room **B** 62 percent for heroin mentions and 50 percent for cocaine mentions.[23] Addicts are more likely to seek treatment as they age, and treatment episodes seem to become more frequent over time.[24] For this reason alone, we would expect to see emergency room mentions increase even if the number of hardcore heroin and cocaine users did not change. Furthermore, we suspect that hardcore heroin and cocaine users will develop an increasing number of chronic health conditions as their addictions advance and as they age. This, too, can account for an increase in emergency room mentions. While DAWN can be very valuable for detecting short-term changes in specific jurisdictions **B** such as a spike in overdose deaths **B** it would seem to have little or no value as a tool for monitoring long-term trends in the prevalence of substance abuse.

Average Amount Spent on Cocaine and Heroin

DUF interviews from 1989 and later asked respondents how much they spent on drugs during a week. The question did not separate cocaine from heroin spending or exclude other drugs, so we must infer how much was spent on cocaine and how much was spent on heroin. Also, some respondents gave answers that were implausibly large, so based on the methodology explained in Appendix B, we adjusted estimates to moderate the effect of extreme values. Because of a change in questionnaire design, DUF does not provide comparable estimates after 1995. Estimates for 1996-2000 are just the 1995 estimates adjusted for inflation.

Table 4 provides estimates of the median expenditure on cocaine and heroin. Based on evidence presented in Appendix B, using the median expenditure in retail sales calculations has a greater justification than using

12

a mean expenditure. All estimates were converted to 1998 dollar equivalents based on the consumer price index.[25]

In 1998, hardcore cocaine users spent $191 a week on cocaine, and hardcore heroin users spent $214 a week on heroin (Table 4). These DUF estimates lack precision, but they are reasonable considering other data about expenditures on illicit drugs. For example, an analysis of data from a special addendum[26] to the 1998 DUF instrument in 1995 gives some information for the heroin numbers.[27] Based on the median,

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Table 4 - Weekly Median Cocaine and Heroin Expenditures Reported by Arrestee Hardcore Users, 1989-2000

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	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine												
Median	$352	$331	$292	$255	$229	$210	$202	$198	$195	$191	$188	$186
Heroin												
Median	$446	$417	$364	$308	$266	$236	$226	$221	$219	$214	$211	$209

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Sources: DUF 1989 through 1994

hardcore heroin users spent $140 per week; based on the mean, they spent $330 per week. The mean is probably too high, because it likely includes purchases by some users who intend to resell part of the lot.[28] Appendix B provides a review of expenditure patterns reported by other researchers.

Of course, occasional users spend less per week than do hardcore users. Based on NHSDA data, occasional cocaine users spent $19 per week in 1988, $23 in 1989, $27 in 1990, $30 in 1991, $34 in 1992, and $35 in 1993. More recent estimates are unavailable. No such estimates are available from the NHSDA for occasional heroin users. For them, we assumed a weekly expenditure of $50 per week.

Total Expenditures on Cocaine and Heroin

Between 1988 and 1998 American users spent $39 billion to $77 billion yearly on cocaine and $10 billion to $22 billion yearly on heroin (Table 5). We derived these estimates by multiplying the number of hardcore

and occasional users in Table 3 by the median expenditures in Table 4 (and the figures cited earlier for occasional users) and adding the results.

How the Estimates are Affected by Varying the Assumptions

The estimates of expenditures may vary due to assumptions made about the number of hardcore and occasional users and about their average expenditures. Because hardcore users account for the bulk of drug spending, estimates of total expenditures are especially sensitive to the accuracy of estimates of expenditures by hardcore users. Consequently, we tested how sensitive our expenditure estimates are to assumptions made about the number of hardcore users and their typical expenditures. Because the factors that entered the calculations were not derived from probability samples, it is impractical to develop a statistically based margin of error.

First, we determined how the expenditure estimates would be affected if we used lower or higher estimates of the number of users than were reported in Table 3. Because the retail sales estimates are roughly proportional to the number of hardcore users, if the estimate of hardcore users is off by plus or minus 25 percent, then the retail sales estimates would be off by the same proportion.

Second, we determined how the expenditure estimates would be affected if we varied our assumption about typical drug expenditures. Some studies reported in Appendix B are based on reported expenditures by cocaine users entering treatment, and those users have much higher expenditure patterns than are assumed in the retail sales calculations. If these expenditures were considered typical, the retail sales value of cocaine would be two to four times the amount reported here. This seems an implausibly large expenditure that would exceed not only available income for most users,[29] but the value of the supply of the drugs as well. (For a further discussion of this topic, see Appendix B.)

Although an average expenditure figure based on a treatment population is certainly too high, it might be realistic to adopt the average (rather than the median) drug spending numbers reported by DUF as a high estimate. Then, the composite totals on both cocaine and heroin use would be 60 to 80 percent greater than estimates based on the median expenditure patterns. For the reasons we cited above, it is doubtful that expenditures in the United States approach this high estimate.

14

At the opposite extreme, hardcore users who report their use in the NHSDA appear to consume less than half as much cocaine as hardcore users represented in the DUF data. Their expenditures might be considered a low estimate of typical cocaine spending by hardcore users. Giving more weight to the NHSDA expenditure figures would reduce the amount reported in Table 5 by half. However, it is difficult to reconcile estimates that are half as large with the amount of heroin and cocaine that enters the country.

Other analysts have made clever use of available data to derive their own estimates of retail expenditures on cocaine and heroin. Even after adjusting for the limitations of these other studies, our estimates are higher than theirs, perhaps suggesting that B if anything B we might adjust our estimates downward.[30] But, for reasons noted above, a large downward adjustment seems unwarranted.

Table 5 - Total Expenditures on Cocaine and Heroin, 1988-2000 ($ in billions, 1998 dollar equivalents)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine													
heavy use	$71.0	$64.4	$54.8	$48.1	$43.2	$39.8	$36.8	$37.4	$35.1	$35.5	$33.1	$32.7	$32.1
occasional	$5.9	$6.3	$6.5	$7.0	$6.2	$6.1	$5.3	$5.6	$6.2	$6.3	$5.9	$4.4	$3.9
total	$76.9	$70.8	$61.3	$55.0	$49.4	$45.9	$42.2	$43.0	$41.3	$41.8	$39.0	$37.1	$36.1
Heroin													
heavy use	$21.4	$20.5	$17.3	$12.9	$10.1	$9.6	$9.8	$10.0	$10.6	$10.6	$10.9	$10.7	$10.6
occasional	$0.4	$0.4	$0.4	$0.9	$0.8	$0.6	$0.7	$1.1	$1.2	$1.6	$0.7	$1.3	$1.3
total	$21.8	$20.9	$17.6	$13.8	$10.9	$10.2	$10.5	$11.2	$11.7	$12.2	$11.6	$12.0	$11.9

Since weekly expenditures from DUF data were not available for 1988, we used the 1989 amounts as proxies for 1988 in calculating total expenditures.

Sources: See Tables 3 and 4.

Accounting for Income in Kind

Our expenditure estimates reflect money that actually changed hands at the retail level. But drugs are often obtained as Aincome in kind,@sometimes as payment for serving a role in the distribution chain and sometimes as payment for sex. For reasons explained in Appendix B, we assume that hardcore users of heroin received 22 percent of their drugs as in-kind payment in 1988, but that this percentage fell linearly to 11 percent as of 1995 because of changes in the way that heroin was distributed.[31] We assumed that users of cocaine received 11 percent of their cocaine as income in kind throughout the period.

If we monetize in-kind payments at street prices, then the 1998 dollar expenditure on cocaine would increase by about $4 billion, and the 1998 dollar expenditure on heroin would increase by about $1.5 billion. These totals are not reflected in Table 5, but we do take them into account later when we estimate the bulk amounts of cocaine and heroin used in America.

How Much Cocaine and Heroin is Consumed?

To estimate how much cocaine and heroin Americans consume, we used data from the System to Retrieve Drug Evidence (STRIDE) to estimate the street prices paid for cocaine and heroin. These data come from laboratory analyses of purchases by Drug Enforcement Administration agents, other Federal agents, and some State and local agents. The price varies with the size of the purchase lot. Cocaine is much less expensive when bought as a large lot than when purchased as a smaller lot. This is also true of heroin. Therefore, to estimate the average street price of illicit drugs, it is necessary to know how much a typical buyer purchases each time he makes a purchase. The larger the quantity of drugs purchased, the lower the per unit price. There is scant evidence on this topic. Appendix C details our assumptions.

The price of cocaine fell sharply throughout the early 1980s (not reflected in the table), increased during 1990, and then declined again into 1998 (Table 6). Most of the decline after 1990 is caused by an increase

in the consumer price index. The price of heroin also fell throughout most of the 1980s and the mid 1990s. It has remained relatively constant as of 1995.

Table 7 shows estimates of the amount of cocaine and heroin that was consumed based on the expenditures reported in Table 7 (adjusted to account for drugs earned as income in kind) and the retail prices reported in Table 6. According to the data for the 1988 to 1998 period, cocaine users consumed somewhere between 270 and 400 metric tons of pure cocaine each year. The level of consumption has stayed close to 300 metric tons throughout the 1990s. Heroin users consumed between 7 and 13 metric tons of pure heroin each year during the same period. Consumption has been close to 13 metric tons during the latter part of the decade.

Because estimates are not totally accurate, trends are uncertain. However, it appears that the amount of cocaine consumed in the United States has changed very little over the last eight years. The estimates are somewhat higher in 1988 and 1989 than in later years, but given the margin of error in these estimates, no strong trend is apparent. Total expenditure on cocaine has fallen over time, but this is attributable almost exclusively to using the consumer price index to inflate past expenditures.[32]

Trends in heroin use may be different. The amount of heroin used seems to have decreased from 1988 and 1989 into the early 1990s. Thereafter, heroin consumption may have increased. As already noted, there seem to be fewer heroin addicts in the middle 1990s than there were at the end of the 1980s. The HIV virus and AIDS have taken a toll, and many users have been incarcerated. Yet, prices have fallen so much that remaining users have been able to purchase much more than they did in the past, and these lower prices may have attracted new users into the market.[33]

Other studies provide comparable estimates. Using a much different estimation methodology, Rand researchers estimated that about 451 metric tons of cocaine entered the United States in 1989.[34] This compares with our estimates of 394 metric tons. The Rand researchers estimate that 7.8 metric tons of heroin entered the States in 1991.[35] Our estimate is 6.8 metric tons.

Table 6 - Retail Prices Per Pure Gram for Cocaine and Heroin, 1988-2000 (dollars, 1998 dollar equivalents)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine	$213	$199	$251	$204	$201	$172	$153	$157	$159	$149	$149	$149	$149
Heroin	$3,153	$2,407	$2,378	$2,377	$1,925	$1,468	$1,131	$1,089	$1,048	$1,029	$1,029	$1,029	$1,029

Source: STRIDE 1981 through 1998

Table 7 - Total Amount of Cocaine and Heroin Used, 1988-2000 (in metric tons)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine	401	394	271	299	273	296	305	304	288	312	291	276	269
Heroin	8.5	10.5	8.8	6.8	6.5	7.9	10.5	11.4	12.4	13.1	12.5	12.9	12.9

Sources: See Tables 3 through 6.

Methamphetamines

We applied the computing algorithms used to derive estimate for cocaine and heroin to the problem of getting estimates for methamphetamines. When applied to methamphetamines, the approach does not work as well, for reasons that are discussed in this section. Nevertheless, the calculations are sufficiently accurate to provide rough measures of the number of heavy users as well as of the scale of expenditures and amount used. Calculations are summarized in Table 8.

According to our calculations, there are probably between 300,000 and 400,000 hardcore users of amphetamines. As before, a hardcore user is someone who uses a drug on more than ten days per month. The estimate is technically about amphetamines, because that is the question posed in the DUF interview. Hereafter, however, amphetamine users are assumed to be methamphetamine users. This assumption is

justified by the observation that in 1997, more than 96 percent of those who tested positive for amphetamines were confirmed by a second test to be positive for methamphetamine.

This estimate is tentative for two reasons. The first is that methamphetamine use is rare among arrestees in many cities, so the estimates are really based on the experiences of a few cities, and those experiences are then prorated across the nation. The fact that so few cities account for the estimates may impart additional uncertainty to the calculation. The second reason for skepticism is that the estimates vary markedly from year to year. Most of that year to year variation is hidden in Table 8 because a three-year moving average was applied to smooth the data.

Combining the DUF data from all years, hardcore amphetamine users spend about $90 per week on their use of methamphetamines. The table shows the $90 after adjustment by the consumer price index from 1989 to 2000. Because the sample size is relatively small, we did not attempt to determine a trend in expenditures, but rather, we assumed the $90 estimate applied to all years.

The estimate of total revenue comes from multiplying the number of hardcore users by their weekly expenditure, and then multiplying by 52 to determine a yearly expenditure. The result was multiplied by 4/3 (the reciprocal of 0.75) to account for occasional users. Methamphetamine users currently spend somewhat more than $2 billion per year on methamphetamine use. The next step was to estimate the price of methamphetamine. Appendix C explains the price derivation, and that the price estimate is probably too high or too low over the entire reporting period. It is difficult to know which. The final step is to divide total revenue by the price per pure gram. If casual users account for roughly 25 percent of consumption, the estimate is 9 to 16 metric tons. As noted, seeking precision would be quixotic; these estimates are best treated as matters of scale with a wide (but unknowable) confidence interval.

There is scant evidence to support any secondary check on these calculations. According to the TEDS data, 15 to 18 percent of treatment admissions between 1992 and 1997 identified cocaine as the primary drug of abuse. Methamphetamine was the primary drug for between 1.0 percent (1992) and 3.6 percent (1997) of admissions. If we take the 1997 numbers to imply that there were 5 hardcore cocaine users for every 1 hardcore methamphetamine user, and if we accept the estimates of the number of hardcore cocaine users from earlier, then there would be about 700,000 hardcore methamphetamine users. That is about double the estimate reported in Table 8. If we take the 1992 numbers to imply that there were roughly 15 hardcore

cocaine users for every hardcore methamphetamine user, and if we again use the earlier estimates of hardcore cocaine users, we would say there are about 230,000 hardcore methamphetamine users, somewhat more than half of the number that we actually estimate. Perhaps there is some comfort here that the scale is about right, but precision is elusive.

Assuming the scale is about right, what can be said about the trend? The TEDS data show an increase in admissions with methamphetamine named as the primary drug of abuse. Just 1.0 percent of admissions in 1992 and 1.3 percent of admissions in 1993 were for methamphetamines. This compares with 2.6 percent in 1996 and 3.6 percent in 1997. We do not see those trends reflected in Table 8. This may be because hardcore users can take years to enter treatment for the first time, but after their first admission, subsequent admissions happen more frequently. Thus, a relatively constant number of hardcore methamphetamine users between 1989 and 1999 could be consistent with an increase in treatment admissions.

Drug prices might be considered a barometer of the availability of an illicit substance, which in turn partly determines the number of hardcore users. Rhodes, Johnson and McMullen[36] report that the proportion of hardcore methamphetamine users in five jails, which had an appreciable number of methamphetamine users, showed cyclical behavior between 1989 and 1998. The proportion fell through 1991, and it then increased to a new peak in 1994. Thereafter, the proportion decreased. Rhodes, Johnson and McMullen show that prices moved in the opposite direction (up when use was down, and down when use was up) throughout this period, reinforcing the inference that prices are a barometer of methamphetamines= availability.

Table 8 - Calculation of Total Methamphetamine Consumption, 1989-2000

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of Hardcore Users (thousands)	386	339	290	314	389	479	414	376	310	356	356	356
Median weekly expenditure	$118	$112	$108	$105	$102	$99	$96	$93	$91	$90	$87	$87
Price per pure gram	$207	$227	$194	$229	$215	$192	$184	$171	$167	$140	$140	$140
Total expenditures (billions)	$	$	$	$	$	$	$	$	$	$	$	$
	3.2	2.6	2.2	2.3	2.7	3.3	2.8	2.4	2.0	2.2	2.2	2.2
Metric tons	15.3	11.6	11.2	9.9	12.7	17.1	15.0	14.3	11.8	15.9	15.4	15.4

Sources: NHSDA 1988, 1990 through 1997; STRIDE 1981 through 1998; DUF 1989-1998; Uniform Crime Reports 1988-1997.
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Marijuana

In this section, we estimate the dollar value of marijuana consumption by multiplying the following factors: number of users in the past month, by the average number of joints used in the past month, by the average weight per joint, by the cost per ounce. Calculations are summarized in Table 9.

Number of Marijuana Users

More Americans use marijuana than either cocaine or heroin. During 1998, for example, about 11 million Americans used marijuana or hashish at least once in the month before the NHSDA. This number is about the same as it was in 1988: 11.6 million. The trend was for decreasing use into the early 1990s and then increasing use into the late 1990s.

Average Number of Joints Used Each Month

We calculated an individuals total number of joints used each month by multiplying the number of days of marijuana use in the past month by the number of joints used per occasion. For those without valid answers

for these questions, we imputed the total monthly use (see Appendix D). In 1995 the NHSDA stopped asking respondents about the number of joints and amount of marijuana used in the last month. Because marijuana users reported using an estimated 18.7 joints per month in 1994, we assumed the same was true for years after 1994.

Average Amount of Marijuana Used

The average amount of marijuana used in the past month was calculated from several questions in the survey (see Appendix D). This number has changed little over time **B** about 0.014 ounces per joint.

However, the average number and weight of joints used by those who smoke marijuana cannot tell the entire story about trends in marijuana use because marijuana=s THC content has changed over time. Delta-9 tetrahydrocannabinol (THC) is marijuana=s primary psychoactive chemical. According to a study conducted at the University of Mississippi,[37] the average THC content of sinsemilla was at a relative peak in 1990 and 1991. That average fell from 10.5 percent in 1991 to 8.6 percent in 1992, and to 6.0 percent in 1993. The THC content of commercial-grade marijuana remained fairly constant at less that 4.0 percent from 1985 to 1992, but jumped to about 5.4 percent in 1993. According to the 1995 National Narcotics Intelligence Consumers Committee (NNICC) report, the THC content of commercial grade marijuana averaged 3.3 percent, and the THC content of sinsemilla averaged 6.7 percent, in 1995; according to the 1997 NNICC report, the commercial grade content was 5.0 percent, and the sinsemilla content was 12.2 percent. Because we do not know the mix of sinsemilla and commercial-grade marijuana used by the typical user, we cannot know, for certain, whether users are smoking more or less marijuana as measured by THC content.

Price

Price is the final factor in calculating the total value of marijuana consumption (see Appendix D). Marijuana prices were roughly $350 per ounce in the late 1980s. These prices are for a one-third ounce purchase, which appears to be a typical purchase size by frequent users. They jumped to closer to $450 per ounce during the early 1990s. Throughout the rest of the decade, prices were considerably lower. The price trends appear to be roughly consistent with trends in THC content. That is, marijuana prices were relatively low in the late 1980s when sinsemilla=s THC content was comparatively high. Excluding 1990, prices were comparatively high in the early 1990s when THC content was low. Low prices toward the end of the 1990s

correspond to high THC content. Taken together, these two trends suggest that marijuana was more difficult to buy in the early 1990s than it was before and than it has been since the early 1990s.

Table 9 - Calculation of Total Marijuana Consumption, 1988-2000

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of Users (millions)	11.6	10.9	10.2	10.4	9.7	9.6	10.1	9.8	10.1	11.1	11.0	11.4	11.7
Joints used per month	16.9	17.3	17.6	16.6	17.2	17.8	18.7	18.7	18.7	18.7	18.7	18.7	18.7
Weight of a joint (ounces)	0.0134	0.0135	0.0137	0.0135	0.0134	0.0136	0.0136	0.0136	0.0136	0.0136	0.0136	0.0136	0.0136
Price per ounce, 1/3 ounce purchase	$357	$364	$459	$457	$465	$403	$369	$310	$293	$297	$320	$293	$293
Total expenditure for the year ($ in billion dollar equivalents)	$11.3	$11.1	$13.5	$12.8	$12.5	$11.2	$11.4	$9.3	$9.0	$10.1	$10.7	$10.2	$10.4
Metric Tons	894	866	837	793	761	791	874	848	874	960	952	982	1009

Sources: NHSDA 1988, 1990 through 1998; STRIDE 1981 through 1998.

Total Consumption Estimates

The factors required to calculate total marijuana consumption are shown in Table 9. In 1998, we estimate that average users consumed 18.7 joints a month. The average amount of marijuana used per joint equaled 0.0136 ounces.[38] At a retail price of $320 an ounce, these users spent an average of $81 each month ($980 a year) on marijuana. This number, multiplied by the 11 million monthly users, yields a consumption estimate of $11 billion for the year.

These estimates may be low. Users are likely to under report socially disapproved behaviors, even when those behaviors are legal.[39] They would seem to have even more incentive to under report illegal behaviors.[40] Given under reporting rates for tobacco and alcohol use, it might be reasonable to inflate marijuana estimates by about one-third. On the other hand these estimates could be too high. Joints are frequently shared, and it seems plausible that these calculations double count some consumption. At any rate, our estimates of total spending are in line with estimates by others.[41]

Other Drugs

Most of the money spent on illicit drugs in America is spent on cocaine, heroin, marijuana, and methamphetamine. However, expenditures on other illicit substances (inhalants and hallucinogens) and on licit substances consumed illegally (other stimulants, sedatives, tranquilizers, and analgesics) is not small. Much of this drug use appears to be reported to the NHSDA.[42] We do note, however, that the NHSDA undoubtedly misses some users, and those who are reached probably have an incentive to misrepresent their consumption.

Table 10 shows the number of respondents who, according to the NHSDA, used these other drugs between 1988 and 1998. To complete the table, estimates for 1999 and 2000 were set to the 1998 estimate. Those respondents who admitted use during the year were asked how frequently they used the drug.[43] We then used these data to compute an average number of days a year that the respondents used a drug.[44] Since the survey lacks information about the number of doses taken on days that the drug was used, we assumed that each day of use resulted in a single dose. This is most certainly an underestimate.

It is difficult to determine prices per dose. Both the Drug Enforcement Administration's (DEA) Illegal Drug Price/Purity Report and the National Institute on Drug Abuse's Community Epidemiological Working Group (CEWG) provided wide ranges.[45] For current purposes, we assumed that each dose costs $5, a price that was consistent with those reported by the DEA and the CEWG. These street prices may be too high, however, because many of the legal drugs were likely to have been purchased at prescription prices and diverted to illegal use.

To estimate the yearly expenditures on these drugs, we multiplied three factors: the number of users, by the average number of doses per year, by the price per dose. Our best estimate is that Americans spent between $1.5 billion and $3.3 billion on other drugs during each of the last eleven years (Table 10).

These estimates are imprecise for the reasons noted above. However, even if we halve or double the estimates to reflect uncertainty, drugs other than cocaine, heroin, marijuana and methamphetamines must be a relatively small part of the total expenditure that Americans make on illicit substances and on legal substances consumed illegally.

Conclusion about Consumption

According to the consumption-based procedure, Americans spent about $66 billion on heroin, cocaine, methamphetamine, marijuana, and other illegal drugs in 1998: $39 billion on cocaine, $12 billion on heroin, $11 billion on marijuana, $2.2 billion on methamphetamine, and $2.3 billion on other illegal drugs (Table 11). Table 11 appears to show a substantial decrease in expenditures on illicit drugs between 1988 and 1998. Most of this change is attributable to inflation as reflected in the consumer price index. This decrease may not be apparent to hardcore users, because illicit drug consumption is a predominant part of their market basket (illicit drugs are not part of the market basket used to compute the CPI), while the nominal price of heroin and cocaine have fallen or remained about the same since 1988, and the price of marijuana has fallen since 1992. On the other hand, these decreased expenditures may have very real consequences for dealers, who probably have market baskets that are much more like that of typical American consumers.

In this section of the report we examined the use of drugs, that is, the demand for illicit drugs and for licit drugs used illegally. In the next section, we examine the availability of illegal drugs in the domestic market. Comparing the amount of drugs consumed (from this section) with the amount of drugs available for

consumption (the next section) provides additional confirmation that consumption-based estimates are credible.

Table 10 - Other Drugs: Total Yearly Users (thousands) and Expenditures ($ in billions, 1998 dollar equivalents), 1988-1998

Drug Used	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of Users													
Inhalants	2,441	2,327	2,212	2,379	1,889	1,940	2,213	2,308	2,427	2,329	2,009	2,009	2,009
Hallucinogens	3,200	2,775	2,350	2,562	2,530	2,479	2,725	3,416	3,602	4,063	3,565	3,565	3,565
Stimulants	2,698	3,009	2,319	2,010	1,478	1,774	1,419	1,656	1,896	1,687	1,489	1,489	1,489
Sedatives	1,376	1,184	991	946	702	702	736	666	678	638	522	522	522
Tranquilizers	4,124	3,250	2,376	3,143	2,380	2,380	2,405	2,210	2,430	2,122	522	522	522
Analgesics	5,342	5,164	4,986	5,063	4,560	4,560	4,247	4,102	4,510	4,210	4,070	4,070	4,070
Expenditures	**$3.3**	**$2.8**	**$2.2**	**$2.3**	**$1.5**	**$1.5**	**$2.6**	**$2.7**	**$2.7**	**$2.5**	**$2.3**	**$2.3**	**$2.3**

Source: NHSDA 1988, 1990 through 1998

Table 11 - Total Expenditures on Illicit Drugs, 1989-2000 ($ in billions, 1998 dollar equivalents)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cocaine	$76.9	$70.8	$61.3	$55.0	$49.4	$45.9	$42.2	$43.0	$41.3	$41.8	$39.0	$37.1	$36.1
Heroin	$21.8	$20.9	$17.6	$13.8	$10.9	$10.2	$10.5	$11.2	$11.7	$12.2	$11.6	$12.0	$11.9
Methamp	$3.2	$3.2	$2.6	$2.2	$2.3	$2.7	$3.3	$2.8	$2.4	$2.0	$2.2	$2.2	$2.2
Marijuana	$11.3	$11.1	$13.5	$12.8	$12.5	$11.2	$11.4	$9.3	$9.0	$10.1	$10.7	$10.2	$10.4
Other Drugs	$3.3	$2.8	$2.2	$2.3	$1.5	$1.5	$2.6	$2.7	$2.7	$2.5	$2.3	$2.3	$2.3
Total	$116.5	$108.8	$97.3	$86.1	$76.5	$71.5	$70.0	$68.9	$67.2	$68.6	$65.6	$63.7	$62.9

Columns may not add due to rounding error.
Sources: Tables 3 through 9

2   Drug Supply Estimates

This section discusses the information and assumptions we used to estimate the supply of cocaine and heroin to the United States. For reasons discussed below, it is not practical to develop estimates for marijuana, methamphetamine, or other illegal drugs.

Cocaine

The process for estimating cocaine supply has been evolving over the past ten years. Since 1990, ONDCP has estimated the supply of cocaine by beginning with the potential cocaine production estimate and sequentially decreasing this amount by subtracting losses. The potential cocaine production estimate was based on imagery of coca crop fields, whose figures were then combined with leaf yield, alkaloid content, and base processing efficiency multipliers. In 1996, a U.S.-intelligence working group initiated an event-based process for estimating the amount and routes of cocaine departing South America. In March 2000, the Crime and Narcotic Center integrated data on potential cocaine production estimates with Western-hemisphere consumption estimates to calculate the amount of cocaine available for the non-U.S. markets. Our approach was to design a cocaine flow model, which standardized the terms and measures, so various existing estimation-processes (e.g., coca cultivation, domestic consumption estimates) could be integrated into one complete and coherent set of flow estimates. This model attempts to triangulate a coherent estimate of cocaine availability along the entire route of cocaine flow, and is referred to as the Sequential Transition and Reduction (STAR) model.

The STAR model incorporates diverse estimates of the production and distribution of cocaine into one cohesive, connected model. The model hinges on the notion of a transition, or movement, of cocaine from one stage in the production/distribution process to the next stage in that process. A transition is a computational link between stages that, after accounting for reductions (seizures, losses, etc.), converts drug (or drug precursor) at one stage into drug at another stage. Stages are geographic locations corresponding to established levels (e.g., political borders, growing areas, transshipment countries) in the course of drug (or source constituent) flowing from source to street. Details regarding this model are available in a companion report.[46] Readers should consult that report for specifics; a summary follows.

Description of Stages

    This model establishes a coherent set of stages, established on the basis of existing supply-reduction strategies, which conform to the trafficker's patterns in cultivation, production, transshipment, and distribution. Mathematically, the model links supply estimates at each stage by transition matrices that account for conversions in cocaine state, reductions such as consumption and seizures, and geographic routing of the cocaine. In this way, the model contains a consistency between the "micro" flow within a geographic region and the "macro" estimates of cocaine supply between stages. Figure 1 presents a geographic presentation of the nine stages of movement describing cocaine supply.

Figure 1- Description of stages in the flow of cocaine from source to street
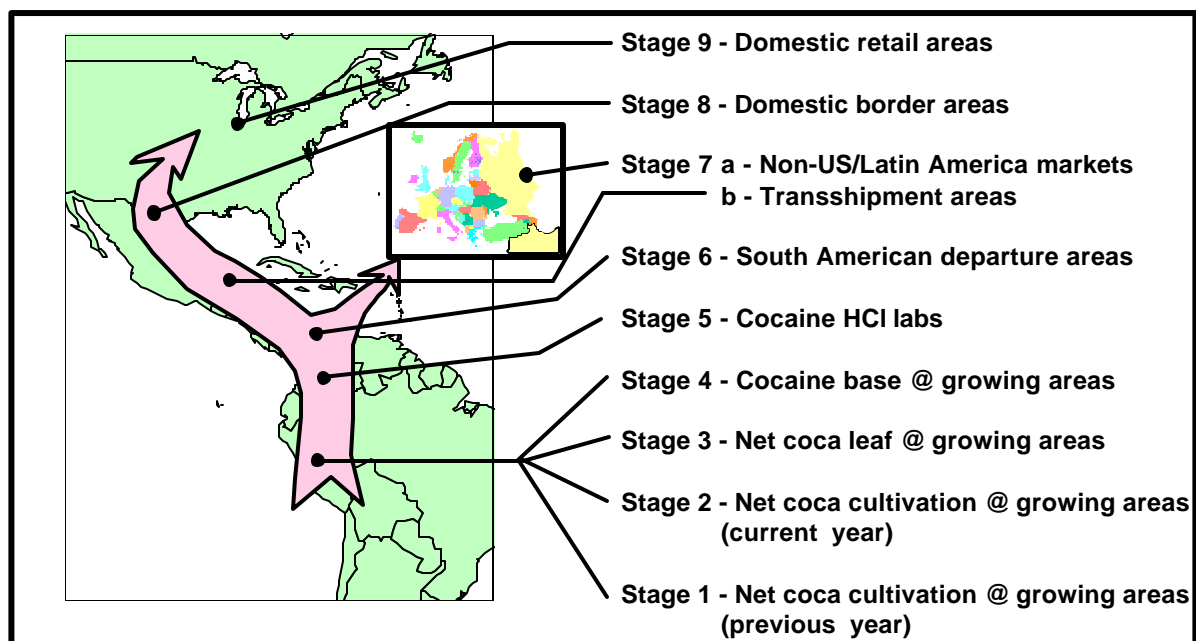
Each of the stages can be described as follows:
- Stage 1, Net coca cultivation for the previous year. Expressed in hectares and is distributed among the various coca-growing areas of the Andean Ridge.
- Stage 2, Net coca cultivation for current year. Expressed in hectares and is calculated from taking the previous stage and accounting for new growth and reductions from eradication and field abandonment in the various growing areas.
- Stage 3, Net leaf tonnage. Expressed in metric tons and is determined by applying leaf-yield conversions to the previous stage, then accounting for leaf seizure and consumption reductions.
- Stage 4, Cocaine base: is expressed in metric tons of cocaine base and is determined by applying

29

alkaloid-content and lab processing efficiency figures to the previous stage and accounting for cocaine-base seizure reductions.

- Stage 5, Cocaine at HCl labs.. Expressed in metric tons of cocaine, is measured at the HCl labs distributed within South America, and accounts for losses of cocaine-HCl at the labs.
- Stage 6, South American departure areas. Expressed in metric tons of cocaine, is measured at the South American departure areas, and is reduced by South American seizure and consumption losses.
- Stages 7a and b, Transshipment area and world markets. After departure from South America, cocaine is smuggled toward its markets in the United States, Canada, Europe, and the rest of the world. Most of the cocaine destined for the United States is initially smuggled to transshipment locations (Stage 7a) in Mexico, Central America, and the Caribbean islands including the Bahamas and the Antilles. Additionally, cocaine is shipped to non-U.S./Latin American markets overseas and in Canada (Stage 7b). Cocaine estimates at both stages 7a and 7b are reduced by en-route losses due to en-route seizures and consumption in the transshipment countries.
- Stage 8, U.S. border. From the transshipment areas, cocaine moves across the U.S. border, after accounting for seizure losses at the U.S. border.
- Stage 9, U.S. retail locations. From the border, cocaine is transported to retail markets in the United States, after accounting for domestic seizures.

Although the STAR Model theoretically provides a complete and coherent set of connected stages, input data was not always available. Additionally, supply data has varying degrees of certainty. As a result, the STAR Model combines data from various sources to triangulate an estimate of cocaine availability. One of the triangulation legs begins with the coca cultivation estimates and works toward an annual estimate of cocaine available for export from South America. The second leg in the triangulation begins with the domestic consumption estimate, described earlier in this paper, and works backward toward an independent estimate of cocaine departing South America. The third triangulation leg is the event-based estimate of cocaine availability developed by the Interagency Assessment of Cocaine Movement (IACM) working group, which also estimates the amount of cocaine annually departing South America. Development of each of these triangulation estimates will be described, and then compared to illustrate the coherence of the STAR Model estimates.

Cultivation-based Supply Estimates

The STAR Model starts with data on cultivation and cocaine processing. CNC uses statistical survey methods, similar to those employed by agricultural organizations estimating the size of licit crops, to estimate the quantity of coca under cultivation in Colombia, Peru and Bolivia. CNC-s survey randomly samples potential growing areas, placing a higher sampling probability on known growing regions, and satellites and airplanes then photograph the selected areas. CNC analysts interpret the resulting images to develop country-wide coca crop estimates. The uncertainly in this approach has been estimated by CNC to be +/-10%.

Operation Breakthrough, a series of studies done by the DEA, provides data on coca crop productivity and base processing efficiencies. The three critical factors in calculating cocaine production from the cultivation estimates are the leaf yields, alkaloid content of the coca leaf, and the base processing efficiency. These factors can have significant uncertainty during transition periods, such as 1993-99, when Colombian cultivation increased dramatically. Figure 2 depicts the annual changes in the distribution of Andean potential production, and the effect of the revised estimates.

Figure 2 - Andean Potential Cocaine Production Estimates, 1990-1999 (pure metric tons)
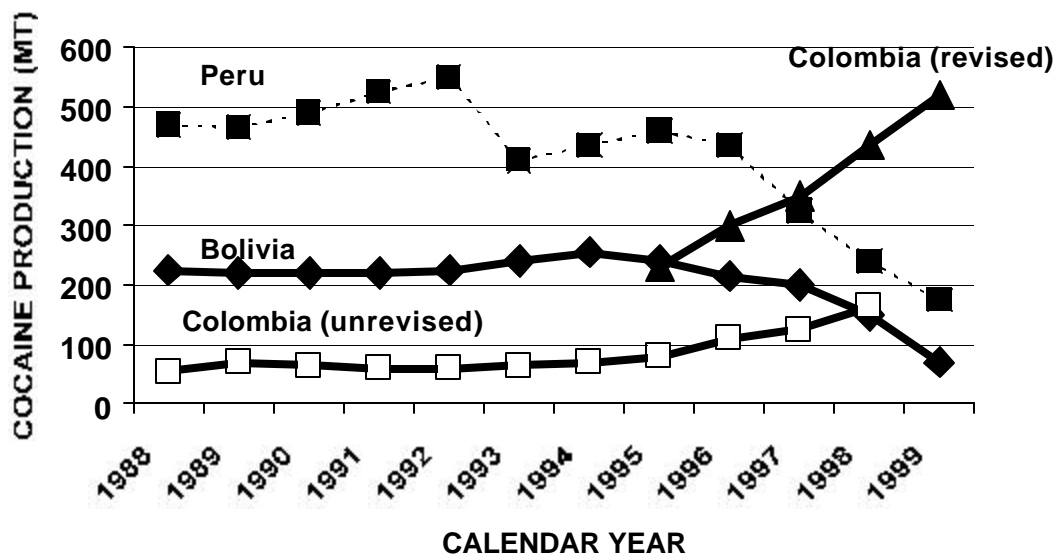
Table 12 shows the STAR Model's estimates of cocaine and its source-constituents, from cultivation, through production, to export from South America. The reader should be aware that these figures will be lower than the annual potential production estimates because they account for losses such as leaf seizures and spoilage, base seizures, and HCl seizures in South America.   The STAR Model estimates for cocaine at the various stages is discontinuous from Stage 5 (at the HCl labs) to Stage 6 (at the South American departure areas) because that transition requires an estimation of South American cocaine consumption, which is currently not available. Stage 5+, shown in Table 12 below, represents the estimate of cocaine supply available for export (or consumption in South America), once South American seizures have been

31

subtracted from the Stage 5 estimate.

Table 12 - Net cocaine produced for illicit markets (units as noted)

STAGE	DESCRIPTION	1996	1997	1998	1999
1	Previous Net Cultivation (ha)	214,800	209,700	194,100	190,800
2	Net Cultivation (ha)	209,700	194,100	190,800	183,000
3	Dry Coca leaf (mt)	306,782	267,663	239,435	203,305
4	Cocaine base (mt)	887	803	759	687
5	Cocaine HCl at labs (mt)	841	774	702	666
5+	HCl at labs, less South American seizures (mt)	795	715	628	613

Domestic Consumption-based Supply Estimates

Once the stages and transitions were established by the STAR Model, cocaine supply estimates could be calculated by starting at either end: either by beginning with the coca cultivation estimates and working forward to estimate cocaine supply available for domestic consumption, or by beginning with the domestic consumption estimates and working backward to estimate actual cocaine production. This section will describe the latter approach.

An estimate of cocaine availability at departure from South America (Stage 6) was determined by the STAR Model, based on the domestic consumption estimate, discussed earlier. The annual estimates of domestic cocaine consumption, shown in Table 7, were input into the STAR Model for Stage 9. From this estimate, losses such as domestic, border and transshipment seizures were added. Consumption estimates for non-U.S. countries were also added to the domestic consumption figures to result in an estimate of actual cocaine production departing South America. Table 13 shows the stage-by-stage figures.

Table 13 - Net cocaine produced for domestic retail market (metric tons)

STAGE	DESCRIPTION	1996	1997	1998	1999
6	HCl at South American departure	532	596	564	574
7a	Non-US/Latin America HCl consumption	(-78)	(-99)	(-88)	(-105)
7b	HCl at transshipment area	382	385	375	347
8	HCl at U.S. border area	333	337	337	313
9	HCl at U.S. retail markets	288	312	291	276

Note: Non-U.S./Latin American consumption is shown as a negative loss.

Event-based Supply Estimates

The Interagency Assessment of Cocaine Movement (IACM)[ii] uses an event-based, interagency consensus methodology to quantify intelligence reports about cocaine movement through the transit zone. Each quarter, intelligence and operations analysts from the various interdiction agencies meet to discuss their perception of cocaine movements departing South America. If the information for a particular event is sufficient, the event is included into a data base, and pertinent data on the event is recorded. One piece of information is the load-size of the cocaine contraband conveyed by the movement. This load-size is based on one of three sources: observation (usually a seizure), confidential informants, or historical trend analysis. Once the data base of events is complete for the year, the sum of the load-sizes provides an estimate of cocaine departing South America.

Table 14 shows the annual estimates for cocaine flow through each transshipment corridor, assuming export quality purity. The annual total is converted to pure metric tons by adjusting for purity, to result in an independent estimate of cocaine departing South America.

Table 14 - Event-Based Cocaine Amounts Departing South America By Transit Corridor, 1996-1999 (bulk metric tons) [iii]

	1996	1997	1998	1999
Caribbean	174.5	138.4	160.3	220
Mexico/Central America	341.7	250.7	318.6	277
Direct to U.S.	91.2	43.9	51.4	15
Non U.S. Destinations	42.8	62.6	64.5	75
Unknown	2.5	-	1.0	-
Total (*Export Quality*)	**652.7**	**495.6**	**595.8**	**587.0**
Total (*Pure)*	**541.7**	**411.8**	**488.0**	**480.8**

Comparison of Cocaine Supply Estimates

The three sets of figures described above all provide estimates of cocaine departing South America. Figure 3 compares these three annual estimates of cocaine departing South America:

       1) based on the coca cultivation estimates, from the STAR Model,

       2) based on the domestic consumption estimates, from the STAR Model, and

       3) based on an assessment of movement events.

The domestic consumption-based and the event-based estimates correlate closely in magnitude (500-600 mt /year), and in trend. An uncertainty bar of -148 metric tons was attached to the cultivation-based estimate to account for the unknown South American consumption losses. This was the estimate of South American consumption for 1999 developed by the Crime and Narcotics Center. When the uncertainty-bars are included, the cultivation based estimate encompasses the other two figures for 1998-99. The STAR estimate of cocaine departing South America shows a decreasing trend over the four years, which is not consistent with other trends. Worldwide seizures and domestic consumption have been stable over the past four years; Latin American and European consumption is believed to be increasing; therefore, cocaine availability for world consumption should be stable or increasing. But without better cocaine cultivation and production data, these uncertainties will remain.

Figure 3 - Comparison of cocaine availability estimates, metric tons
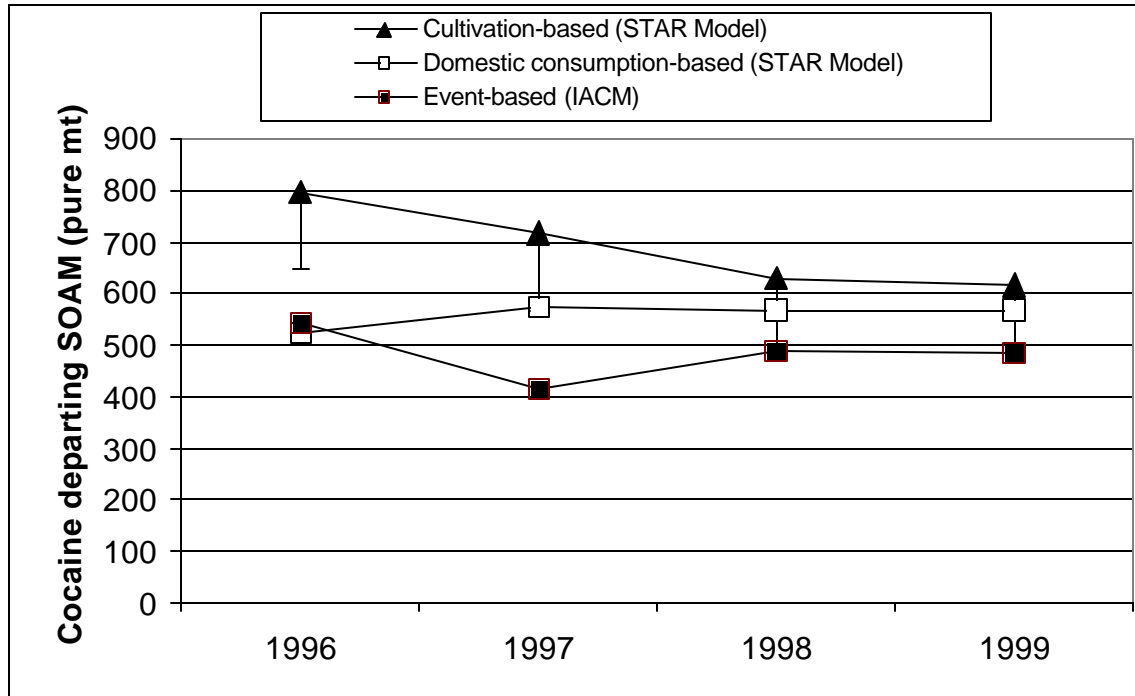
For this paper, we wanted to compare the supply estimates with our consumption estimates to understand the reasonableness of our approach. To this end, we used the STAR Model to extrapolate both the cultivation-based estimate and the event-based estimates of cocaine departing South America, to calculate domestic consumption. Each estimate of cocaine availability departing South America was reduced by the figures shown in Table 15 below.

Table 15 - Cocaine Losses (pure metric tons)

	1996	1997	1998	1999
Non-US seizures	19.1	30.7	24.6	39.3
Non-US consumption	68.8	72.7	91.2	108.1
Transshipment seizure.	44.0	71.5	66.3	60.6
Transit Zone consumption	9.3	10.4	10.0	21.0
Border seizures	48.9	47.7	38.0	34.7
Domestic seizures	45.1	25.0	45.8	25.4
SUM	235.2	258.1	275.9	289.5

Table 16 below shows a comparison of domestic consumption estimates based on three approaches: 1) consumption estimate explained in this paper, 2) the event-based estimate, and the cultivation-based estimate. The cultivation-based estimate is shown as a range, because the 148 metric ton estimate of South American consumption has been subtracted for the lower limit.

Table 16 - Comparison of Domestic Consumption Estimates (pure metric tons)

	1996	1997	1998	1999
Consumption Estimate	288	312	291	276
Event-based	307	154	212	191
Cultivation-based	411-559	309-457	204-352	176-324

Heroin

The modeling approach used for heroin differs from that for cocaine. While the bulk of cocaine production is destined for the United States, less than five percent of worldwide heroin/opiate production is sent to the United States, so modeling the flow from production to consumption is impractical. Also, dissimilar data are

collected for heroin and cocaine. For example, heroin has no counterpart to the Interagency Assessment of Cocaine Movement (IACM), so we know less about the dynamics of heroin movement than about cocaine movement. On the other hand, cocaine has no counterpart to the DEA=s Domestic Monitor Program (DMP) and Heroin Signature Program (HSP). A heroin availability model must differ from a cocaine availability model, because it is constructed from a different empirical base.

This section presents a model of the movement of heroin into the United States. Details appear in a companion report.[47] We do not consider the model as final, because data about heroin trafficking continues to grow, and modeling improvements will follow from better data. Nevertheless, the model is an important step toward structuring what is currently known about the ways that heroin suppliers provide drugs to the United States. Like its cocaine counterpart model, the heroin flow model seeks to weave together and reconcile various estimation systems into one comprehensive model.

Model of Heroin Availability

Figure 4 depicts an overview of the heroin model. The rest of this report elaborates, and the companion report provides details. Whereas the cocaine movement model takes potential production estimates as its starting point, the heroin model begins at the other end **B** with the U.S. consumption estimates that were developed earlier in this report.

The source of heroin consumed in the U.S. is partitioned into four production areas: South America, Mexico, Southeast Asia and Southwest Asia. That partitioning is based on an analysis of data from the Heroin Signature and Domestic Monitor Programs, first done by Abt Associates for the Drug Enforcement Administration [48] and later extended for the Office of National Drug Control Policy.

The Federal-Wide Drug Seizure system provides the best estimates of where heroin enters the United States. As shown subsequently, most seizures were in California, Texas (and Arizona), Florida (and Puerto Rico), and New York (including New Jersey) so the figure identifies those four principal entry points. The source country of those seizures is estimated from the Heroin Signature Program (HSP).

Figure 4 - Overview of a Heroin Flow Model
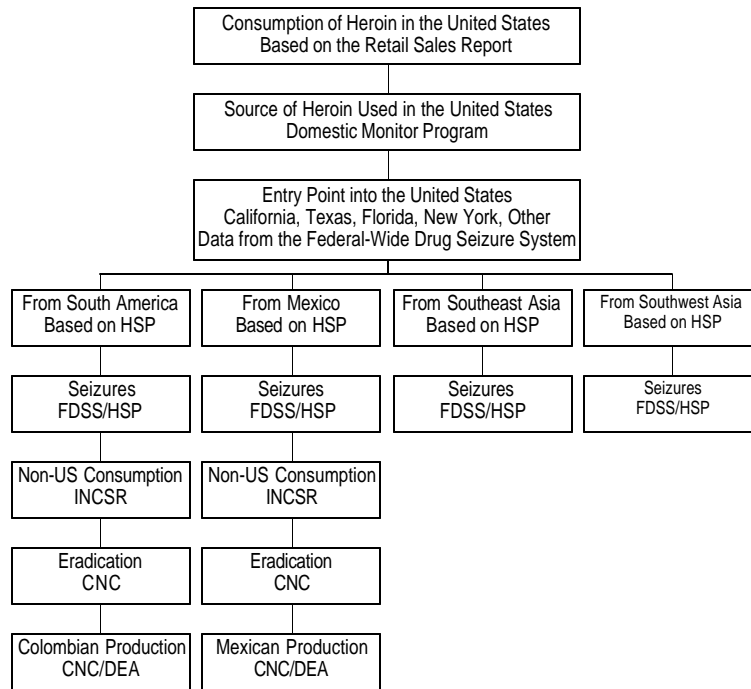
The model takes into account seizures and non-U.S. consumption of South American and Mexican heroin. However, according to reports by the Community Epidemiological Working Group (CEWG) and the U.N. World Drug Report, consumption seems minimal within Colombia and Mexico, so most South American and Mexican heroin is probably destined for the United States. Because non-U.S. consumption accounts for so much of the Southeast and Southwest Asian heroin, the model accounts for heroin movement from Southeast and Southwest Asia at the U.S. border, but not earlier.

The model provides a consumption-based estimate of the amount of heroin produced in South America and Mexico. CNC provides a production-based estimate of the heroin production potential in the same areas. After accounting for seizures and other leakage, the supply-based estimates should agree with the consumption-based estimate at least roughly B if not, something is wrong with the consumption model, with CNC=s production estimates, or both. CNC also estimates potential production for Southeast and Southwest Asia, but there is no apparent way to tie a consumption-based model into those estimates.

Determination of Source Area

The Drug Enforcement Administration supports two programs ẞ the Heroin Signature Program and the Domestic Monitor Program ẞ to determine the source area (South America, Mexico, Southeast Asia and Southwest Asia) of heroin collected at three points: seizures at ports of entry, a random sample of other seizures and purchases, and DMP purchases. We included all specimens weighing less than one gram in a retail-level sample, comprising all the DMP data and several purchases from the random sample. We used that retail-level sample to estimate the sources of heroin used in the United States.

Our inferences are based on the retail-level sample, rather than an importation-level sample, because the retail-level sample comes closest to representing heroin actually consumed in the United States. Still, raw data tabulations are not very useful, for two reasons. First, some of the retail level specimens have too little drug to afford a signature, so the source area is unknown. This creates some problems, because Mexican heroin is easily identified and therefore is rarely classified as unknown. To prevent Mexican heroin from being over-represented in the data, we developed imputation routines for assigning a signature to every sample in the retail level data where an imputation seemed justified. Second, the Domestic Monitor Program oversamples in places where heroin use is relatively rare. (For example, St. Louis has a quarterly sample size of 10 purchases, while Baltimore has the same sample size but many more heroin users and purchases.) We developed a weighting procedure so that the signature program would represent a national estimate.

We have been unable to classify about 10% of the heroin seized and purchased since 1995. These unclassified samples are reported as unknown (UNK) in Table 17, which details estimates for the percentage of heroin from each source area. Because data were not available for 1998 and later, the 1998 and 1999 estimates are projections ẞ that is, they are the averages for 1995 through 1997.

If we are correct about these percentages, and if we are correct that between 1995 and 1998 about 12 to 13 metric tons of heroin used per year in the United States, then we can derive estimates of the amount of heroin that come from each area (Table 18). We do not provide estimates before 1995, because the unknown signature category is comparatively large before 1995.

Table 17 - Source of Heroin Used in the United States (Projected for 1998 and 1999) (Percentages)

Year	Mexico	South America	Southeast Asia	Southwest Asia	Unknown
1993	26.2	13.1	17.6	9.1	34.1
1994	25.6	27.6	21.4	3.8	21.6
1995	26.4	46.6	11.6	2.6	12.7
1996	26.1	51.2	11.6	4.0	7.1
1997	22.8	52.5	10.0	5.6	9.1
1998	25.1	50.1	11.0	4.1	9.6
1999	25.1	50.1	11.0	4.1	9.6

Sources: Data from the Heroin Signature Program and Domestic Monitor Program

According to these calculations, U.S. consumers use somewhat less than 7 metric tons of South American heroin and somewhat more than 3 metric tons of Mexican heroin. However, the South American and the Southeast and Southwest Asian numbers might be somewhat higher depending on how the unknown signatures are partitioned across the data.

Table 18 - Estimated Amount of Heroin from Each Source Area (metric tons)

	1995	1996	1997	1998
Mexico	3.0	3.2	3.0	3.1
South America	5.3	6.3	6.9	6.2
Southeast Asia	1.3	1.4	1.3	1.4
Southwest Asia	0.3	0.5	0.7	0.5
Unknown	1.4	0.9	1.2	1.2
Total	11.4	12.4	13.1	12.5

Source: See Table 7.

Seizure Levels

Some foreign production gets seized as it enters the United States. We tabulated heroin seizures reported in the FDSS from 1991 through the first half of 1998. To provide greater comparability between 1998 and earlier years, we interpolated seizures for the entire year by doubling seizures from the first half of 1998. The figure seems to show that seizures have varied between about 1.2 and 1.6 metric tons from 1991 through 1998. There is no apparent trend.

There is a second useful way to look at these data. Between 1991 and 1998, 99.2 percent of all seizures were less than 10 kilograms. Likewise, 99.7 percent of all seizures were less than 20 kilograms and 99.9 percent of all seizures were less than 50 kilograms. If we exclude all seizures larger than 50 kilograms from the tabulation, seizures have remained fairly constant at about 1.2 metric tons. Apparently, exceptionally large seizures can occasionally lead to spikes in the seizures observed during any year, distorting the trend. When large seizures are included in the estimates, an annual seizure rate of 1.3 metric tons seems representative of law enforcement success at preventing heroin from entering the United States.

Figure 5 - Heroin Seized by Year Metric Tons
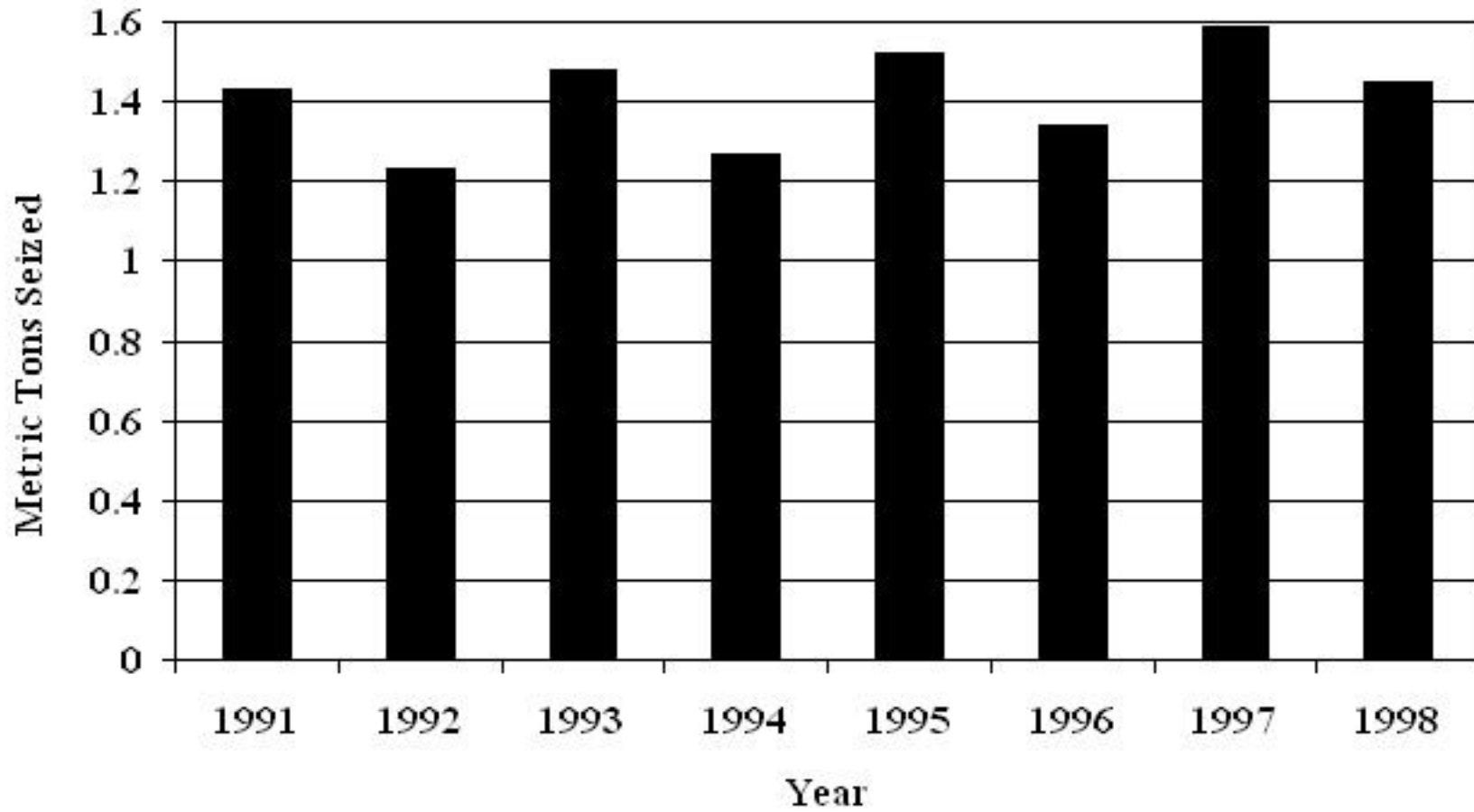
In fact, when imported into the United States, heroin is typically about 80 percent pure.[49] Thus the 1.3 metric tons of bulk heroin probably translate into somewhat more than 1 metric ton of pure heroin being seized as it enters the United States. According to the 1999 INCSR, Mexican authorities have seized between 0.14 and 0.38 metric tons of heroin (or opium equivalent) every year since 1995. Given what U.S. authorities seize, Mexican traffickers seem to lose on average about 0.34 metric tons per year. Colombian authorities never seized more than about 0.15 metric tons per year, so seizures probably account for an average of about 0.75 metric tons of Colombia=s production per year.

Importation Points

Where do these seizures occur? Most seizures happen in one of four importation areas, defined:

$ New York (includes New Jersey)
$ Florida (includes Puerto Rico)
$ California
$ Texas (includes Arizona)

The rest of the seizures occur throughout the United States.

Figure 6 –Proportion of Heroin Seized by State (Region) Weighted by Seizure Size
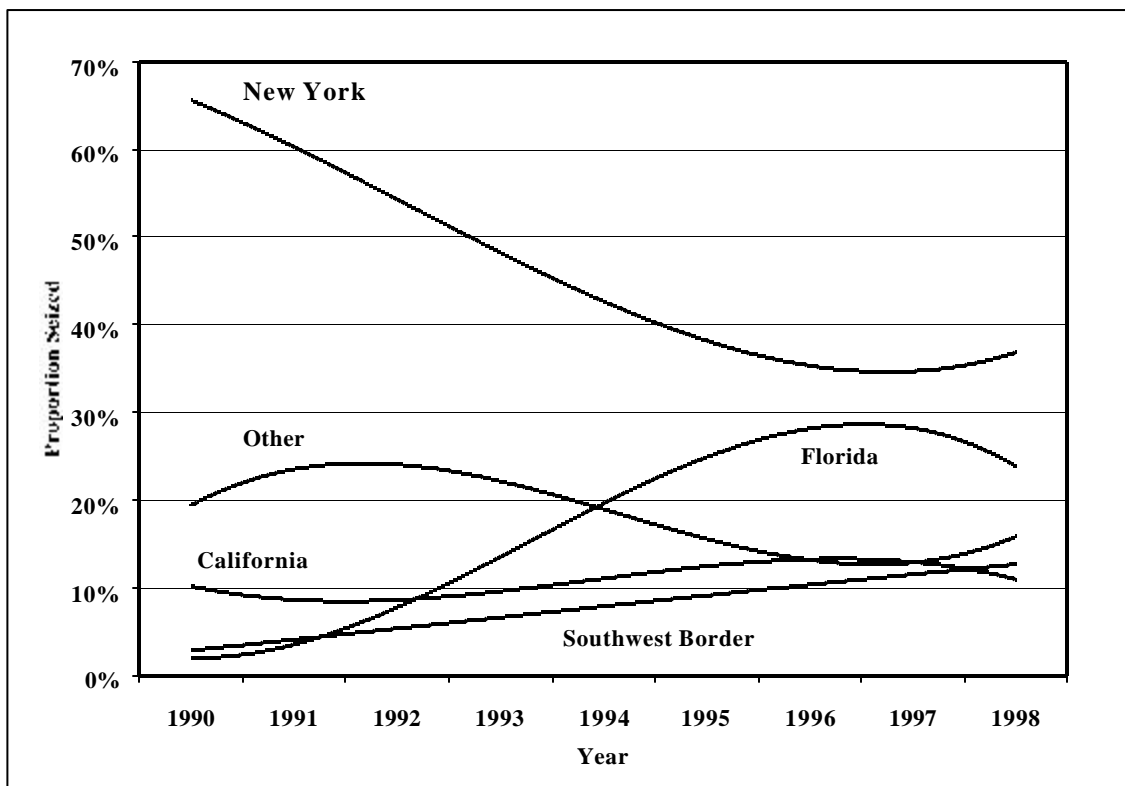
The curves shown in Figure 6 are a smoothed representation of how the location of seizures changed over time. Seizures have been weighted to reflect the amount of heroin involved in the shipment. A companion report explains the methodology used to develop these curves.[50]

The figure shows that the proportion of seizures made in New York, represented by the highest line in this figure, decreased precipitously from 1991 through 1995 and then stabilized. Most of that reduction was balanced by a dramatic increase and then stabilization of seizures made in Florida. The figure suggests that more heroin was being shipped to New York during 1998 than was the case in 1996 and 1997. This may be true, or it may be that a few especially large shipments have distorted the trend. Also, the smoothing procedure can distort trends at the end of the period. It would be prudent, therefore, to discount the apparent increase in New York seizures and decrease in Florida seizures observed in 1998.

One point is clear: By 1995, seizures had decreased markedly in New York, and they had increased correspondingly in Florida. There was little change in seizures in the rest of the nation. Using the geography of seizures as an indication, after 1995 the geographic movement of heroin into the United States has been relatively stable.

Movement of Heroin from Source Areas into the United States

Table 19 reports the source of heroin that was seized in the five areas identified in the previous figure. This table is based on seizures made at airports, at the borders, and through the mail. The probability that a shipment is seized likely varies across conveyance mode and geographic location, so a simple tabulation of seizure data would be a biased representation of where heroin enters the United States. To make the tabulations more representative of heroin imports, we weighted the data so that the source area of heroin *seized* was the same percentage as the source area of heroin *used* in the United States.[51] Estimates of the source areas of heroin in the United States have been reported already in Table 18.

Table 19 should be read down its columns. For example, an estimated 82 percent of the heroin that entered the U.S. through California came from Mexico. Almost 86 percent of the heroin that entered through Florida came from South America.

Table 19 - Estimated Percentage of Heroin Entering the United States by Importation Point for Each Source Area

Source Area	Importation Point				
	California	Florida	New York	Texas	Other
Mexico	82.4	0.0	0.0	69.2	53.2
South America	7.1	85.9	60.3	13.0	7.6
Southeast Asia	5.5	0.3	22.9	7.0	17.3
Southwest Asia	0.0	0.4	8.9	0.0	9.7
Unknown	4.9	13.5	7.9	10.8	12.2
Total	100.0	100.0	100.0	100.0	100.0

Table 20 reports the estimated percentage of heroin from each source region that entered the United States through each of the five importation areas. This table should be read across its rows.

Table 20 - Estimated Percentage of Heroin Entering the United States by Source Area for Each Importation Point

Source Area	Importation Point					
	California	Florida	New York	Texas	Other	Total
Mexico	64.3	0.0	0.0	16.3	19.4	100.0
South America	2.8	52.9	41.3	1.5	1.4	100.0
Southeast Asia	9.9	1.0	71.2	3.8	14.4	100.0
Southwest Asia	0.0	3.1	75.0	0.0	21.9	100.0
Unknown	10.0	43.3	28.3	6.7	11.7	100.0

If weighted seizures are a good reflection of where heroin enters the United States, then 64.3 percent of Mexican heroin enters through California and 16.3 percent enters through Texas. That is, more than 80

percent of Mexican heroin probably comes across the Southwest border, and the rest of Mexican heroin enters the United States through other diverse locations. More than half of South American heroin enters the United States through Florida, and most of the rest comes through New York. Almost three-quarters of Southeast Asian heroin enters through New York and the rest goes through diverse places. Three-quarters of the Southwest Asian heroin also seems to enter through New York City, and the rest goes through various places. The increased role of South America as a supplier of heroin explains why Florida has become an increasingly important heroin importation point.

Table 20 provides another useful way to summarize these data. Multiplying the percentages by source area and importation point (Table 18) by the amounts per source area (Table 16) provides an estimate of metric tons moved through each importation point by source area. To develop this estimate, we average across the five years reported in Table 16.

If we are correct that Americans used about 12.3 metric tons of heroin per year between 1995 and 1998, then Table 21 gives some idea of how much heroin from each source moves into the country through each region of the United States. Of course, there exists considerable uncertainty in estimates that provide this much detail.

Table 21 - Estimated Amount of Heroin (Metric Tons) Entering the United States by Source Area and Importation Point, 1995-1998

Source Area	Importation Point					
	California	Florida	New York	Texas	Other	Total
Mexico	2.0	0.0	0.0	0.5	0.6	3.1
South America	0.2	3.3	2.6	0.1	0.1	6.2
Southeast Asia	0.1	0.0	1.0	0.1	0.2	1.4
Southwest Asia	0.0	0.0	0.4	0.0	0.1	0.5
Unknown	0.1	0.5	0.3	0.1	0.1	1.2
Total	2.4	3.8	4.2	0.7	1.1	12.3

Almost 10 percent of the heroin was classified as unknown B that is, DEA chemists could not assign a source area to that heroin. Note that, excluding the unknown category, virtually all heroin seized in Florida came from South America. It seems reasonable to suppose that most of the 13.5 percent of the heroin seized in Florida and identified as Aunknown@ also came from South America. This same reasoning cannot be applied to other places where South America is not the dominant supplier, but it does suggest that South America=s share of the U.S. market may be greater than is indicated by Tables 16 and 19.

CNC Potential Production Estimates

How do our estimates of the amount of heroin from the producer nations compare with CNC=s reports of production potential? Since 1995, CNC has consistently estimated the production potential of South America at about 6.1 to 7.5 metric tons. (These estimates are after subtracting eradication losses from total hectares. The 7.5 metric ton figure is for 1999; it was never previously larger than 6.6 metric tons.) Unfortunately, estimates are of uncertain accuracy because the assumed conversion ratios from poppy to opium is based on intelligence fieldwork in Southeast and Southwest Asia. We cannot know for sure whether or not those conversions apply to South America. Nevertheless, we must take those conversion estimates as the best currently available.

According to our consumption estimates, Americans consume somewhat more than 6 metric tons of heroin from South America, and United States authorities seize about 0.75 metric tons. Our consumption/seizure estimates exceed South America=s production capacity, but the difference is not great. This suggests that the estimated 12 to 13 metric tons of total domestic heroin consumption is about right if somewhat high.

Since 1995, CNC=s estimates of the production potential for Mexico vary over time between 4.3 and 6.0 metric tons. According to our estimates, Americans consume somewhat more than 3 metric tons of Mexican heroin and another 0.34 metric tons are seized by U.S. or Mexican authorities. The consumption-based estimates are less than the production-based estimates. The Mexican production estimates suggest that the estimated 12 to 13 metric tons of domestic heroin consumption is too low.

CNC-s production estimates for Mexico are inconsistent with our consumption estimates. There seems to be no ready reconciliation, but speculation may be helpful. CNC emphasizes that its estimates are for *potential production*, and actual production may differ. Perhaps Mexico-s production is well below its potential, but it is difficult to reason why potential production would be consistently less than realized production. A better explanation comes from CNC-s warning that:

> The wide variation in processing efficiency achieved by traffickers complicates the task of estimating the quantity of cocaine or heroin that could be refined from a crop. These variations occur because of differences in the origin and quality of the raw material used, the technical processing method employed, the size and sophistication of laboratories, the experience of local workers and chemists, and decisions made in response to enforcement pressures. (INCSR, 1999)

CNC-s assumptions may overstate Mexico-s production efficiency. This is speculation, of course, but we observe that heroin imports are about 44 percent pure when from Mexico, 80 percent pure when from Colombia, and 70 to 75 percent pure when from Southeast and Southwest Asia. Because CNC makes the same assumptions about production efficiency for Mexico as it does for Southeast and Southwest Asia, the potential production may overstate Mexico-s actual production.

Suppose that Mexican production were 0.59 as efficient as is assumed by CNC. (The 0.59 comes from dividing 0.44 purity by 0.75 purity.) Then an estimate of Mexico-s actual production would be between 2.5 and 3.5 metric tons, numbers that agree with the consumption estimates. Using this same argument, we might assert that Colombian production is 1.07 times more efficient than is assumed by CNC. This would lead to a higher estimate of Colombia-s production, which would be more consistent with the consumption estimates. This reasoning is speculative, but not unreasonable in the face of having no reliable data about the actual production efficiency in Mexico and Colombia.

The intelligence community has estimated that, during the late 1990s, Americans used about 18 metric tons of heroin per year. To get this estimate, the community accepted the ONDCP estimate of 980,000 hardcore heroin users and assumed those users consumed an average of 50 mg per day. Use by occasional users was apparently factored into these calculations, but the method is unclear.

47

This amount is considerably more than the 12 to 13 metric tons estimated in this report. The intelligence community considers the 50 mg per day estimate to be conservative. Indeed, some addicts can use much more as evidenced by consumption by opiate users who enter treatment. But beyond this upper bound, the 50 mg estimate seems to have no justification beyond the assertion that "Many analysts and treatment professionals, however, believe that 50 mg as the estimate for average daily dosage for heroin users in the United States underestimates overall US market demand." Thus, the 18 metric ton estimate would seem to rest on a shaky and unverifiable assumption.

This is not to say that the estimate from the intelligence community is wrong, of course. Nevertheless, if we accept the estimate of 18 metric tons, we have to deal with some inconsistencies. Perhaps those inconsistencies are ultimately resolvable, but surely they cannot be readily dismissed. For example, if we are correct that a milligram of heroin costs roughly $1, then the implied $350 per week expenditure exceeds our estimates of expenditures by hardcore users. As another example, the estimates imply that 8 metric tons of heroin come from Colombia and 5 to 6 metric tons come from Mexico. For reasons explained earlier, we doubt that Colombia can provide this amount of heroin after accounting for seizures. Furthermore, even this high estimate of 8 metric tons is lower proportionately than Colombia's apparent share of the heroin market. Mexico might be able to supply this level, presuming production estimates are realistic, but for reasons stated, we think that Mexico's production is overstated.

Non-U.S. Consumption

How much heroin is consumed within Mexico and within South America? What other reductions occur in the production and distribution systems? Unfortunately the answers to these questions are all but unknown.

Perhaps the most useful published information about consumption comes from reports of the Community Epidemiological Working Group (CEWG). The CEWG is focused on the United States, of course, but most of its reports include sections on consumption in other nations. These reports are seldom quantitative, because nations outside the United States rarely have data collection systems affording estimates of domestic consumption. Based on CEWG assessments, we assume that the consumption of heroin within South and

Central America is negligible. Most heroin produced in South and Central America is probably destined for North American markets.

Canada is a bigger problem. According to CEWG reports, heroin is seen as a major drug problem, at least in Vancouver and Toronto. But we do not know the amount of heroin used in Canada; nor do we know the source.[52] It seems reasonable to assume that some South American and Mexican heroin is shipped to Canada, but we do not yet have an estimate of the amount.

Heroin - the Supply-Side Assessment

Our best estimate is that roughly 12 to 13 metric tons of heroin is used in the United States during a given year. The level of use could be lower, of course, but if it were much lower than 12 metric tons, then we could not account for production potential in Colombia and Mexico, most of which is presumably exported to the United States. Likewise, the level could be higher, and while Mexico could be providing more than 4 metric tons, estimates of more than 12-13 metric tons would be difficult to reconcile with Colombia=s apparent production capacity.

Modeling the Flow of Methamphetamines

In 1990, Mexican organized crime groups began large-scale production of methamphetamine and rapidly expanded distribution into California and other parts of the Southwest. In addition to combating large-scale production, United States government efforts to control the distribution of methamphetamines have become increasingly difficult due to the proliferation of small clandestine labs, each of which produces small quantities of the drug. Methamphetamines can be produced easily and inexpensively using chemicals bought at local drug stores or chemical supply companies. A person with little technical training can easily learn how to make methamphetamines. This has become increasingly possible due to several Internet sites that include detailed step-by-step Acooking@ directions.[53]

Prior to 1989, methamphetamines were produced primarily by outlaw motorcycle gangs using a technique called APhenyl-2-Propnanone (P2P) synthesis.@ During this time, P2P was a controlled substance; however, the precursors required to make P2P were not controlled, which enabled the motorcycle gangs to Alegally@

produce methamphetamines. The precursors of P2P were subsequently controlled by the first US chemical control act, the 1989 Chemical Diversion Trafficking Act (CDTA).[54] After 1989, the primary methamphetamines precursor shifted from P2P to ephedrine. The ephedrine reduction method became the primary method of synthesis due to a CDTA loophole: The CDTA restricted the importation of bulk ephedrine but made no restrictions on the tablet form of the chemical.[55]

From 1990 to 1994, ephedrine-based production, based in Mexico and California, was the predominant production method. During this time, methamphetamine production rapidly expanded from Mexico and the Southwest corner of the United States into the Midwest and the South.[56] The Mexican drug cartels used existing marijuana and heroin distribution networks to distribute the methamphetamines. Passage of the Domestic Chemical Diversion Control Act (DCDCA) in 1994 made ephedrine tablets a List 1 chemical, restricting their sale. This Act did not stop the Mexicans, who in 1994 began the illegal smuggling of ephedrine. Mexican drug rings purchased large amounts of ephedrine indirectly from rouge companies outside of Mexico that, in turn, purchased the chemicals and then delivered them to Mexico.[57]

The DCDCA also caused a shift in methamphetamine=s mode of production. Although the DCDCA controlled the sale of ephedrine, it did not control the sale of pseudoephedrine, which became the precursor of choice.[58] Pseudoephedrine is found in Sudafed and other similar over-the-counter cold medicines. This made it much easier for average criminals to get access, leading to a rapid increase in the number of small clandestine labs, especially in the Midwest. From 1994 to 1996 the number of pseudoephedrine imports into the United States (in metric tons) increased by almost 50 percent.

Clandestine labs in the Midwest primarily use a method of synthesis called the ANazi method,@ because it was first used in Germany during World War II. The Nazi method has become the dominant production procedure in the Midwest because it requires ammonia, which is used throughout the Midwest in fertilizers. Stolen ammonia is the primary source of ammonia for the clandestine labs. The Nazi method is popular because it can produce a highly pure methamphetamine product very quickly: in about 3 hours, compared with the ephedrine reduction method, which can take several days. Small clandestine labs are often mobile and typically produce between 1 and 4 ounces of methamphetamine at a time.[59] From 1995 to 1996, the DEA reported a 169 percent increase in the number of DEA clandestine lab seizures (327 and 879 respectively). This trend continued in both 1997 and 1998.[60]

Although the number of small clandestine labs have grown rapidly, the methamphetamine seized from them (see figure 7) only accounts for a small portion of the methamphetamine seized by the DEA from labs. In 1998 small clandestine labs accounted for 95 percent of the lab seizures, but only 22 percent of the lab-seized methamphetamine; a majority of the seized methamphetamine (78 percent) came from seizures of the super labs.[61]

Figure 7 – Methamphetamine Clandestine Lab Seizures by DEA
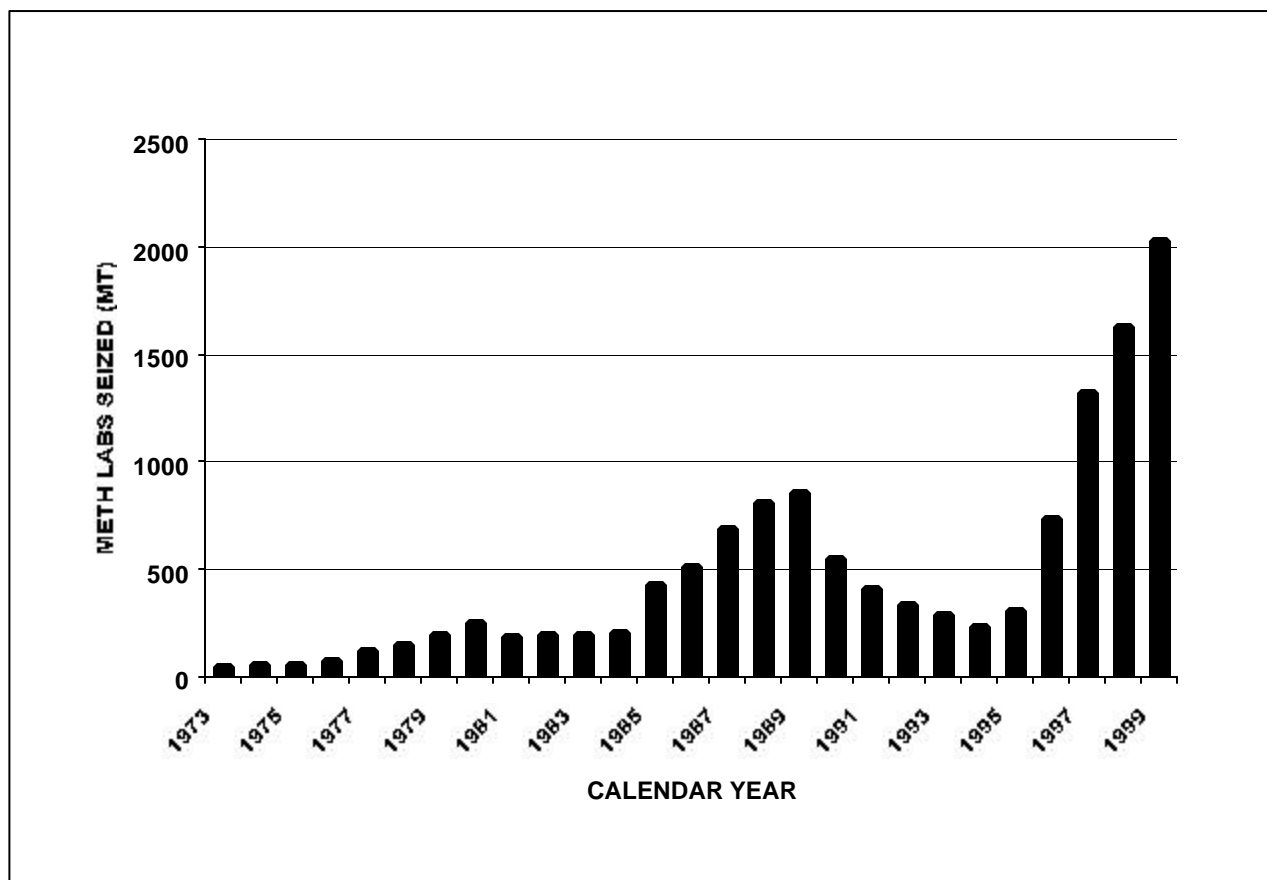
Source: U.S. Department of Justice, Drug Enforcement Administration, Office of Diversion Control, Chemical Investigations Section

Modeling the flow of methamphetamines poses unique challenges. A cocaine model can begin with estimated production in known growing areas, but methamphetamine production has no comparable geographic boundaries. A heroin model can begin with consumption-by-production region estimates, but developing signatures has proved to be much more difficult with methamphetamine, primarily because of the large

number of clandestine labs that have spread all over the United States. In order to develop a signature for a drug, there must be large geographic variability between different drug sites. Clandestine labs are now in almost every state in the United States, making it much more difficult to decipher between different drug sources. In addition, methamphetamine is completely synthetic. Using the Nazi method, clandestine labs can make a highly pure drug product, mitigating the levels of impurities that are necessary to accurately determine the signature of a drug. Unlike heroin or cocaine, which are grown in specific geographic locations (Columbia, Thailand, etc.), anyone can manufacture methamphetamines with the proper ingredients and cooking instructions. This adds a dimension of difficulty to finding an accurate model of methamphetamine production and distribution in the United States.

An alternate way to model the production and distribution of methamphetamine is to monitor the production and distribution of precursor chemicals. This approach has serious limitations, including the need to make allowance for the legitimate use of those precursors. For example, methamphetamine production requires a large quantity of pseudoephedrine. In order to produce 1 ounce of methamphetamine, a small lab requires 680 60 mg tables (roughly 1.44 ounces) of pseudoephedrine (based on a 70 percent conversion rate). Figure 8 shows that pseudoephedrine imports increased by roughly 200 metric tons after 1994, although this increase was only about 100 metric tons by the late 1990s. If we assume this 100 metric ton increase reflects methamphetamine production, then it represents 70 metric tons of methamphetamine. Given a typical street purity of about 40 percent, this represents just under 30 metric tons of pure methamphetamine **B** considerably more than the consumption-based calculations, and this does not account for production imported into the United States.

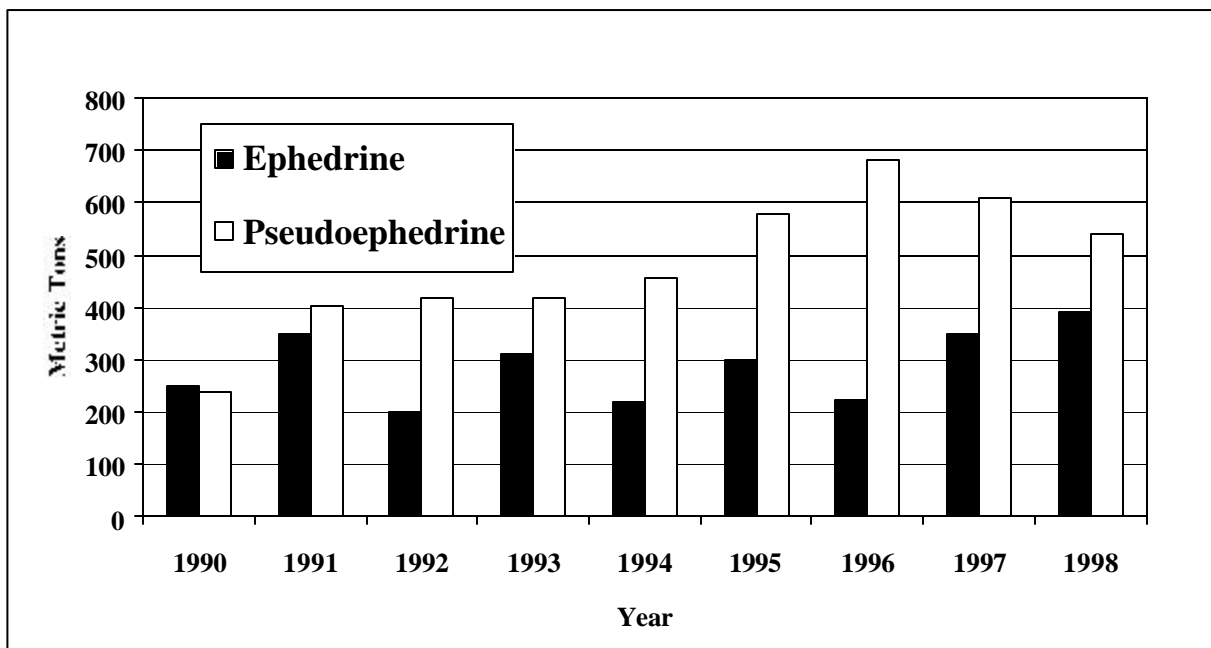**Figure 8 – Ephedrine & Pseudoephedrine Imports into the United States**

Source: U.S. Department of Justice, Drug Enforcement Administration, Office of Diversion Control, Chemical Investigations Section

According to the DEA, [62] between June 1993 and December 1994, an estimated 170 metric tons of ephedrine were supplied to Mexican traffickers. Also according to the DEA, this could have yielded 170 tons of methamphetamine. Again assuming 40 percent purity, this represents almost 70 metric tons of pure methamphetamine, far in excess of the consumption-based estimates.

The above arguments are not intended to argue that the consumption-based estimates are correct while these supply-based estimates are wrong. Rather, the point is that supply-based estimates, which are based on precursor chemicals, provide estimates that are difficult to reconcile with reasonable inferences about the use of methamphetamine. According to the DEA, the 170 tons of methamphetamine were "...enough to supply 12.4 million abusers with three 10-milligram doses a day for 365 days per year." Even assuming this eighteen-month estimate implies just over 8 million hardcore methamphetamine users, DEA's estimate seems much too high. The consumption-based estimate is about 400,000 hardcore users. The NHSDA estimates about 800,000 past month users of any amphetamine during this same period, and not all these used methamphetamine. Furthermore, TEDS reports 53,000 treatment admissions in 1997, a figure than has grown from only 15,000 in 1992. It is difficult to see how 8 million daily methamphetamine users could

generate only 53,000 treatment admissions, when an estimated 3.5 million weekly cocaine users generate 255,000 treatment admissions. Modeling based on precursor chemicals does not seem to provide a suitable way of estimating the supply of methamphetamine to the United States.

Marijuana

It is also difficult to develop an estimate of the size of the U.S. retail market for marijuana from estimates of available supply. First, the amount of marijuana that Americans cultivate for personal use cannot currently be estimated. Second, even though a large amount of the domestic marijuana market is grown in the United States, countries in South and Central America, the Caribbean, Asia, North Africa, and the Middle East also supply cannabis to the domestic market.[63] Unfortunately, the data needed to develop better estimates are not available, and, therefore, we cannot develop a plausible supply-based estimate of the retail value of the marijuana market in the United States.

Legitimately Manufactured Controlled Substances and Illicitly Manufactured Dangerous Drugs

It is impossible to know the amount of controlled substances, such as inhalants and hallucinogens, that are produced legally but diverted for illicit consumption. It is also impossible to know the amount of drugs that are manufactured illicitly in domestic or foreign laboratories. We do know that these substances are readily available.[64]

Price and Purity of Illicit Drugs

Drug prices and purity offer some information about the availability of drugs in the United States. By themselves, trends in illicit drug prices are not a convincing indication of whether the demand or the supply for illicit drugs is either increasing or decreasing. For example, price might remain about the same if both the supply and the demand for drugs were increasing, but then again, a decrease in both the supply and the demand could also result in stable prices. Nevertheless, to the extent that price trends are not inconsistent with trends in supply and demand, they provide some confirmation for consumption-based and supply-based estimates.

Because illicit drugs can be bought and sold in different amounts, degrees of purity, and levels of distribution, prices can vary greatly from sale to sale. Using the Drug Enforcement Administration=s System To Retrieve Information from Drug Evidence (STRIDE) data from January 1981 through June 1998,[65] we have developed statistical models to estimate typical prices for standardized purchases of cocaine, heroin, methamphetamine, and marijuana. A standardized purchase involves a set quantity and quality of drugs exchanged at a specified distribution level. A useful application of these estimates is to examine price trends for these standardized purchases over time.

$ Figure 9 shows the estimated retail level[66] and importation level[67] prices per pure gram of cocaine over time. The average price per pure gram at the retail level has decreased considerably from just over $400 per pure gram in 1981 to about $170 per pure gram in 1998. The average price at the importation level has also decreased from roughly $75 per pure gram in the early 1980s to about $25 per gram in the late 1990s.

$ Figure 10 compares the estimated retail-level purchase price with the estimated importation[68] purchase price of heroin. The figure shows two retail prices because the retail heroin market appears to be bifurcated into a sector selling relatively low purity heroin to injection drug users[69] and a sector selling comparatively high purity heroin to those who either inject or sniff the drug.[70] At the lowest retail level, heroin prices have fallen from about $3,000 per pure gram in 1981 to about $2,000 per pure gram in 1998. At the second retail distribution level, prices have fallen from about $2,000 per pure gram in 1981 to about $400 per pure gram in 1998. In 1998, a weighted average of the two lowest distribution levels suggests a price of roughly $1,000 per pure gram. Prices at the importation level have also fallen B from $400 to $500 per gram in the early 1980s to under $200 per pure gram in the late 1990s. In fact, border prices are probably lower, but these trends are descriptive.

$ The street price[71] of methamphetamine has fallen over the last twenty years (see Figure 11). In the early 1980s, prices were close to $300 per pure gram. By the late 1990s, methamphetamine was selling for under $200 per pure gram. Importation[72] level prices changed by less than retail-level prices. In the early 1980s, prices seemed to range between $40 and $50 per pure gram, but there were so few high-level purchases that estimates are suspect. By the late 1990s, prices seemed to be closer to $20 to $30 per pure gram.

$ Figure 12 shows trends in the predicted prices per bulk gram of marijuana.[73] The average price per bulk gram has risen steadily from just under $5 per bulk gram in 1981 to its peak of about $15 in 1991. Prices returned close to their 1981 levels by 1998.

Indeed, price trends are broadly consistent with trends in consumption-based and supply-based estimates. During most of the 1990s, cocaine prices have been fairly constant; so too has the consumption of cocaine. During the 1990s, heroin prices have tended to fall, and relatively high-purity heroin has been increasingly available at retail. Consistent with this, heroin use appears to have increased. As noted before, marijuana use increased as marijuana prices fell, and use decreased as prices increased. Price trends are broadly consistent with consumption trends.

Figure 9 - Predicted Price per Gram of Cocaine at the Retail and Importation Distribution Levels
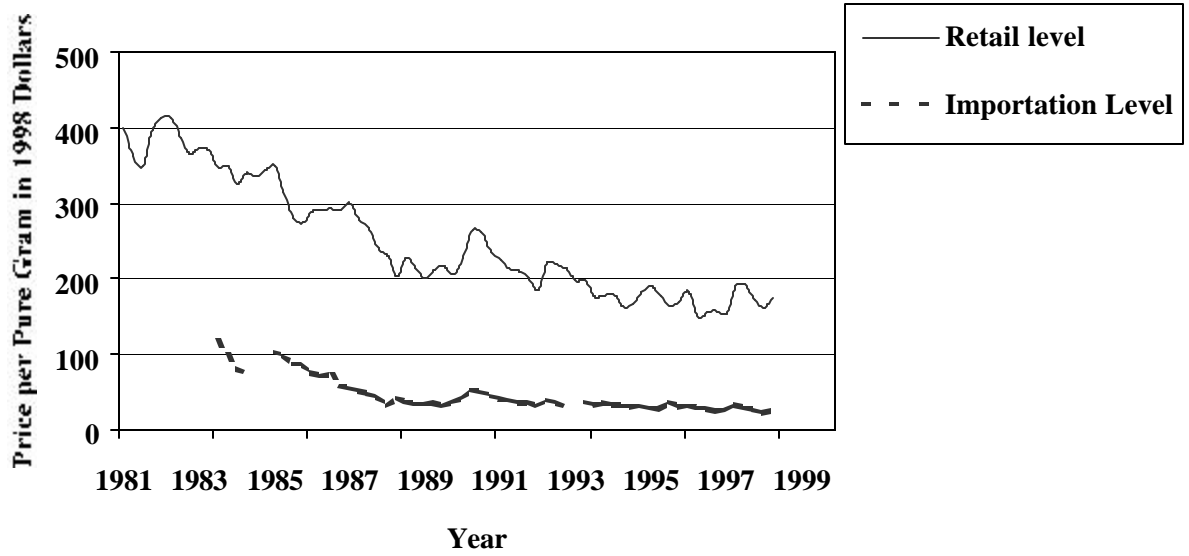
Figure 10 – Predicted Price per Pure Gram of Heroin at the Retail and Importation Distribution Levels
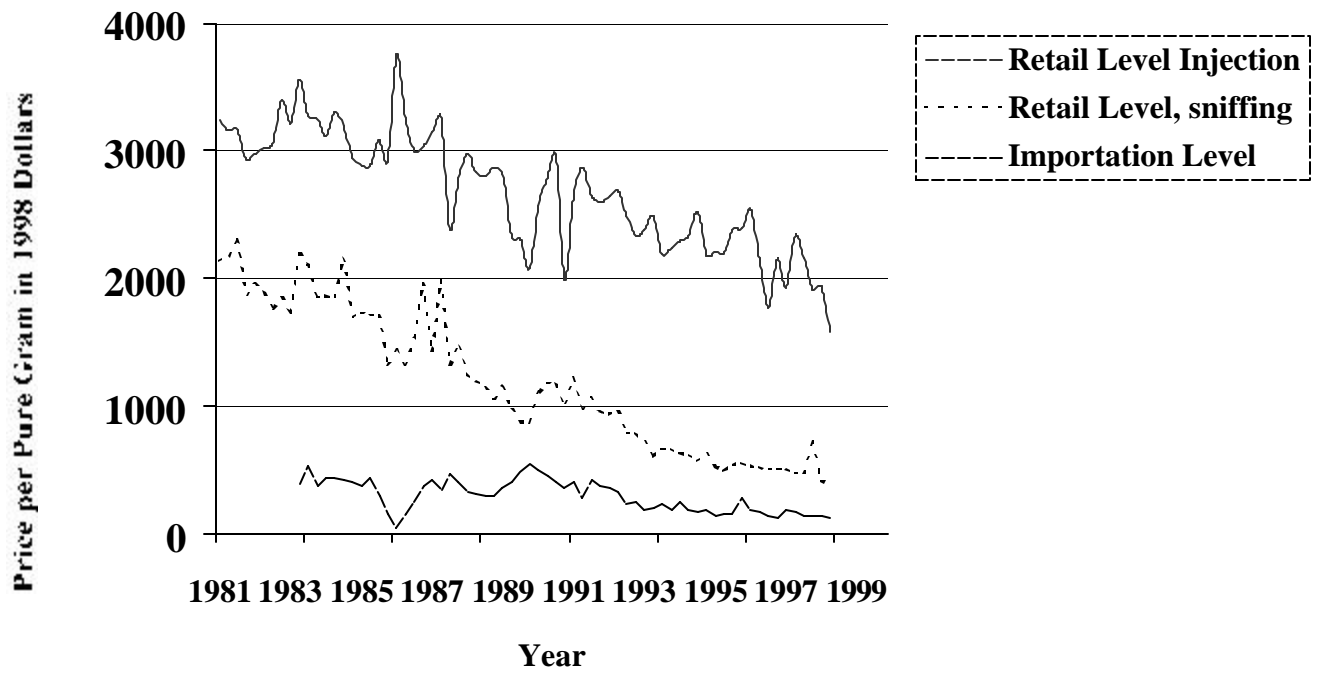
Figure 11 – Predicted Price per Pure Gram of Methamphetamine at the Retail and Importation Distribution Levels
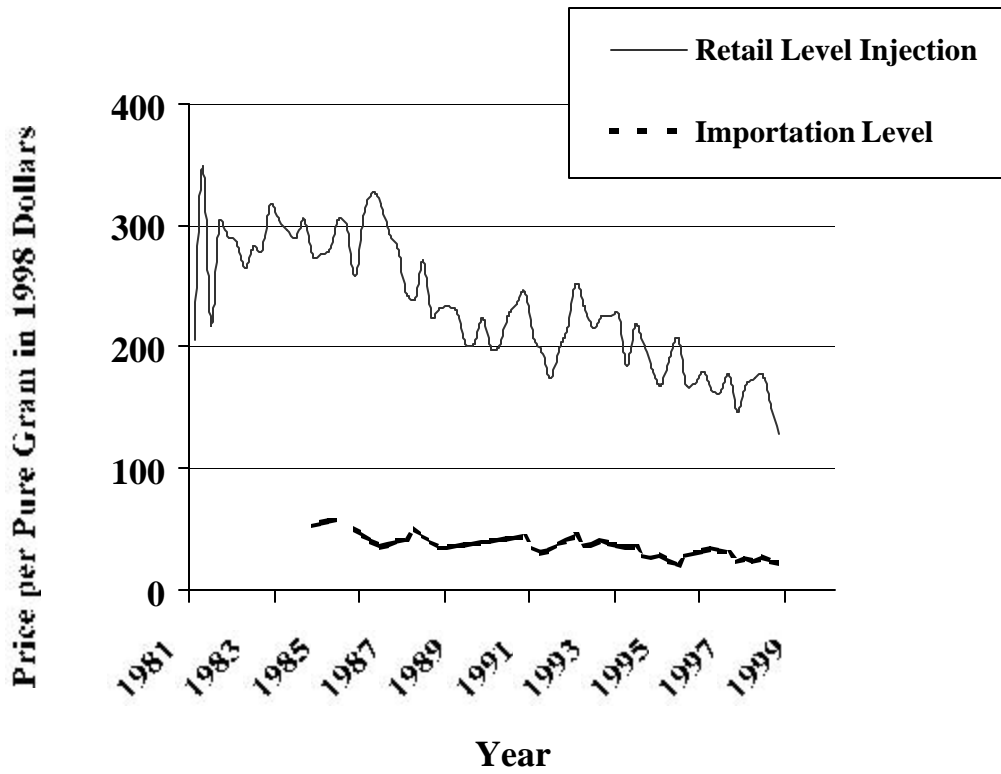
Figure 12 –Predicted Price per Bulk Gram of Marijuana at the Retail and Importation Distribution Levels
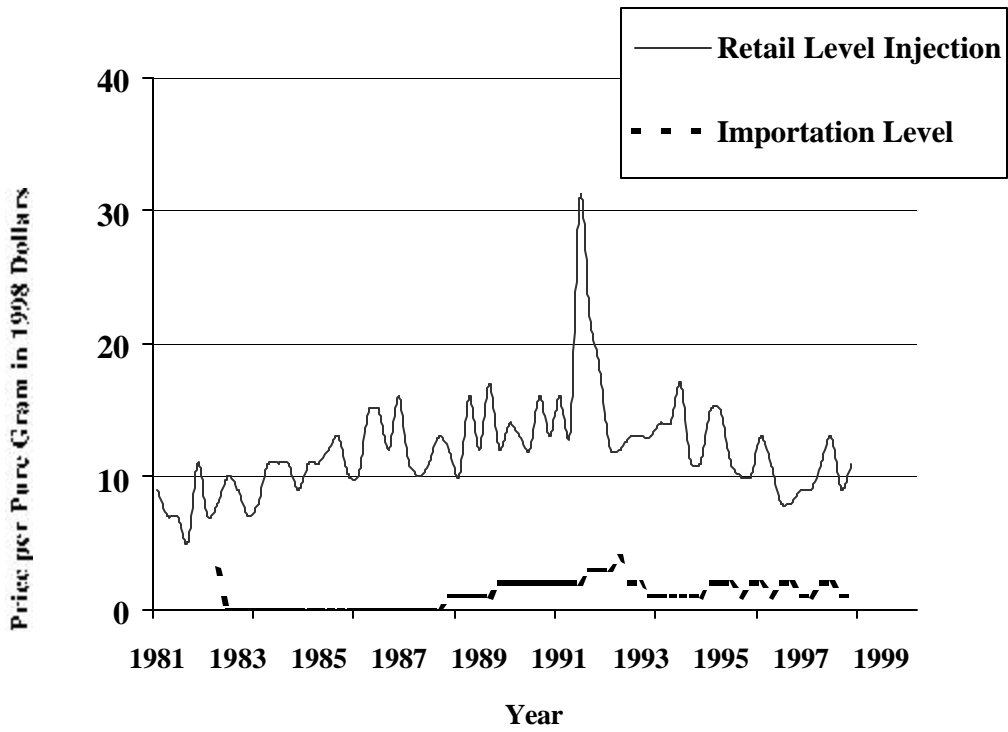
Summary

Because of the quality of available data, there is considerable imprecision in estimates of the number of hardcore and occasional users of drugs, the amount of drugs they consume, and the retail sales value of those drugs. The best estimates (all for 1998) follow:

$ In 1998, about 3.3 million Americans were hardcore cocaine users, and about 980,000 were hardcore heroin users. The number of hardcore cocaine users has remained fairly stable over the last six years (the figure was 3.9 million in 1988). The number of hardcore heroin users has decreased and then increased. The initial decrease in the number of hardcore heroin users (1990-1992) is probably attributable to the impact of the AIDS epidemic on injection drug users and increasing rates of incarceration, while the rebound in 1993-1995 may be the result of new users progressing to hardcore use.

$ About 3.2 million Americans were occasional cocaine users, and about 500,000 were occasional heroin users. (The estimate is 253,000 for 1998, but this is anomalous given the three preceding years.) The number of occasional cocaine users dropped from 6.0 million in 1988, and the number of occasional heroin users increased from 170,000 in 1988.

$ More Americans use marijuana than either cocaine or heroin. In 1998, about 11 million Americans had used marijuana at least once in the month prior to being surveyed. The number of marijuana users has remained fairly constant over time, with some dip in use during the early 1990s when prices were relatively high.

$ Methamphetamine abuse is now recognized as a major problem, but estimates of the size of the problem are imprecise. Perhaps 300,000 to 400,000 Americans are hardcore methamphetamine users, but trends are difficult to detect.

$ Many Americans use illicit drugs other than cocaine, heroin, methamphetamine and marijuana, or they may use licit drugs illegally. About 12 million Americans admitted using these other drugs in 1998. These numbers include some overlap of polydrug users.

Deriving estimates of the total expenditure on illicit drugs and licit drugs consumed illegally is more difficult and uncertain because those estimates require more data about amounts used and prices paid. Nevertheless, the best estimates indicate the following:

$ In 1998, Americans spent about $39 billion on cocaine, $12 billion on heroin, $1.5 billion on methamphetamine, $11 billion on marijuana, and $2.3 billion on other substances.

$ Again, estimating trends is risky, but it appears that expenditures on cocaine, heroin, and marijuana have fallen some over the last decade. However, almost all the reduction can be attributed to a fall in prices.

Estimates of the total amount of cocaine consumed are broadly consistent with estimates of the total amount of cocaine available for consumption in 1998:

$ From the supply-side perspective, the cultivation-based estimates imply that fewer than 352 metric tons of pure cocaine were available for consumption in the United States (1998). The event-based estimates imply that more than 212 metric tons were available for consumption.

$ From the consumption perspective described in this paper, Americans consumed roughly 290 metric tons of cocaine (1998).

The cultivation estimates are surely overstated. First, they do not account for the actual harvesting of the potential cultivation , and second, they do not account for losses such as consumption in South America. In contrast, the event-based estimates are surely understated, because authorities cannot identify all shipments. Although the supply-based and the consumption-based estimates are remarkably close, they cannot be completely reconciled.

This report provides, for the first time, a model of the supply of heroin to the United States. The model cannot fully resolve the problem that Colombia=s heroin production potential is somewhat less than estimates of the amount of South American heroin used in the United States. Nor can it fully resolve the observation that Mexico=s production potential is more than what is consumed in the United States. Nevertheless, consumption and production estimates are remarkably close.

Although these estimates paint a picture of drug consumption with an extremely broad brush, and although not all estimates can be reconciled, the approach we use provides an important perspective on what is *not known* about drug production and consumption and what *needs to be known* to better understand the policy choices available to the Nation.

62

We make no pretense here that the model and estimates we present in this report are fully adequate to the larger task of informing public policy decisions. They are, at best, a start, but they offer important possibilities of integrating what are otherwise seen as disparate pieces of information about the consumption and supply of drugs.

We expect incremental improvements to the estimates and methods offered here, particularly as better data become available. We also expect improvement in the models. In fact, the Office of National Drug Control Policy has started a project to improve and integrate drug use and supply indicator data. In fact, the Office of National Drug Control Policy has started a program to improve and integrate drug use and supply indicator data. The National Institute of Justice, through its Arrestee Drug Abuse Monitoring program, has instituted projects to more accurately estimate the number of hardcore drug users and to better describe illicit drug markets. Also, the Substance Abuse Mental Health Services Administrations, through the NHSDA, is implementing an important series of questions about marijuana purchasing practices. These emerging data will greatly improve future versions of these estimates.

Moreover, the estimates by themselves have only modest importance **B** they tell us nothing more than that the drug trade is large, a conclusion that requires no special study. The real utility of these numbers is the development of a systematic methodology for integrating the various indicators **B** crops in foreign countries, drugs seized at the borders, arrests made in American cities, etc. **B** that can help policymakers to better understand the dynamics of the drug trade and to fashion appropriate policy responses.

The current process for integrating this research into policymaker decisions is through the ONDCP Performance Measure of Effectiveness (PME) system. The PMEs set 97 performance targets and 127 associated measures. Many of these targets involve supply-side activity, such as reduction of heroin flow into the United States. These targets are instrumental toward increasing the price of illicit drugs, reducing the supply of illicit drugs, or both. The results of this heroin model are inputs into the PME process, and will therefore be updated on an annual basis.

Endnotes

1. Money is not the only form of payment for illicit drugs. Dealers often keep drugs for personal use, users help dealers in exchange for drugs, and users perform sex for drugs (especially crack cocaine). When such Aincome in kind@ is valued at current retail prices, an additional $4 billion to $7 billion must be added to the total for cocaine and an additional $2 billion to $4 billion to the total for heroin. In this report, all expenditures are in 1998 dollar equivalents. These expenditure estimates do not include income in kind.

2. By comparison, Americans spent about $43 billion on tobacco in 1993. *The Tax Burden on Tobacco* (Washington, D.C.: The Tobacco Institute, 1993).

3. The NHSDA excludes military personnel, those incarcerated in jails and prisons, and those who are residents of treatment facilities. Military personnel, whose consumption of illicit substances is monitored through urinalysis, do not have the opportunity to be heavy drug users. Those incarcerated in jails and lockups may use drugs, but that consumption must necessarily be limited by restricted availability. A Bureau of Justice Statistics study reports AIn State correctional facilities, 3.6 percent of the tests for cocaine, 1.3 percent for heroin, 2.0 percent for methamphetamine, and 6.3 percent for marijuana found evidence of drug use. In Federal prisons, 0.4 percent of the tests for cocaine, 0.4 percent for heroin, 0.1 percent for methamphetamine, and 1.1 percent for marijuana were positive.@ C. Harlow, *Drug Enforcement and Treatment in Prison, 1990* (NCJ-134724, July 1992). These percentages are probably high because tests are most likely to be conducted when drug use is suspected. In any case, drug use in prisons cannot account for much of the drug use that occurs in America. Sources at the National Institute on Drug Abuse consider drug use by those in residential treatment facilities to be minimal.

4. Evidence that a large segment of the drug-using population is excluded from the NHSDA comes from a number of sources. According to the 1991 NHSDA, drug use is twice as high among respondents who lived in households considered unstable than it is among those who lived in more stable environments, indicating that the NHSDA=s bias toward reporting on stable households is likely to miss many heavy drug users. Additional evidence also comes from interviews with nearly 35,000 intravenous drug users who were contacted by National Institute on Drug Abuse-sponsored researchers as part of an AIDS outreach project. Abt Associates=tabulations show that of these drug users, an estimated 40 percent lived in unstable households and about 10 percent could be considered homeless.

   Available evidence indicates that NHSDA=s respondents understate heavy drug use. A. Harrell, K. Kapsak, I. Caisson, and P. Wirtz, AThe Validity of Self-Reported Drug Use Data: The Accuracy of Responses on Confidential Self-Administered Answer Sheets,@ paper prepared for the National Institute on Drug Abuse, Contract Number 271-85-8305, December 1986. M. Fendrich, T. Johnson, S. Sudman, J. Wislar and V. Spiehler, AValidity of Drug Use Reporting in a High-Risk

Community Sample: A Comparison of Cocaine and Heroin Survey Reports with Hair Tests,@ *American Journal of Epidemiology* 149(10): 955:62, 1999. Consistent with these observations, the Substance Abuse Mental Health Services Administration reports that virtually no heroin addicts answer the National Household Survey on Drug Abuse. Substance Abuse Mental Health Services Administration, *Preliminary Estimates from the 1993 National Household Survey on Drug Abuse* (June 1994).

A comparison of the demographic characteristics of the heavy cocaine users in the NHSDA with those of heavy cocaine users based on other sources (the Drug Use Forecasting program, the Drug Abuse Warning Network, and the National AIDS Demonstration Research project) shows a marked difference between those populations and the one represented in the NHSDA. Incomes are greater, unemployment is lower, and there are fewer respondents using more than one drug in the NHSDA. D. Hunt and W. Rhodes, CCharacteristics of Heavy Cocaine Users Including Polydrug Use, Criminal Behavior, and Health Risks,@ paper prepared for Office of National Drug Control Policy (ONDCP), December 14, 1992.

Finally, estimates of heavy drug use reported in the NHSDA are difficult to reconcile with other data sources maintained by the Substance Abuse Mental Health Services Administration, especially with reports of the treatment for cocaine or heroin. These incompatibilities are discussed later in this report.

5.   A large percentage of heavy drug users are arrested at some time in their drug-using Acareers,@ so the criminal justice system provides valuable supplemental data when counting heavy drug users. For example, in the 1993 Household Survey, about 58 percent of weekly cocaine users surveyed had been arrested and booked at some time, 39 percent during the year prior to the survey. In the National AIDS Demonstration Research data, 81 percent of heavy cocaine users had been arrested at some time in their lives, and one-third had been in jail or prison during the six months prior to the interview.

6.   The population of hardcore users is not identical to the population of users who need substance abuse treatment. Still, using the 10 days per month threshold, the DUF data show that 57 percent of hardcore cocaine users and 77 percent of hardcore heroin users deemed themselves to be in need of treatment. These self-reports probably understate the need for treatment, because denial of the need for treatment is high among hardcore users.

7.   Because urinalysis will detect cocaine and heroin use within two to three days of its consumption, it is unlikely that urinalysis will fail to identify an individual who uses cocaine on at least a weekly basis. (Most weekly users use it more frequently than once a week.) However, an occasional user is likely not to have used cocaine or heroin within two to three days of his or her arrest. Consequently, DUF would frequently fail to identify occasional users. Arguably, the EMIT test used by DUF understates drugs in the urine of arrestees. C. Visher and K. McFadden, *A Comparison of Urinalysis Technologies for Drug Testing in Criminal Justice*, NCJ-129292, June 1991. However, it seems reasonable that occasional users are more likely than hardcore users to have an erroneous negative urine test, so we have not adjusted the DUF urine test results to reflect the EMIT tests

false negative rate of about 20 percent. For evidence supporting this decision, see T. Mieczkowski, AImmunochemical Hair Assays, Urinalysis, Self Reported Use and the Measurement of Arrestee Cocaine and Marijuana Exposure in a Large Sample,@ paper presented at the Annual Meetings, American Society of Criminology, New Orleans, November 7-22, 1992.

8. S. Everingham, C. Rydell and J. Caulkins, ACocaine Consumption in the United States: Estimating Past Trends and Future Scenarios,@ *Socio-Economic Planning Sciences*, Vol. 29 (4) December 1995: 305-314. The authors report that heavy users of cocaine use 70 percent of all cocaine. Estimates based on retail sales expenditure, reported later, are consistent, but also show that hardcore heroin users account for a larger fraction of heroin sales than hardcore cocaine users account for cocaine sales.

9. Drugs are sometimes received as income-in-kind, especially by drug-using dealers who keep part of what they otherwise would deal, and also those who exchange drugs for sex. Income-in-kind is not included in the retail sales dollar amounts, but it is factored into the measures of metric tons of drugs consumed.

10. To project hardcore user estimates from the DUF data, we estimated the number of hardcore users in 1998 as a linear projection of estimates from 1995, 1996 and 1997. We set estimates for 1999 and 2000 equal to the 1998 projection. Finally, we applied a three-year moving average to all the estimates from 1989 through 2000. The three-year moving average is reported in the text. Statistics for 1998 had already been reported for the NHSDA, so we used a linear projection (using data from 1988 through 1998) to estimate comparable figures for 1999 and 2000. The final hardcore users estimates equal the smoothed estimates from DUF data plus one-half the estimate of hardcore use from the NHSDA.

11. A large number of drug users use both heroin and cocaine. For example, of the hardcore drug users in the 1995 DUF sample: 70 percent are hardcore users of cocaine only, 16 percent are hardcore users of heroin only, and the other 14 percent are hardcore users of both.

12. W. Rhodes, S. Langenbahn, R. Kling, and P. Scheiman. *What America=s Users Spend on Illegal Drugs: 1988-1995* (Washington, D.C.: Office of National Drug Control Policy, Fall 1997). See Appendix A.

13. D. Hamill and P. Cooley, *National Estimates of Heroin Prevalence 1980-1987: Results from Analyses of DAWN Emergency Room Data*, RTI Technical Report, (Triangle Park, N.C.: Research Triangle Institute, 1990).

14. R. Simeone, W. Rhodes, and D. Hunt, *Methodology for Estimating the Number of Hardcore Drug Users*, report submitted to the Office of National Drug Control Policy, March 1997.

15. SAMHSA estimates that 7.1 million people needed treatment in 1994. Persons needing treatment are divided into two categories, Level 1 and Level 2. The Level 2 category is a more severe category of need and contains about 3.6 million people. We have used this 3.6 million figure in our

calculations under the assumption that Level 2 users are similar to the hardcore drug users described in our report. See: Substance Abuse and Mental Health Services Administration, AThe Need for and Delivery of Drug Abuse Services: Recent Estimates,@February 22, 1996.

16.   SAMHSA defines those who are severely in need of drug treatment using four criteria. NHSDA respondents were classified as in need of treatment if they reported any of the following in the past 12 months:

> $ Been dependent on any drug other than marijuana;
> $ Reported injecting cocaine, heroin or stimulants;
> $ Received drug abuse treatment at a specialty facility; and
> $ Used drugs frequently.

To account for the underestimation of hard-core drug use in the NHSDA, SAMHSA adjusted the number of people needing treatment using a ratio estimation technique that links NHSDA data to data from the Uniform Crime Reports and the National Drug and Alcohol Treatment Unit Survey. This ratio estimation technique inflated estimates of treatment need by 20% in 1991 and 1992 and 30% in 1993. Although we did not have figures for the ratio estimation in 1994, we assumed a similar adjustment of 20 to 30%. See: Substance Abuse and Mental Health Services Administration, AThe Need for and Delivery of Drug Abuse Services: Recent Estimates,@ February 22, 1996 and AEstimating Substance Abuse Treatment Need for a National Household Survey,@ by Joan Epstein and Joseph Gfoerer, OAS Working Paper, presented at the 37th International Congress on Alcohol and Drug Dependence, August 20-25, 1995, UCSD Campus, La Jolla, California.

17.   Using SAMHSA=s description of their technique for estimating the number of persons needing treatment, we developed the following algorithm using the NHSDA. Persons were classified as severely needing treatment if they met at least one of the following criteria:

> $ Dependence on any drug other than marijuana in the past 12 months. Six question types from the 1994 revised NHSDA were used to approximate the DSM-III-R criteria for drug dependence. Respondents were classified as dependent if they answered at least three of these six questions positively for any drug except marijuana. We originally defined dependence using positive answers to at least two of the six questions, since the DSM-III-R uses three of nine questions to determine dependence. However, this procedure yielded estimates that were too high.
>
> $ Reported using needles to inject cocaine, heroin or stimulants at least once during the last year.
>
> $ Reported receiving drug treatment at a hospital (as an inpatient), a drug treatment facility (as an inpatient), or at a mental health facility over the past year.
>
> $ In the past year, reported using marijuana daily and met the criteria for marijuana dependence described above, reported any heroin use, reported using cocaine at least weekly, or reported daily use of other drugs, including inhalants, hallucinogens, stimulants, sedatives, analgesics,

and tranquilizers.

We inflated the estimate obtained through this method by 25% to approximate the ratio estimation technique used by SAMHSA.

18. National Institute on Drug Abuse, *Epidemiological Trends in Drug Abuse, Volume I: Highlights and Executive Summary*, Community Epidemiological Work Group, December 1996: Exhibit 5, page 18. We excluded Minneapolis/St. Paul from this summary, because that site did not exclude alcohol B only from its treatment statistics.

19. Treatment Episode Data Set (TEDS): 1992-1997. SAMHSA, August 26, 1999. Downloaded from the Internet 11/18/1999: www. samhsa.gov/teds9297.htm

20. Center for Disease Control and Prevention, *HIV/AIDS Surveillance Report* 1998, Vol. 10 (No. 2).

21. Trends in lifetime prevalence of heroin use among 12th graders rose from 1993 to 1997, but leveled or dropped from 1997 to 1998. Table 5-1, *National Survey Results on Drug Use from the Monitoring the Future Study, 1975-1998* (Bethesda, Maryland: National Institute on Drug Abuse, 1999).

22. Treatment data are difficult to interpret. From the Treatment Episode Data, we observe that treatment admissions for heroin increased from 167,000 in 1992 to 218,000 in 1997; furthermore, while 77 percent of heroin users injected in 1992, only 68 percent injected in 1997. Perhaps these trends imply more heroin users in the late 1990s. It certainly implies a larger prevalence on non-injection drug use. Substance Abuse Mental Health Services Administration, Treatment Episode Data Set (TEDS): 1992-1997.

23. Table 2.10 Downloaded from the Internet on 11/15/99: www.samsha.gov/oas/p0000018.htm

24. R. Simeone, W. Rhodes, and D. Hunt. *Methodology for Estimating the Number of Hardcore Drug Users*. Report submitted to the Office of National Drug Control Policy by Abt Associates Inc., March 1997.

25. Weekly expenditures on cocaine and heroin have decreased over time, but this change results from using the CPI to convert expenditures to 1998 dollar equivalents. Many hardcore users spend two-thirds of their incomes on drugs, but they probably do not see themselves as spending less over time because the price of cocaine and heroin has fallen in real terms since 1988. The CPI is not a good reflection of a hardcore drug users= market basket.

26. K.J. Riley, *Crack, Powder Cocaine, and Heroin: Drug Purchase and Use Patterns in Six U.S. Cities*, joint report of the National Institute of Justice and the Office of National Drug Control Policy (Washington, D.C., December 1997).

27. We are indebted to Linda Truitt for these calculations.

28. On this point, see J. Caulkins, B. Johnson, A. Taylor and L. Taylor, AWhat Drug Dealers Tell Us About Their Costs of Doing Business,@ *Journal of Drug Issues* 29(2), Spring 1999. This study was about the distribution of crack, but a similar marketing scheme is likely to pertain to heroin.

29. Two factors make the assumption of higher spending questionable. First, incomes of most drug users cannot support a higher level of drug use. Second, heavy drug users have a high level of unemployment and underemployment. D. Hunt and W. Rhodes, ACharacteristics of Heavy Cocaine Users, Including Polydrug Use, Criminal Activity and Health Risks,@ paper prepared for ONDCP, December 14, 1992. As discussed in Appendix B, illegal income from property crimes and prostitution accounts for much of the expenditure on drug use. However, illegal income cannot account for higher expenditures than are reported in this study. Drug dealing is often advanced as a way to support hardcore drug use, but in total, street-level dealing cannot generate the dollars that ultimately must go to satisfy the cash demands of middle-level and upper-level dealers. If expenditures are much greater than reported here, the income source for supporting that level of consumption is suspect.

30. Reuter and Kleiman estimated that the market for cocaine was about $8 billion in 1982. This is about $14 billion in 1998 dollars. Because of the accelerating use of cocaine from that time until the mid-1980s, and after accounting for inflation, it is not surprising that their estimate is less than the figure reported here. Their $8 billion estimate for heroin expenditures equals about $14 billion in 1998 dollars. That is considerably less than our 1989 estimate. P. Reuter and M. Kleiman, ARisks and Prices: An Economic Analysis of Drug Enforcement,@ in *Crime and Justice: An Annual Review of Research*, volume 7, ed. M. Tonry and N. Morris (Chicago: University of Chicago Press, 1986), 194. Carlson, who conducted a study of the underground economy for the Internal Revenue Service, reported that an estimated $11 billion was spent on cocaine in 1982. K. Carlson et al., "Unreported Taxable Income for Selected Illegal Activities: Volume I: Consensual Crimes," paper prepared for the Internal Revenue Service under contract number TIR-81.57, September 1984. In an update of his study, Carlson estimated that cocaine expenditures increased from $5.8 to $6.6 billion between 1988 and 1991. K. Carlson, AUnreported Illegal Source Income 1983-1995,@ paper prepared for the Internal Revenue Service under order number 89-11565, May 15, 1990. Since he relied heavily on the NHSDA, and because his estimates are not adjusted for inflation, it is not surprising that his estimate is much lower than the one reported here. Carlson=s estimate of heroin expenditures, based on the National Narcotics Intelligence Consumers Committee estimates for 1982, was in keeping with Reuter and Kleiman=s $8 billion figure. His updated study, based on NHSDA data, put that figure at roughly $7 billion a year between 1988 and 1991.

31. Heroin distribution seemed to change toward the end of the 1980s and 1990s. As discussed later in this report, there was a marked decrease in the cost of heroin and an equally marked increase in the purity of heroin available to American consumers. At least as of 1995, Colombia had replaced Southeast and Southwest Asia as the principal source of heroin sold in the United States, and distribution practices changed as a consequence. As Appendix B argues, ethnographers increasingly reported that drugs were being distributed by profit dealers instead of users.

32. Using the CPI to inflate expenditure on drugs is arguable. The Federal government computes the

CPI from a weighted average of prices paid by consumers for what is deemed to be a typical market basket. The problem when applying this CPI to hardcore users is that their market basket is grossly atypicalCtwo-thirds to three-quarters of their income may be spent on illicit drugs. (See J. Fagan, ADrug Selling and Illicit Income in Distressed Neighborhoods: The Economic Lives of Street-Level Drug Users and Dealers,@ in *Drugs, Crime and Social Isolation*, edited by A. Harrell and G. Peterson, (Washington, D.C.: The Urban Institute Press, November 1994). Because the nominal prices of cocaine and heroin have fallen over much of the period examined through the retail sales calculations, hardcore users have seen a deflation, not an inflation, in how much they spend on their typical market basket, most of which may be for illicit drugs. Thus, when asked about drug expenditures, hardcore users may well say they spend about the same amount in 1998 as they spent in 1988.

33.   Recent reports by the Community Epidemiological Work Group have told of increasing numbers of heroin users: AIn the most recent reporting period (1997-1998), heroin indicators continued to increase in 12 CEWG cities. In some cities, heroin use indicators have been trending upward for more than three years.@ December 1998 Advance Report. Downloaded from the Internet 11/15/99: www.cdmgroup.com/cewg/docs/1298-miami/1298adv.ntm#heroin

34.   M. Childress, B. Dombey, and S. Resetor. *A Systems Description of the Cocaine Trade* (Santa Monica, CA: Rand, 1994).

35.   M. Childress, et al. *A Systems Description of the Cocaine Trade* (Santa Monica, CA: Rand, 1994).

36.   W. Rhodes, P. Johnson, S. Han, Q. McMullen, and Lynne Hozik. *Illicit Drugs: Price Elasticity of Demand and Supply*. Report submitted to the National Institute of Justice by Abt Associates Inc., February 17, 2000.

37.   National Narcotics Intelligence Consumers Committee, *The NNICC Report 1993: The Supply of Illicit Drugs to the United States* (Washington, D.C., August 1994): 61.

38.   The estimate of 0.0136 ounces is equivalent to 0.39 grams. The 1997 NNICC report says that a joint contains one-half gram on average, and that a A. . . blunt may contain as much as 6 times this amount.@ If the NNICC estimate is correct, our estimates would be about 25 percent too low, but the source of the NNICC estimate is unknown. *The NNICC Report 1997: The Supply of Illicit Drugs to the United States* (Washington, DC: DEA, November 1998).

39.   Researchers disagree about trends in reporting practices, but they agree that self-reported tobacco use is only about three-quarters as large as reports based on foreign imports and tobacco sales resulting in state and federal excise taxes. K.E. Warner, APossible Increases in the Under reporting of Cigarette Consumption,@ *Journal of the American Statistical Association*, 73 (1978):314-317. E.J. Hatziadreu, J.P. Pierce, M.C. Fiore, et. al, AThe Reliability of Self-Reported Cigarette Consumption in the United States,@ *American Journal of Public Health*, 79, (1989): 1020-1023.

40.   In 1993, about 74 percent of arrestees who tested positive for marijuana use at the time of booking reported some marijuana use during the month before the survey.

41.   Using several self-report surveys, BOTEC Analysis Corporation estimated that marijuana costs $222 an ounce and that an ounce could be divided into 60 joints, yielding a unit price of $3.70 per joint. Based on these assumptions, BOTEC estimated that Americans spent $13.1 billion on 1,599 tons of marijuana in 1992. After adjusting for inflation, BOTEC's estimate is greater than the estimate presented in this report. The difference can be accounted for by three factors: methodological differences in estimating the number of users based on the NHSDA; BOTEC's inclusion of criminally active user estimates; and BOTEC's higher price estimates. A..L. Chalsma and D. Boyum, AMarijuana Situation Assessment,@ (Washington, D.C.: Office of National Drug Control Policy, September 1994).

42.   We noted previously that heavy cocaine users and heavy heroin users frequently appear in the DUF data, but infrequently appear in the NHSDA data. The reverse occurs for other illicit substances. With few exceptions, which are specific to cities, other illicit substances have relatively low prevalence among arrestees.

43.   Their answers, which were in ranges of days per year, were converted to a fixed number. For instance, the range three to five days became four days.

44.   Estimates of frequency of use from the 1991 NHSDA were applied to earlier years.

45.   Drug Enforcement Administration, *Illegal Drug Price/Purity Report United States: January 1990 B December 1993*, April 1994. Community Epidemiology Work Group, *Epidemiologic Trends in Drug Abuse*, (Rockville, MD: National Institute on Drug Abuse, June 1994).

46.   M. Layne, P. Johnston, W. Rhodes, *Following the Flow of Cocaine: The Sequential Transition and Reduction (STAR) Model, 1996-1999*, May 2000.

ii.   Defense Intelligence Agency, 1999. *Interagency Assessment of Cocaine Movement: August 1999* Eighteenth Edition, Mid-Year Review, p. 2

iii.   We used movement events from the CCDB for our calculations, and they differ slightly from figures published in the IACM. See Cala, 1999.

47.   W. Rhodes, M. Layne and P. Johnston, *Estimating Heroin Availability*. Report submitted to the Office of National Drug Control Policy by Abt Associates Inc., May 2000.

48.   Rhodes, W., Truitt, L., Kling, R. and Nelson, A. *The Domestic Monitor Program and the Heroin Signature Program: Recommendations for Change* (Cambridge MA, Abt Associates Inc., June 30, 1998).

49.   Coomber argues that this dilution of imported heroin is a product of the heroin production process. Thus it probably varies from source to source. South American heroin appears to be the most pure; Mexican is typically the least pure. R. Coomber, AThe Cutting of Heroin,@ *Journal of Drug Issues, 29 (1), 1999: 17-35.*

50. W. Rhodes, M. Layne, and P. Johnston. *Estimating Heroin Availability*. Report submitted to the Office of National Drug Control Policy by Abt Associates Inc., May 2000.

51. Calculations began with all the seizure reports contained in the Heroin Signature Program data file. These reports are not comprehensive of all seizures at ports of entry. From this file we selected all reports where: (1) the seizure occurred at an airport, at the border, or through the mail; (2) the seizure happened in 1995 or later; and (3) the seizure involved less than ten kilograms. Each report was characterized by the amount of pure heroin seized, and then the sample was weighted so that the distribution by source country for the seizure data matched the distribution by source country for the consumption data. For example, if 10 percent of the seizures came from South America while 15 percent of consumption came from South America, we weighted the seizures from South America by 15/10 or 1.5. By source area, the weights were:
    0.73 for unknown
    2.67 for Mexico
    0.87 for Southeast Asia
    1.32 for Southwest Asia
    1.67 for South America
As a practical matter, then, this weighting gives greater emphasis to Mexican and South American heroin.

52. The Canadian Center on Substance Abuse reports that 5.9 percent of Canadians tried heroin at some time; 1.1 percent of the population used heroin during 1994. Canadian Center on Substance Abuse, *Canadian Profile 1999 Illicit Drugs*, downloaded from the Internet www.ccsa.ca/cp99.11.htm, November 11, 1999.

53. Personal communication with Bill Wolf, Drug Enforcement Administration; November 12th, 1999.

54. Drug Enforcement Administration Memo: AInternational Chemical Conference on the Multilateral Chemical Reporting Initiative.@

55. http://www.usdoj.gov/dea/programs/diversion/divpub/substanc/methamph.htm.
    G. Haislip, *Methamphetamine Precursor Chemical Control in the 1990s.*

56. http://www.usdoj.gov/dea/pubs/meth/threat.htm. *Methamphetamine:A Growing Domestic Threat B The Methamphetamine Problem.*

57. Personal communication with Bill Wolf, Drug Enforcement Administration; November 12th, 1999; Drug Enforcement Administration Memo: AShifts in Predominance of Precursors.@

58. http://www.usdoj.gov/dea/programs/diversion/divpub/substanc/methamph.htm.
    G. Haislip, *Methamphetamine Precursor Chemical Control in the 1990s.*

59. Personal communication with Bill Wolf, Drug Enforcement Administration; November 12th, 1999.

60. Drug Enforcement Administration Memo B April 9, 1997.

61. Drug Enforcement Administration Memo B W.J. Wolf Jr., July 27, 1999.

62. G. Haislip, *Methamphetamine Precursor Chemical Control in the 1990s*, Drug Enforcement Administration, January 1996, downloaded from the Internet www.usdoj.gov/dea/programs/diversion/divpub/substance/methamph.htm.

63. The DEA no longer estimates the amount of marijuana under cultivation outdoors in the United States. The DEA also notes that indoor cultivation continues and that there is no way to estimate the extent of this practice. *The NNICC Report, 1995: The Supply of Illicit Drugs to the United States* (Washington, D.C.: National Narcotics Intelligence Consumers Committee, August 1996).

64. Drug Enforcement Administration, Intelligence Division, *U.S. Drug Threat Assessment* (Washington, D.C.: U.S. Department of Justice, 1993).

65. Details of the statistical model can be found in P. Johnston, W. Rhodes, K. Carrigan and E. Moe, AThe Price of Illicit Drugs: 1981 Through the Second Quarter of 1998.@ Paper prepared for the Office of National Drug Control Policy by Abt Associates Inc., February 1999.

66. A standardized retail cocaine purchase consists of 0.35 pure grams of cocaine at 67 percent purity. By assumption, retail cocaine purchases involve transactions of 0.01 to 1.0 pure grams.

67. A standardized middle level cocaine sale involves 30 pure grams (37.5 bulk grams) of cocaine at 80 percent purity. Middle level cocaine transactions are estimated to range from 15 to 140 grams, costing between $10 and $1000 per gram.

68. A standardized importation level purchase is 358 pure grams at 73 percent purity. Importation level purchases were 0.1 metric tons and larger.

69. A standardized purchase level for injection drug users is 40 milligrams at 13 percent purity. Purchases of 100 pure milligrams or less were considered to be purchases by injectors.

70. A standardized purchase level for those who sniff heroin is about one-third pure gram at 39 percent purity. Purchases between 0.1 and 1.0 pure grams fit this category.

71. A street-level purchase is 2.94 pure grams at 41% purity. This includes purchases of between 0.001 and 10 pure grams.

72. An importation-level purchase is 321 pure grams at 71 percent purity. A purchase was considered to be at the importation level if it exceeded 100 pure grams.

73. These estimates reflect retail level sales ranging from 0.001 to 10 grams; the retail price is evaluated at 3.1 grams. The importation level is for purchases of 1 metric ton and more. The prices are evaluated at 1.8 metric tons.

Appendix A

How Did We Estimate the Number of Heavy Users?

Estimates of the number of heavy users rely principally on the Drug Use Forecasting data from 1989 through 1997. The National Institute of Justice collected these data on a quarterly basis in 24 sites. During each quarter, at each site, interviewers asked arrestees about recent and past drug use, and they requested a urine specimen. Analysis of the urine provides a reliable test of drug use within the last 72 hours.

We mapped DUF sites into counties and collapsed the data into years. Within each county and year, we separated the data by the arrestee=s most serious offense at the time of booking (six offense categories) and gender. Define:

P_{IJKL} The proportion of arrestees in the Ith county, charged with the Jth offense category, and of the Kth gender, during the Lth year who said that he or she used drug X on more than 10 days during the month before the interview. The 10 day threshold was the criterion for being a heavy user. Drug X was heroin or another opiate, or else it was crack or cocaine. That is, we developed separate estimates for heroin/opiates and for cocaine/crack, but the methodology was the same for both. Because the data was not available for female arrestees for all sites for all years, we assumed that drug test rates for men also applied to women. Since females do not make up a large percentage of hardcore users, modest errors in this assumption should have no big effect

A_{IJKL} The number of arrestees in the Ith county, charged with the Jth offense, of the Kth gender, during the Lth year. The number of arrestees was taken from the Uniform Crime Report. We imputed arrest numbers when police failed to report for any one of the twelve months included in the UCR. When the police reported for more than six months, we simply prorated the reported total for the entire year. When they reported for fewer than seven months, we used a regression model (based on region and population served by the police force) to impute the total.

A preliminary estimate of the number of heavy (hardcore) drug users in the Ith county during the Jth year is written as:[1]

$$HC(1)_{IJ} = \sum_J \sum_I A_{IIJKL} P_{IJKL}$$

This estimate is preliminary. It certainly underestimates the number of heavy drug users who are booked into jails in the Ith county during the Jth year, because many hardcore drug users deny their substance use. The degree of underreporting can be inferred from the DUF data. Of 13,759 arrestees who tested positive for opiates, 8,342 said they had used heroin during the 30 days before the interview.[2] This implies a truthful reporting rate of about 0.61 for heroin users. Of 73,504 arrestees who tested positive for cocaine, 41,346 said they had used cocaine or crack during the 30 days prior to the interview. This suggests a truthful reporting rate of 0.56.

These estimates of the rate of truthful reporting seem too low. There are three problems.[3] The first problem is that the urine tests have a small but appreciable false positive rate. As an illustration, we observe that DUF sites with a low prevalence of heroin use (based on urine testing) have a lower than average rate of admissions of use (based on the above criterion).

The pattern is clear: The larger the number of arrestees who tested positive for heroin, the larger the proportion

Proportion of Arrestees Admitting Use as a Function of the Number Who Tested Positive
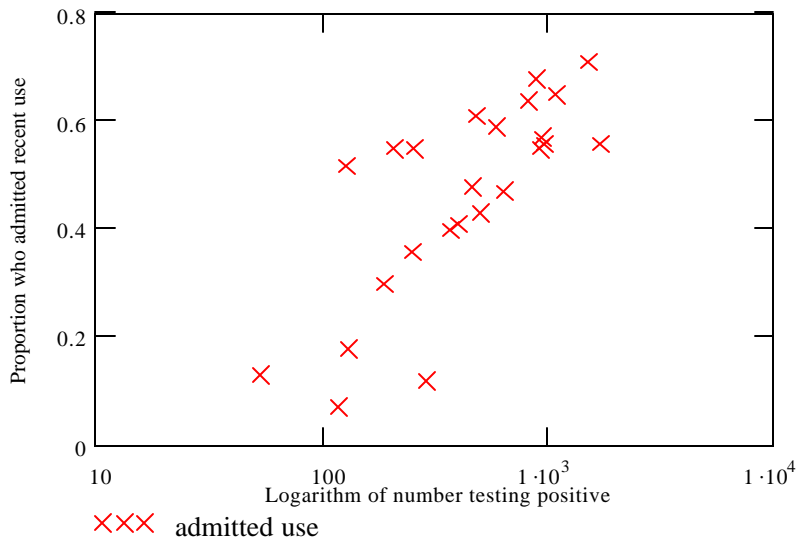
of those who tested positive who also admitted recent use. The interpretation is less clear. Certainly we would expect false positive rates on the urine screen to be larger when the prevalence of heroin use is relatively low. Consistent with this explanation, 7 percent of arrestees who test positive for opiates in Omaha (only 116 positive urine tests) admitted 30-day use of heroin and 18 percent of those who tested positive in Fort Lauderdale (only 130 positive urine tests) admitted 30-day use. In contrast, we see reporting rates of 71 percent in New York

(1493 positive urine tests) and 65 percent in San Diego (1069 positive urine tests). This same problem with truthful reporting does not seem to affect cocaine, whose prevalence is fairly high everywhere.

Another problem with self-reports for heroin is that the DUF interview asks about the use of methadone purchased on the street, but it does not ask about the use of methadone received from methadone clinics or physicians. According to SAMHSA=s Uniform Facilities Data Set, twenty of these twenty-four DUF sites have methadone clinics, and three more have methadone clinics in neighboring towns. Some of the negative responses to recent heroin use are likely to be truthful, then, despite evidence of a positive urine test. That is, some arrestees who denied recent heroin use despite positive urine tests were in methadone programs.

A third problem is that heroin and cocaine are sometimes mixed and administered together. Although users are generally aware that the drugs are mixed, it seems reasonable to assume that at least some users of heroin do not know they have used cocaine (or do not think of it as use of cocaine). Similarly, some users of cocaine do not know they have used heroin (or do not think of a mixture of heroin and cocaine as heroin use.)

Thus, the rate of truthful reporting for heroin use would seem to be higher than 61 percent, and the rate for cocaine use would seem to be higher than 0.56, but we are uncertain how much higher. Another way to look at these data is to ask: Of those people who tested positive for opiates, what percentage of them were willing to admit to illicit use of *any* drug during the month before the survey. Unless there is some reason to expect people to deny heroin use but admit other use, this percentage would seem to be a reasonable measure of being truthful. For this purpose, we excluded marijuana, because its use is quasi-legal in many places, so there is no reason to deny its use. Of those who tested positive for opiates, 73 percent were willing to admit *some* illicit drug use other than marijuana. For those who tested positive for cocaine, 61 percent reported that they used *some* illicit drug other than marijuana during the month. As expected, given this alternative criterion for truthful reporting, truthfulness by heroin users is greater than truthfulness for cocaine users.

Thus, let TRUTH = 0.73 for heroin and 0.61 for cocaine. Then an adjusted estimate for the number of heavy users equals:

$$HC(2)_{IJ} = \frac{HC(1)_{IJ}}{TRUTH}$$

Although HC(2) provides an estimate of the number of heavy users among arrestees, we seek to estimate the number of hardcore users in the county. Suppose that heavy drug users are arrested and booked an average of

AVG_BOOK per year. Then the number of hardcore drug users necessary to produce HC(2) heavy users among arrestees equals:

$$HC(3)_{IJ} = \frac{HC(2)_{IJ}}{AVG\_BOOK}$$

There are no national survey results to provide the average yearly arrest rate of hardcore users, but there are local studies. According to an ONDCP study, hardcore users in Cook County, Illinois, averaged 0.34 arrests per year.[4] This compares with figures of 0.39 and 0.37 for arrestees who tested positive for cocaine and heroin, respectively, and 0.36 for intravenous drug users, in Los Angeles, California.[5] Cohen reports yearly arrest rates of 0.36 for robbers and burglars who tested positive for drugs (exclusive of marijuana) in Washington, D.C.[6] According to Abt Associate=s tabulation of the 1993 National Household Survey on Drug Abuse, 39 percent of weekly cocaine users had been arrested during the year before the survey, so their arrest rate must have been greater than 0.39. These estimates are probably low, partly for study-specific methodological reasons (Cohen), partly because those who test positive for drugs are not necessarily hardcore users (some of the studies), and partly because the studies do not control for time spent in jail and prison (all the studies). On the latter point, Abt Associate=s analysis of responses from 12,000 male non-incarcerated intravenous drug users suggests they spent an average of 15 percent of the last five years in jail or prison, and 4,000 female IDUs spent an average of 10 percent of their time in jails and prisons. Using self-reports from DUF data, Hammett, Harmon and Rhodes find that heavy users of cocaine and heroin caused about an average of 0.38 arrests per year across five cities. Presuming that some interviewers would deny previous arrests, and given that some arrestees were not at liberty for the entire year, 0.38 probably understates the underlying arrest process.[7] Analysis by Rhodes, Hyatt and Scheiman was used to estimate annual arrest rates of 0.44 for cocaine users across six cities and 0.51 for heroin users across five cities.[8] These estimates, too, are probably too low. Although they pertain to time on the street, they are for individuals who tested positive, not necessarily those who are hardcore, and evidence is that hardcore users have higher arrest rates than more casual users.[9]

We adopted the estimates from Rhodes, Hyatt and Scheiman because they are conceptually the cleanest measure of arrest rates for people at liberty to be arrested. That is, we assumed that AVG_BOOK equals 0.44 for heavy cocaine users and 0.51 for heavy heroin users.

At this point $HC(3)_{ij}$ is an estimator of the number of heavy users in the counties represented by DUF. For reasons that will become clear, we seek to convert $HC(3)_{ij}$ into an estimate for the Metropolitan Statistical Area (MSA) that includes the DUF site. Define:

A_RATIO$_{IJ}$ as the ratio of drug-related arrests in the MSA to drug-related arrests in the county. This is typically a number close to one, except in New York City, where it is close to five, and Washington D.C. and Philadelphia, where it is close to two.[10]

The number of heavy users in the MSA is estimated as:

$$HC(4)_{IJ} = HC(3)_{IJ}A\_RATIO_{IJ}$$

The next step is to sum HC(4) over the DUF sites that have counterparts in the Drug Awareness Warning Network (DAWN). Call this summation:

$$HC(5)\bullet_J = \sum_{I \in DAWN}HC(4)_{IJ}$$

HC(5) estimates the number of heavy users in the MSAs that include a DUF site and also are part of the DAWN system. We observe that over ten years of DAWN data **B** 1988 through 1997 **B** this subset of DAWN sites accounted for 57 percent of all the emergency room mentions for cocaine and 50 percent of all emergency room mentions for heroin. If we adopt these figures as adjustment ratios, so that ADJ=0.57 for cocaine and ADJ=0.50 for heroin, then the final national estimate for heavy users is:

$$HC(6)_j = \frac{HC(5)\bullet_j}{ADJ}$$

HC(6) is reported in the text.[11]

To this point, we have estimates of the number of hardcore heroin users and cocaine users. At any time, a significant proportion of those hardcore users will be in jail or prison. The Bureau of Justice Statistics reports that 744,000 people were held in Federal or State custody in 1985 and 1.1 million were held in 1990. This suggests that about 1.0 million were held in custody in 1988, the beginning of the data series reported here. By 1998 the number had grown to 1.8 million.[12] According to BJS[13], the percentage of inmates on a 1991 survey who reported ever using drugs during the month before the survey were 25 percent of inmates for cocaine, 9 percent for opiates, and 7 percent for stimulants. Comparable figures on a 1997 survey were 25, 9 and 9 percent, respectively, so estimates of prior drug use have not changed appreciably over time. Multiplying the number of

inmates by 0.25 (for cocaine) and 0.09 (for heroin) provides yearly estimates of the number of hardcore users incarcerated during each year. We subtract the number of incarcerated hardcore users, INCAR, to estimate hardcore users on the street:

$$HC(7)_J = HC(6)_J - INCAR_J$$

Estimation requires two more final steps. The DUF data were provided by special request from the National Institute of Justice, whose contractor created a uniform file for DUF data from 1989 through 1998. This meant that we could not estimate hardcore drug use for 1988, and instead, for the 1988 estimate, we just used the figure reported previously in *What America=s Users Spend on Illegal Drugs: 1988-1995*. The FBI data were only available through 1997, so we could not use the methodology described above to estimate 1998. Furthermore, given that these calculations were being made in late 1999, the UCR data had not been collected for 1999 or 2000.

To project hardcore heroin and cocaine use for 1998-2000, we used a simple methodology: The 1998 estimate is a linear projection based on observations from 1995-1997. The 1999 and 2000 estimates were set equal to the 1998 estimate. As a final step, we used a three year moving average (centered on the reported year) to smooth the estimates. The end year (1988 and 2000) are based on a two-year moving average. The smoothed estimates are reported in the text.

We had to modify this approach for methamphetamine.

Methamphetamine users seemed to have an unusually high rate of truthful reporting, at least when compared with the rate for cocaine and heroin users. About 69 percent of those who tested positive said they used during the last month.

$ We did not have separate arrest rates for methamphetamine users.

$ We used the same rate as was used for cocaine users: 0.44 arrests per year.

$ The DUF MSAs accounted for only 23 percent of emergency room mentions for methamphetamines. Thus, to adjust data from DUF sites to represent the nation, we used an adjustment factor based on 1/0.23.

$ We assumed that the proportion of hardcore methamphetamine users in the prison population grew linearly so as to achieve 7 percent of arrests in 1991 and 9 percent in 1997.

Given the high year by year variance in the resulting estimates, we did not project a trend into 1998. Instead, we set the estimates for 1998 through 2000 equal to the estimate for 1997. Three-year moving averages were then used to smooth the data.

Endnotes

1. DUF is not a probability sample, and in some places, the DUF sample looks unlike the larger population of bookings. (J. Chaiken and M. Chaiken, Understanding the Drug Use Forecasting [DUF] Sample of Adult Arrestees. Lincoln, MA: LINC, 1993.) To deal with the fact that DUF is not a probability sample, we weighted the data by FBI arrests and by gender. Provided that DUF can be treated as random conditional on the booking charge and the arrestee=s gender, this approach should provide estimates that approximate that of a true random sample.

    This assumes, however, that we know the number of bookings by charge and gender. There are no booking data, so we had to used arrest data to approximate booking data. We assumed that all arrests for crimes of violence, property crime, robbery, drug-law violations and sex-related crimes resulted in bookings. We assumed that all other offenses resulted in bookings for half the arrests.

    Another problem with DUF is that the survey is generally based on a single jail in each county. This is often little or no problem, because one jail served the entire county. At some other places it is a minor problem, because there is one dominant jails and a few small ones. But at a few other places B such as in New York and Los Angeles B one jail (Manhattan and Los Angeles City) must represent bookings in the rest of the county. Until ADAM implements its new sampling plan, we cannot estimate the bias, if any, imparted by assuming that, say, Manhattan (New York County) represents the other four New York boroughs.

2. Someone who tested positive for opiates must have used an opiate within about three days of their interview. This three-day period is included within the last thirty days, so anyone who tested positive would be lying if they said they had not used in the last thirty days. Of course, people could have used in the last thirty days and still tested negative at the time of the interview, but that fact is irrelevant to a judgement about the rate of truth telling.

3. There may be a fourth problem not discussed in the text. The DUF survey is being replaced by the Arrestee Drug Abuse Monitoring (ADAM) survey. When pretesting the ADAM instrument, the ADAM team found that many people who tested positive for a drug denied use during the last three days but admitted use during 27 or 28 days during the last month. Apparently they simply wanted to avoid an admission of the drug use episode most associated with their arrest, but they were willing to report about other use. This phenomena would cause hardcore drug users to be more truthful than occasional drug users, so estimates of truthfulness may be understudied for hardcore users.

4. R. Simeone, W. Rhodes and D. Hunt, AMethodology for Estimating the Number of Hardcore Drug Users,@ report submitted to the Office of National Drug Control policy, March 1997.

5. Y. Hser, APopulation Estimation of Illicit Drug Users in Los Angeles County,@ *Journal of Drug Issues* 23(2), 1993: 323-334.

6. J. Cohen, AIncapacitation Effects of Incarcerating Drug Offenders,@ Final Report Submitted to the National Institute of Justice, May 4, 1992, figures interpolated from figure 4.

7. T. Hammett, P. Harmon and W. Rhodes, paper prepared for the National Commission on Correctional Health

Care, Abt Associates Inc., October 14, 1999.

8.   Calculations based on W. Rhodes, R. Hyatt and P. Scheiman, APredicting Pretrial Misconduct with Drug Tests of Arrestees: Evidence from Eight Settings,@ *Journal of Quantitative Criminology*, 12(3): 315-348.

9.   E. Wish, M. Cuadrado, and J. Martorana, ADrug Abuse as a Predictor of Pretrial Failure-to-Appear in Arrestees in Manhattan,@ unpublished paper prepared under Grant 83-IJ-CX-K048 to Narcotic and Drug Research Inc.

10.   Using drug arrest ratios across an MSA poses some problems. We would like to prorate based on arrests for cocaine and for heroin, as appropriate, but this is not possible. The FBI lumps all drug-law violations together. We cannot distinguish heroin arrests from cocaine arrests.

11.   Using DAWN to prorate estimates from DUF sites to other locations poses potential problems. It is difficult to know just what DAWN represents especially given trends that contrast sharply with trends reported in other sources. Because trends are so difficult to interpret, we employ the average ratio of ER mentions over the entire ten years in our calculations.

      Although trends are difficult to interpret, DAWN clearly reflects the behavior of hardcore drug users, so DAWN is helpful for our purposes. Of course, DAWN reports vary from year to year for reasons that have little to do with long term trends in drug use. About 32 percent of the time heroin users go to the emergency room because of unexpected reactions or overdose. The figure is 38 percent for cocaine users. Such visits are likely to result from idiosyncrasies in the drug markets across cities. Assuming that the ratio of ER mentions in city A to city B reflects the ratio of hardcore heroin users in city A to city B is unjustified in part because of those idiosyncrasies. But when we adopt a longer time-frame, and when we base the ratio on larger groups of MSAs, the assumption that ER mentions is proportional to the number of heavy drug users seems supportable.

12.   D. Gilliard, Prisoners and Jail Inmates at Midyear 1998, Bureau of Justice Statistics Bulletin, U.S. Department of Justice, March 1999.

13.   C. Mumola, Substance Abuse and Treatment, State and Federal Prisoners, 1997, Bureau of Justice Statistics Special Report, U.S. Department of Justice, January 1999.

Appendix B
Estimating Typical Expenditures on Drug Consumption

This appendix discusses the methodology used to develop estimates of weekly expenditures on cocaine and heroin by arrestees who used either or both of these drugs on more than 10 days during the month before their arrests. The estimates reported here are based on self-reports by arrestees in 24 cities. These self-reports, which are for 1989 and later, are from the Drug Use Forecasting (DUF) program.[1]

The Data

DUF respondents reported how much they spent on *all* drugs combined (during a typical week) but not how much they spent on each individual drug. They also reported the number of days they used any of 22 kinds of drugs during the month before their interview. We used regression analysis to infer expenditure patterns for cocaine and heroin based on these data.

The greatest obstacle to accurate reporting is a respondent's denial of drug use.[2] Therefore, drug use is underreported. Once a respondent admits drug use, however, he or she would seem to have less incentive to underreport or overreport consumption. To be included in this analysis, the respondent had to have admitted some illicit drug use during the last 30 days and had to have admitted some drug expenditure during the typical week. (These different time periods were required because of the wording of the DUF questions.) We estimated expenditure patterns for each year separately.

The dependent variable (EXPEND) was the weekly expenditure on all drugs. This variable was skewed (a few individuals reported very high amounts). Dealing with this skewed distribution required two steps. The first step was to trim the data by excluding all cases where a respondent claimed to spend more than $500 per day on drugs. Reasoning was that large reported amounts resulted from hyperbole, or else respondents were buying for others or for resale. Even $500 per day is a large level of expenditure. This trim to the data eliminated 2-3 percent of observations. The second step was to convert weekly expenditures to a logarithm before estimating the regression discussed subsequently. We then converted the predictions back to the original dollar scale.

The number of days that a respondent consumed each of four categories of drugs were the independent variables. We collapsed drugs into four general categories: COCAINE (powdered and crack), HEROIN (black tar and other), MARIJ (marijuana and hashishCcombined in the DUF interview), and OTHER. Cocaine, heroin, and marijuana were the only drugs consumed by a large percentage of the arrestee population. OTHER comprised a large number of infrequently consumed substances. Except for MARIJ, each variable comprised at least two drugs.

The category variable represents the maximum number of days any one of those drugs was consumed. For example, if powdered cocaine had been consumed on 15 days and crack cocaine had been consumed on 20 days, then COCAINE was coded as A20 days.@

We expected the relationship between expenditures and days of consumption to be nonlinear, but the logarithmic translation may not have been adequate to capture that nonlinearity. Consequently, each of the above category variables was raised to the second power, creating additional independent variables: COCAINE2, HEROIN2, MARIJ2, and OTHER2.

Cocaine, heroin, and other drugs are frequently consumed in combination. For example, heroin users often use cocaine, a stimulant, to moderate the effect of heroin, a depressant. However, someone who uses a combination of heroin and cocaine on a daily basis is unlikely to consume the same amount of heroin and cocaine that is consumed by two people who are daily users and exclusive in their drug use.

Consequently, two interaction terms were added to the regression. COKEHER equals COCAINE x HEROIN. COKEHER2 = COKEHER^2/300. The division by 300 facilitates the computing algorithm, but otherwise has no substantive importance for the analysis. The consumption of other drugs was relatively infrequent, so we did not add an interaction term to the regression for this variable.

Starting in 1990, DUF respondents were asked whether they had consumed any drugs in addition to those listed in the interview. A variable OTHERDRG denotes that some other drug had been consumed (1=yes, 0=no). This question was not asked during 1989.

Roughly midway through 1995 a new DUF survey instrument was introduced. While many of the questions remained the same between the two surveys, some questions important to our analysis changed. Most

notably, the old survey instrument asked about the amount of money spent on illegal drug in the past week, while the new survey asked about the amount spent on illegal drugs in the past month. After extensive testing of the data, we concluded that these questions were not comparable, and forced us to use only the data from the old survey.

Estimation

We used ordinary least squares to estimate the regressions. Results are presented in Table B-1.

Table B-1
Statistical Results for Regression Analysis of Drug Expenditures

	Regression Results			
	Male		1989	Female
Variable	Parameter	T-Score	Parameter	T-Score
Constant	3.394037	53.591	3.022931	25.802
Cocaine	0.124865	18.639	0.125573	9.643
Cocaine2	-0.001408	-6.658	-0.001418	-3.573
Heroin	0.120590	9.354	0.166687	6.976
Heroin2	-0.001413	-3.391	-0.002530	-3.314
Marijuana	-0.006798	-1.055	-0.013491	-0.963
Marijuana2	4.61792E-04	2.075	0.001083	2.203
Other	0.040873	3.834	0.037025	2.040
Other2	-8025108E-04	-2.201	-7.88341E-04	-1.241
Cokeher	-0.004535	-8.618	-0.005831	-6.352
Cokeher2	7.86980E-04	4.670	0.001177	4.059
R-Square	0.47937		0.47217	
Number of cases	4,345		1,479	

Table B-1
Statistical Results for Regression Analysis of Drug Expenditures

<u>Regression Results</u>

	<u>Male</u>		<u>1990</u>	<u>Female</u>
<u>Variable</u>	<u>Parameter</u>	<u>T-Score</u>	<u>Parameter</u>	<u>T-Score</u>
Constant	3.338284	60.685	3.061426	27.706
Cocaine	0.127209	22.724	0.115913	11.979
Cocaine2	-0.001600	-8.854	-9.73972E-04	-3.257
Heroin	0.129663	12.472	0.114766	5.774
Heroin2	-0.001678	-4.934	-0.001239	-1.917
Marijuana	-0.021442	-3.742	-0.036425	-3.338
Marijuana2	0.001198	6.025	0.001488	3.811
Other	0.061877	7.369	0.063660	4.509
Other2	-0.001418	-4.743	-0.001503	-3.047
Cokeher	-0.004150	-9.441	-0.001503	-4.402
Cokeher2	6.82710E-04	4.742	4.54228E-04	1.811
R-Square	0.48597		0.48561	
Number of Cases	6,607		2,426	

<u>Regression Results</u>

	<u>Male</u>		<u>1991</u>	<u>Female</u>
<u>Variable</u>	<u>Parameter</u>	<u>T-Score</u>	<u>Parameter</u>	<u>T-Score</u>
Constant	3.159967	56.177	2.904372	32.117
Cocaine	0.133565	25.599	0.105983	11.897
Cocaine2	-0.001776	-10.627	-7.45951E-04	-2.738
Heroin	0.127739	11.382	0.144211	8.013
Heroin2	-0.001546	-4.203	-0.002048	-30514
Marijuana	-0.007340	-1.378	-0.019310	-1.871
Marijuana2	8.13601E-04	4.392	9.15945E-04	2.461
Other	0.062032	7.054	0.041307	2.903

Table B-1
Statistical Results for Regression Analysis of Drug Expenditures

Other2	-0.001371	-4.388	-9.77069E-04	-1.994
Cokeher	-0.004136	-8.654	-0.003920	-5.345
Cokeher2	6.60313E-04	4.260	5.63272E-04	2.422
R-Square	0.48927		0.48131	
Number of cases	6,656		2,788	

Regression Results

	Male	1992	Female	
Variable	Parameter	T-Score	Parameter	T-Score
Constant	3.177672	51.333	2.741723	28.208
Cocaine	0.127932	25.560	0.119312	13.436
Cocaine2	-0.001679	-10.424	-0.001233	-4.534
Heroin	0.130250	11.842	0.107474	5.416
Heroin2	-0.001667	-4.640	-9.07676E-04	-1.419
Marijuana	-0.006954	-1.339	-0.007860	-0.787
Marijuana2	6.76879E-04	3.811	7.36585E-04	2.065
Other	0.058044	6.640	0.038488	2.865
Other2	-0.001148	-3.666	-9.23857E-04	-1979
Cokeher	-0.004307	-9490	-0.002413	-3.309
Cokeher2	7.33071E-04	4.958	-7.56896E-05	0.327
R-Square	0.46822		0.46607	
Number of cases	7,041		2,867	

Regression Results

	Male	1993	Female	
Variable	Parameter	T-Score	Parameter	T-Score
Constant	3.184262	58.079	3.297170	26.248
Cocaine	0.125961	23.823	0.118203	9.507
Cocaine2	-0.001697	-10.010	-0.001324	-3.466
Heroin	0.104632	10.049	0.174792	5.576
Heroin2	-9.89059E-04	-2.888	-0.003153	-3.057

Table B-1
Statistical Results for Regression Analysis of Drug Expenditures

Variable	Parameter	T-Score	Parameter	T-Score
Marijuana	-0.016286	-3.167	-0.012460	-0.931
Marijuana2	9.89328E-04	5.645	0.000619	1.294
Other	0.053566	6.434	0.065086	3.253
Other2	-0.001019	-3.467	-0.001443	-2.086
Cokeher	-0.003760	-8.407	-0.004958	-3.730
Cokeher2	5.73895E-04	3.890	0.000920	2.112
R-Square	0.45711		0.4286	
Number of cases	6,511		1,408	

Regression Results

	Male		1994	Female
Variable	Parameter	T-Score	Parameter	T-Score
Constant	3.416321	55.352	3.046568	31.755
Cocaine	0.103635	19.373	0.086845	9.071
Cocaine2	-0.001072	-6.275	-3.68042E-04	-1.262
Heroin	0.099462	9.393	0.118376	6.007
Heroin2	-9.76055E-04	-2.824	-0.001435	-2.232
Marijuana	-0.016521	-3.133	0.008881	0.917
Marijuana2	9.26518E-04	5.234	-3.48683E-05	-0.101
Other	0.057211	6.618	0.038982	2.669
Other2	-0.001344	-4.411	-5.72144E-04	-1.141
Cokeher	-0.003255	-7.098	-0.004339	-5.633
Cokeher2	4.19132E-04	2.796	8.05411E-04	3.232
R-Square	0.43718		0.43380	
Number of cases	6,139		2,534	

Regression Results

	Male		1995	Female
Variable	Parameter	T-Score	Parameter	T-Score
Constant	3.093118	40.864	3.297170	26.248

Table B-1
Statistical Results for Regression Analysis of Drug Expenditures

Cocaine	0.115361	16.145	0.118203	9.507
Cocaine2	-0.001458	-6.412	-0.001324	-3.466
Heroin	0.126846	7.516	0.174792	5.576
Heroin2	-0.001857	-3.362	-0.003153	-3.057
Marijuana	-0.021327	-2.992	-0.012460	-0.931
Marijuana2	0.001077	4.504	0.000619	1.294
Other	0.054822	4.861	0.065086	3.253
Other2	-0.000915	-2.322	-0.001443	-2.086
Cokeher	-0.005340	-7.865	-0.004958	-3.730
Cokeher2	0.001125	4.968	0.000920	2.112
R-Square	0.4257		0.4286	
Number of cases	3,434		1,408	

Sources: DUF 1989 through 1995

The model's explanatory power appears remarkable given the presumed measurement error in these data. Residuals were plotted against the number of days that the respondent reported using cocaine, heroin, marijuana, other drugs, and the interaction term. These plots indicate that the logarithmic transformation does a sufficient job of inducing normality among the residuals and that the model specification does not systematically distort the relationship between days of use and amount of money spent.

Interpretation

We converted predictions based on the regression reported in Table B-1 from logarithms to natural units using two approaches. When Ln($) is the predicted value of the original regression, then the median value in the original units is Median($) = Exponential(Ln($)), and the mean value in the original units is Mean($) = Exponential(LN($)+s²/2).

When cocaine is the only drug consumed, estimating expenditures on cocaine is straightforward. First, substitute zeros for all independent variables other than COCAINE and COCAINE2. Second, use the

regression results to make predictions when COCAINE = 1, COCAINE = 2, ... COCAINE = 30. Similar calculations yield estimates for expenditures on heroin when heroin is the only drug consumed.

For example, when cocaine is consumed 10 days a month, the median weekly expenditure is somewhat more than $80. It is about $200 a week when cocaine is consumed on 20 days a month, and it is about $300 a week when cocaine is consumed on 30 days a month.

When broken down by daily expenditure, spending on heroin and cocaine is about the same. However, this does not mean that when cocaine and heroin are consumed in combination, expenditures on each are equally divided. More likely, one of the drugs is the drug of preference, and the other is used frequently, but at a lower dosage.

When cocaine and heroin were consumed in combination, we attributed greater expenditure to what appeared to be the dominant drug. Let $ represent the predicted dollar expenditure on drugs by individuals who consume cocaine and heroin, but no other drugs. Let N_c represent the number of days a month that an individual consumed cocaine, and let N_h represent the number of days a month that individual consumed

$$\$_c = \$ \left[\frac{N_c}{N_c + ADJ \bullet N_h} \right] \quad \$_h = \$ \ \$_c$$

heroin. Expenditures on cocaine and heroin are estimated as:

where ADJ = 0.5 when $N_c > N_h$ and ADJ = 2.0 otherwise. According to this formulation, when cocaine is consumed on more days than heroin, at least two-thirds of the drug expenditure is attributed to the purchase of cocaine. When heroin is consumed on more days (or the same number of days) as cocaine, then at least two-thirds of the drug expenditure is attributed to heroin. As a practical matter, this rule dictates that respondents who say that they use both heroin and cocaine daily spend two-thirds of the money on heroin and one-third on cocaine. This division seems appropriate given evidence that such individuals typically are long-established heroin users who add a small amount of cocaine to their consumption.[3]

Typical Expenditures

Using results from the above regression, coupled with assumptions about how joint expenditures on heroin and cocaine should be apportioned, we estimated the median and mean expenditures for cocaine and heroin for every respondent who used either drug heavily. We averaged those estimates over all respondents who admitted using cocaine or heroin on more than 10 days during the month before their arrest. Those averages were weighted by the number of arrests reported by the FBI in each MSA represented by the DUF city. Results are reported in Table B-2.

Two additional adjustments were made to the statistics before transfering them to Table 4. A dollar in 1996 is worth roughly $0.80 in 1989 purchasing power, based on the Consumer Price Index. although it is arguable whether heroin and cocaine purchases should be deflated by the CPI, it seems misleading to ignore inflation over the eight years from 1988 through 1995, and the CPI is the best reflection of how purchasing power has changed. Thus, expenditures have been adjusted to take inflation into account.

The second adjustment was to convert the estimates to a three-year moving average centered on the year in question. For example, the estimate for 1993 is the average of the estimates for 1992, 1993, and 1994. We used a three-year moving average to reduce year-to-year measurement errors, but an examination of Table B-2 will reveal that averaging will not make major changes to the estimates.

The chief problem in interpreting these numbers is that the medians are so different from the means. Which should be used as Atypical@ expenditures? Evidence presented later seems to indicate that the median is preferable, but the evidence is not persuasive. Before turning to this evidence, the matter of earnings from income in kind must be considered.

Table B-2

Mean and Median Expenditures on Cocaine and Heroin, 1989-1995

	1989	1990	1991	1992	1993	1994	1995
Expenditures on cocaine by those who use cocaine heavily							
(Mean)	$414	$390	$381	$338	$309	$307	$303
(Median)	$228	$218	$218	$191	$178	$178	$181
Expenditures on heroin by those who use heroin heavily							
(Mean)	$530	$475	$509	$398	$344	$347	$332
(Median)	$291	$265	$291	$225	$199	$200	$198

Sources: DUF 1989 through 1995.

Accounting for Income in Kind

Hardcore drug users support their drug use through legitimate sources and through crime, especially drug dealing. Returns from dealing are often in the form of drugs as a payment for services rendered, or Aincome in kind.@ How does income in kind affect our estimates?

It is sometimes asserted that most hardcore users pay for their drug use by dealing or assisting others who deal in illicit substances. For example, Johnson and colleagues[4] report that in their sample of New York City heroin users, daily users spent an average of $7,601 a year on heroin, but consumed about $13,189 worth of heroin a year. Regular users (defined in this study as those who use heroin between three and six times a week) spent $4,019 a year on heroin, but consumed about $6,431 worth of the drug a year. The difference

between expenditures and consumption represents in-kind earnings in the form of drugs. If this were a typical pattern, then the expenditures on drugs computed from DUF should be inflated by ($13,189/$7,601) or 1.73 for daily users, and ($6,431/$4,019) or 1.6 for regular users. For reasons reported here, such multipliers seem much too large.

First, consider a hypothetical illustration of a drug market. Suppose that mid-level dealers have 100,000 units of drug X to sell and, at $1 a unit, demand $100,000 for their drugs. Suppose initially that there are 100 hardcore users, but no other users. Then, each hardcore user must generate $1,000 of income for the mid-level dealers.

The 100 hardcore users could support their use partly from dealing, but clearly they cannot support their use entirely from dealing. Selling exclusively to each other would not raise the $100,000 expected by mid-level dealers. The $100,000 must come from some other source.

Now, these 100 users could support one-third of their consumption by selling 66,666 units for $1.50 a unit to each other. This is a Pyrrhic marketing success, of course, but it would be effective if alternative income sources sometimes provided sufficient funds to make purchases and sometimes did not. The total revenue generated is $100,000, enough to satisfy the middlemen. This division of drugs would approximate what was observed by Johnson and colleagues in New York.

This solution requires that the street price of drug X be 50 percent higher than the price to mid-level dealers. In reality, retail prices for cocaine and heroin are about one-third higher than wholesale prices,[5] so income in kind would seem more likely to add about 33 percent to our estimates of drug consumption based on transactions in which money was exchanged.

Moreover, many sellers do not themselves consume drugs (at least not at heavy-use rates). To extend the above illustration, suppose that one-half the 100,000 units of drug X are sold by entrepreneurs who do not themselves consume drugs. Then, the 100 hardcore users could support only about 17 percent of their own drug use by selling drug X at $1.5 a unit to other users. The market opportunities for hardcore users to support their own consumption with income in kind is limited by sales by nonusers. Sales by nondrug users may be sizable.

Reuter and colleagues report that only 11 percent of the dealers they interviewed retained one-half or more of the drugs for personal consumption; 30 percent retained less than one-half, Ausually only >a little of it.=@[6] If Aa little of it@ means 15 percent, then these figures suggest that about 10 percent of the drugs that were available to these dealers were retained for personal consumption. If Reuter=s dealers are typical of those who sell drugs, then the expenditure figures based on dollar transactions should be increased by 0.1/0.9, or about 11 percent to account for income in kind.

In his field study, conducted in 1982 and 1983, of 15 street-level heroin dealers in Detroit, Mieczkowski[7] reports that dealers are typically not hardcore users: A...although runners appear by and large to be recreational drug users, they are not addicted to heroin.@ Mieczkowski=s findings suggest that income in kind represents a smaller percentage of drug consumption than was reported by Johnson.

Altschuler and Brounstein[8] interviewed 387 ninth and tenth grade, minority, inner-city boys from Washington, D.C., during 1988. Of the 387, 7 percent used drugs, but did not sell them; 9 percent sold drugs, but did not use them; and 4 percent both sold and used drugs. These findings suggest that many drug sales are made by dealers who are not hardcore users.

Williams tracked the drug (cocaine and crack) dealing of eight New York juveniles who belonged to a teenage drug ring called the Cocaine Kids, or the Kids. Williams reports that A...virtually all cocaine suppliers expect retail dealers to return with cash amounting to about 60 to 75 percent of potential retail sales of their consignment.@[9] If this profit margin is typical for cocaine and crack retailers, and if all this profit is income in kind spent on the retailer=s consumption, then estimates based on dollar transactions might be multiplied by 0.66 to 0.33. However, the dealers interviewed by Williams did not take their profits primarily in the form of crack: AAll the Kids snort cocaine regularly. This is accepted, but the use of crack is generally frowned upon: those who snort are thought to have more control and discipline than those who smoke crack or freebase. Most dealers see crack smokers as obsessive consumers who cannot take care of business; crack users, they say, tend to become agitated, quickly lose control and concentration, and take one dose after another at the expense of everything else.@[10]

Skolnick,[11] who examined crack sales by gang members in California during 1988, reports two types of dealers: one who sells for profit and one who sells to buy drugs. Interestingly, Skolnick also reports that

75 percent of street sales will be returned to the middleman, a figure consistent with that reported by Williams in New York.

Waldorf and Lauderback interviewed 568 members of 86 different ethnic gangs in San Francisco.[12] They reported that only 16 percent of the crack sellers used crack during the month before the interview, although about one-half of the cocaine sellers and about three-fourths of the heroin sellers used those drugs during the month before the interview. The gang members explained that intoxicated sellers did not make reliable dealers and that drug dependence impaired the gang member's ability to defend the gang. Waldorf and Lauderback reached similar conclusions to Chin[13] (Chinese gang members who sold heroin did not use it) and Vigil.[14]

Mieczkowski, on the other hand, reports that crack sellers in his Detroit sample Aappear to conform closely to the ›classic‹ or ›hustler‹ view of the drug user.@[15] Nearly two-thirds of the respondents said that they sold crack to get money for their own crack consumption.

The important point is that many of the drugs consumed by hardcore users are sold by individuals who do not use drugs heavily. The ability of hardcore users to support their own use through dealing is necessarily limited. Consequently, the amount of drugs that hardcore users receive as income in kind cannot account for much of the cocaine and heroin consumed.

Data are not sufficient to support precise estimates. It seems that a street dealer might be able to retain about one-fourth of the drugs that he markets, and that profit dealers (those taking their profit in cash rather than in kind) are more numerous among cocaine dealers than among heroin dealers. We assume that two-thirds of the cocaine dealers and one-third of the heroin dealers are profit dealers.

Assume that a cocaine retailer must return $3 for every $4 of crack or powdered cocaine that he sells. Also assume that two-thirds of all retail dealers are profit dealers and one-third are users. This means that every $1 spent on crack and cocaine would result in $1 x 0.33 x 0.33 = $0.11 in income in kind, suggesting that the estimates should be inflated by 0.11. This inflation figure equals the 11 percent income in kind figure derived from Reuter and colleagues= study.

Second, assume that a heroin retailer must return $3 for every $4 of heroin that he sells. Also assume that one-third of the retail dealers are profit dealers. This means that every $1 spent on heroin would result in

a maximum of $1 x 0.33 x 0.66 = $0.22, suggesting that the estimate should be inflated by 0.22. This inflation figure is lower than the income in kind figure derived from Johnson and colleagues= study but is more consistent with observations that not all those who sell heroin are hardcore users.

Based on the above evidence, we assume that $0.22 worth of heroin is retained as income in kind for every $1 of heroin sold. For cocaine, we assume one-half that amount, or $0.11, for every $1 sold.

Choosing the Median As the Typical Expenditure

If weekly expenditures on drugs were reported with perfect accuracy, there would be little justification for using any number other than the mean. After all, regardless of how the data are skewed, the mean is the average expenditure, and total expenditures will equal the average expenditure multiplied by the number of hardcore users.

However, another interpretation seems more reasonable. Suppose that the average expenditure is about the same for everybody who uses drugs on a specified number of days a month, but that the amount spent on drugs is reported with great inaccuracy. From this view, the median is the best measure of the average expenditure.[16] Some other sources suggest that the median expenditure is more accurate for our analysis.

Other reports of expenditures on drug use

Other studies, primarily of hardcore users involved with the criminal justice system, estimate expenditures on heroin and cocaine that are broadly consistent with the medians reported here (Table B-2). Reviews of those studies appear here. In each study, the authors=estimates of expenditures have been inflated to 1996 dollar equivalents using the CPI.

Johnson and colleagues[17] interviewed 201 subjects who were street-level heroin users in East and Central Harlem; all were involved in some form of criminality and spent most of their time on the streets. Subjects were interviewed for five consecutive days, and then were interviewed weekly for the following four weeks. About 132 of these subjects were interviewed four more times at three- to six-month intervals. The average user spent $6,200 a year on heroin. These users often sold drugs, and when they did, payment was usually in the form of drugs as income in kind. When income in kind was taken into account, these users spent about $10,300 a year on heroin. Daily users directly purchased $12,000 worth of heroin a year, but when income in kind is taken into account, they spent about $19,000. Regular users (those who used at least weekly, but less than daily) made cash payments of $5,900 for heroin over the course of a year, but with income in kind payments, their annual expenditures were $6,431. These estimates are comparable with those

based on the median responses in the DUF data, which suggest that hardcore users of heroin spend about $18,000 a year on heroin in 1989, the year most comparable to the Johnson study.

Johnson and Wish[18] recruited 105 male New York Ahard-drug abusers@ who had committed one or more relatively serious non-drug crimes (such as robbery, burglary, grand larceny, or assault) in the past 24 hours. Those who had committed recent robberies spent an average of $74 a day on illicit drugs. Those who had committed other crimes spent an average of $46 a day. Thus, for those who had just committed crimes, the expenditure on drugs was $319 to $518 a week.

For those who bought both heroin and cocaine, daily expenditures totaled $368 to $518 week. Those who bought only cocaine spent $249 to $329 a week on cocaine. Those who bought only heroin spent $219 to $358 a week on heroin. It is notable that 86 percent of these subjects reported using some illicit substance on 28 of the past 30 days, so the majority could be considered hardcore drug users. These figures seem to be high estimates of consumption, however. Because all these users had recently committed serious crimes, they had money available from illegal sources to buy drugs. Nevertheless, the average expenditures were about the same as those based on the median values from the DUF dataC$283 in 1989.

Reuter and colleagues report results based on interviews with 186 males on probation in Washington, D.C., who had sold drugs during the mid-1980s. About one-half reported purchasing drugs for their own use. This half had a median expenditure of $580 a month; the mean was $2,300. However, about 40 percent of the respondents consumed some of the drugs that they acquired for dealing, representing income in kind spent on drugs; about 10 percent reported that they consumed one-half the drugs that they acquired by dealing. The median and mean are much smaller than their counterparts in DUF, but the Reuter subjects are not necessarily hardcore users.[19]

Mieczkowski[20] also interviewed 97 crack users who were arrested in Detroit, who tested positive for cocaine, and who admitted to using crack. On average, this group used two dozen rocks of crack, at a cost of $329 per week. Although these were not necessarily heavy users, all used crack cocaine at least weekly. Mieczkowski makes an important point: AIt also appears true that as levels of use rise and approach 20 to 30 rocks a week, respondents have increasing difficulty in estimating their levels of consumption. This is apparently due to sharing crack with friends, increased personal consumption, and accepting in-kind services as payment for crack.@(p. 8)

Mieczkowski[21] also asked 190 Achronic users of crack cocaine@in Detroit about their crack consumption by appending questions to the DUF interview. About one-fourth of these users consumed four or fewer rocks[22]

a week ($50 or less a week); most of the others clustered at 10 to 20 rocks a week ($125 to $250 a week) and 40 to 50 rocks a week ($500 to $625 a week). Only 5 percent used over 100 rocks a week. Mieczkowski speculated that the upper range included dealers who could not distinguish between their own consumption and what they sold, as well as individuals who were sharing with friends.

The Office of National Drug Control Policy sponsored a study of hardcore drug users in Cook County, Illinois, during 1995.[23] A hardcore users was one who: (1) used heroin or cocaine on at least eight days during either of the two months just before the interview, or (2) used heroin or cocaine during the last 60 days and scored high on a scale of addiction. Practically, the first criterion was determinative, so these users satisfy the heavy user criterion used in this report on retail sales.

Each subject in this study was asked separately about his or her use of heroin, powdered cocaine, and crack cocaine. Regarding heroin, he was asked: AIn the past 60 days, how much did you usually spend on heroin for your own use on those days when you were using?@ The interviewer clarified the question by saying: AI know the days can vary quite a bit, but when you were using, how much did you spend for sure on heroin? If you got it in trade, on credit, or for some services, just give me your best guess as to what it was worth.@ Because of this last qualifying statement, consumption includes heroin gotten as income-in-kind, so these estimates do not need to be adjusted to account for heroin that was gotten without being paid for in currency.

Interviewers also asked subjects about how many days they used heroin during the 60 days before the interview. The 304 subjects who used heroin said they used it an average of 5.5 days per week. They spent an average of $61 per day on those days when they used. They spent an average of $369 per week during the two months that predated the interview.[24] The median amount was $290.

Interviewers asked similar questions about crack and powdered cocaine use. The 164 subjects who said they used powered cocaine said they used the drug an average of 3.8 days per week, and they spent an average of $91 per day of use. The average expenditure was $393, and the median expenditure was $240. the 637 subjects who said they used crack cocaine admitted using it on 4.6 days per week and spent an average of $89 per day. They said they spent an average of $422 per week, and a median amount of $300.

Some of these subject used just powdered cocaine, some used just crack cocaine, and some used both. Without distinguishing between powdered and crack cocaine, we estimate that hardcore users of cocaine spend an average of $476, and a median of $290, per week.

The expenditure patterns are skewed. A few hardcore users have relatively high reported expenditure patterns, which causes the average amount spent on cocaine to be much more than the median amount. To illustrate this, suppose that no hardcore users could spend more than $500 per week on cocaine, so that any reports of over $500 should be truncated at $500. Then the mean expenditure on cocaine would be $299. If the upper limit were $750, then the average would be $357. An upper limit of $1,000 yield an average of $388, and an upper limit of $1,250 leads to an average of $412.

Three other studies provide partial support for the estimates used in this report. Fagan[25] interviewed 1003 drug users and sellers, whom he recruited from two sitesCCentral Harlem and Washington Heights, New York using snowball sampling techniques. Crack users were almost two-thirds of the sample, and cocaine/crack users were almost three-quarters of the sample, in both sites. During the year following initiation of crack use, males in Central Harlem spent $1,380 dollars per month and females spent $800 per month. This expenditure patterns were not much different than those assumed in this report. However, in Washington Heights, the averages were $1,950 per month for males and $2,100 per month for females. These expenditure patterns are more like the mean expenditures estimated from DUF.

A study commissioned by ONDCP examines purchase patterns by heroin users. Rocheleau and Boyum[26] located about 50 heroin users in each of three cities (New York, Chicago, and San Diego) using snowball sampling. These users were asked about their purchasing habits and, how much they spent on heroin and other illicit drugs. Across the three sites, heroin users spent an average of $290 (median = $230) per week on heroin and an average of $380 (median = $270) on all drugs. These estimates are consistent with the dollar expenditures assumed in this report, but Rocheleau and Boyum also computed expenditures by multiplying the amount of heroin used by the average price paid, to estimate that heroin users spent an average of $500 (median = $315) per week on heroin. This is more than we have assumed in our calculations.

The studies cited above are consistent with the conclusion that the median values based on DUF data typify spending patterns for those arrestees who admitted using cocaine or heroin on at least 11 days during the

past month. However, some of these studies report expenditures hearer the mean; moreover some of the studies described below report larger expenditure patterns.

Mieczkowski[27] reports on interviews with A100 self-reported dealers and user/dealers of crack cocaine@ who were in residential treatment facilities in Detroit. All can be considered to be hardcore users. The amounts reported on weekly drug usage were highly skewed. The estimates were: $1,232 mean; $1,150 trimmed mean; $789 median; $716 M-estimator. These estimates are considerably higher than those we report, although they are not inconsistent with estimates for the very heaviest users. One explanation of this variation may be that these users had especially high use patterns, as evidenced by their seeking treatment.

Other studies of treatment populations indicate that expenditures can be much higher for the typical hardcore user than is assumed here. Schnoll and colleagues[28] report on expenditures by 172 men and women who received treatment for cocaine abuse in Chicago primarily during 1982 and 1983. Average expenditures were reported as $1,270 a week.

Gawin and Kleber[29] describe cocaine use in a sample of 30 consecutive admissions to a cocaine treatment program in New Haven. Thirteen intravenous drug users used an average of 5.6 grams a week, six smokers used an average of 9.1 grams, and 11 who snorted used an average of 5.3 grams a week. If these users paid $100 a gram, they must have spent $500 to $900 a week for cocaine prior to entering treatment.

Collins, Hubbard, and Rachal (1985) studied annual drug expenditures of 3,276 drug users who entered publicly-funded drug treatment in 1979.[30] For daily heroin users, the median drug expenditure was $17,000, and the mean was almost $28,000. For weekly users (exclusive of daily users), the median was $6,700, and the mean was about $7,400. There were fewer regular cocaine users. On a yearly basis, daily users spent a median of $23,000, and a mean of almost $32,000. Those who used on a weekly (but not daily) basis had median expenditures of $10,000, and a mean of almost $20,000.

Comparing these estimates with those based on DUF is complicated. Because these estimates are from 1978 and 1979, an adjustment for inflation leads to estimates that are higher than those based on DUF. However, the street price of heroin and cocaine have fallen so much since 1978-1979 that, even controlling for inflation, that 1978-1979 is a questionable benchmark. Another limitation is that cocaine users who sought treatment in the late 1970s may have little resemblance to crack users of the late 1980s and early 1990s.

Although the latter studies, all of which are based on a population in treatment, indicate that hardcore users spend more on cocaine than is assumed in this study, users in treatment probably have use patterns that are atypical of hardcore users in general. As Waldorf and colleagues[31] report, most hardcore cocaine users are able to control their consumption, avoiding the ruinous expenditure patterns that often drive other usersCthose who have the least controlCinto treatment.

Evidence from the NHSDA

Additional evidence comes from the NHSDA. The number of individuals who admitted using cocaine on more than 10 days during the month before the interview and reported how much they had spent on cocaine was small, thus the estimates for cocaine expenditures are fairly unreliable (Table B-3). For example, in 1993, only seventy-eight individuals admitted hardcore cocaine use and reported cocaine expenditures. Average expenditures were $81 a week. These average expenditures reported by hardcore cocaine users in NHSDA were much lower than those reported in DUF (Table 2). Although the NHSDA estimates appear to show a decrease in average expenditures by hardcore cocaine users from 1988 ($130) to 1993 ($81), this trend is neither consistent nor reliable.

Table B-3

Average Expenditures on Cocaine by Hardcore Cocaine Users, 1988-1993

	1988	1990	1991	1992	1993
Average Expenditures	$130	$17	$83	$34	$81
Number of valid answers	27	30	119	66	78

Sources: NHSDA 1988, 1990 through 1993

Estimates based on amount consumed

Another way to validate the median as a measure of expenditures is to infer how much hardcore cocaine and heroin users could spend given their consumption patterns.

It is difficult to shoot heroin more frequently than four times a day, and many DUF respondents used heroin less often than daily.[32] According to Division of Substance Abuse Services (DSAS) in New York City, a hardcore user might use one to two bags of heroin a session, and each bag would cost $10. These approximations suggest that a hardcore user could not spend much more than $420 a week.

Although $420 is close to the mean expenditure estimated based on the DUF data, even those heroin users who are hardcore consumers cannot shoot heroin every day, four times a day. Clearly, $420 a week should be considered more as an upper limit than an average for weekly expenditure on heroin.

Cocaine is different. A study commissioned by the National Institute on Drub Abuse[33] provided estimates of the amount of pure heroin used by heroin addicts in San Francisco, Baltimore, and Newark. The estimates, which are summarized below, pertain to addicts with high, average, and low habits.

Table B-4

Heroin Usage Patterns by Heroin Addicts in Three Cities

	San Francisco	Baltimore	Newark
High habit	224 mg	258 mg	227 mg
Average habit	28 mg	168 mg	138 mg
Low habit	14 mg	62 mg	51 mg

The study does not report dollar expenditures, but some estimates are possible based on the apparent price paid per milligram in San Francisco and Baltimore, and an assumption that the price paid per milligram in Baltimore is the same as that paid in Newark. We also assume that these users purchased heroin on 5.5 days per week, a number that is consistent with observations by Simeone, Rhodes, and Hunt in Chicago. These calculations suggest that the average weekly expenditure on heroin was about $98 in San Francisco, $462 in Baltimore, and $380 in Newark. While heroin seems to be self-limiting (the user=s craving can be satisfied much as a diner is satiated after a full meal), cocaine is notable because it immediately engenders a desire for more cocaine. As discussed earlier, there are reports of very hardcore consumption patterns just prior to seeking treatment.

Nevertheless, cocaine consumption has two limitations. The first is physiological. Binge use exhausts the body, so rest is necessary before binge use can recur. The second is that hardcore cocaine use can quickly exhaust financial resources. One way to check estimates of drug spending patterns for cocaine is to assess the user's income from legal and illegal sources.

Estimates Based on Financial Resources

One way to assess the practical upper limit for cocaine use (excluding the minority of users who drain personal resources prior to entering treatment) is to estimate the amount of money that hardcore users have available to spend on cocaine.

According to DUF, most hardcore users who are arrested and questioned have limited legal incomes. Much of their earnings comes from crime. How much do such individuals earn from combined sources?

As would be expected, it is no easier to estimate the amount of money earned from crime than it is to estimate the amount of money spent on drugs. There are, however, a few studies of earnings from property crime. Johnson and colleagues, in a study described above, report that daily heroin users earn an average of $13,000 a year from non-drug criminal activity, and regular users earn $9,200 a year. Total criminal income, including drug income in kind, is $28,000 for daily users and $16,000 for regular users. After living expenses are subtracted from these incomes, the amount available for heroin expenditures could not be much greater than is assumed in this report.[34]

Anglin and colleagues[35] describe the income of 279 male heroin addicts who were selected from those who had first entered a methadone program between 1971 and 1973. The period of time described is the 12 months prior to their first period of legal supervision. Chicano respondents averaged $6,708 in illegal income a year (not counting $924 a year from drug dealing), and whites averaged $8,580 a year (not counting $1,320 a year from drug dealing). Legal incomes were $1,984 to $2,672 a year. Even when inflation is taken into account, these incomes could not support drug use habits far in excess of what is assumed in this paper.

Reuter and colleagues report results based on interviews with 186 males on probation in Washington, D.C., who had sold drugs during the mid-1980s. They report an average income of $4,000 a month, all but $1,200

from illegal activity, mostly drug sales. However, most of this income was spent on expenses other than drugsCdrug expenditures averaged $883 a month.[36]

Fagan also reports monthly income. His table 4.7 is a cross-tabulation with multiple breakdowns and is hard to summarize because he does not report the number of observations in each cell. Nevertheless, patterns are apparent. Those who do not sell drugs regularly make less than $1,100 per month on average, sometimes considerably less when they are disabled. Those classified as sellers make about $3,000 in Central Harlem and roughly $4,000 in Washington Heights. There is considerable variation about these averages, however, and the reported earnings for drug sellers are inflated because they are gross estimates that do not subtract the cost of obtaining drugs for sale.

Conclusions

The evidence is not compelling, but it seems best to assume that the median expenditures on cocaine and heroinCas measured from DUF dataCprovides the best basis for computing dollar expenditures on cocaine and heroin. The uncertainty surrounding this assumption is best handled through sensitivity analysis, which we execute in the main report.

The evidence in support of the percentage of drugs earned as income in kind is also meager. We assume that for every dollar spent on cocaine another $0.11 of cocaine is consumed as income in kind. We assume that for every dollar spent on heroin another $0.22 of heroin is consumed as income in kind.

Endnotes

1. No question was asked about the amount of expenditures on drugs in the 1988 DUF data, so no analysis was performed for that year.

2. Drug users also have difficulty recalling how often they used a drug, how much they used, and how much they paid for it. However, this inaccuracy, unlike intentional denial or deception, probably averages out when the data are aggregated.

3. D. Hunt, ATracking the Prevalence of Heroin Use,@ paper prepared for ONDCP, July 1992.

4. B. Johnson et al., *Taking Care of Business: The Economics of Crime by Heroin Abusers* (Lexington, Massachusetts: Lexington Books, 1985).

5. W. Rhodes, R. Hyatt, and P. Scheiman, AThe Price of Cocaine, Heroin, and Marijuana, 1981-1993,@ *Journal of Drug Issues*, 24, no. 3. (1994): 383-402.

6. P. Reuter et al., *Money from Crime: A Study of the Economics of Drug Dealing in Washington, D.C.* (Santa Monica, California: Rand Corporation, 1990) RAND publication R-3894-RF, p. 61.

7. T. Mieczkowski, AGeeking Up and Throwing Down: Heroin Street Life in Detroit,@ *Criminology*, 24, no.4. (1986): 645-665.

8. D. Altschuler and P. Brounstein, APatterns of Drug Use, Drug Trafficking, and Other Delinquency among Inner-City Adolescents in Washington, D.C.,@ paper presented at the Annual Meeting of the American Society of Criminology, Reno, Nevada, 1989, 9; and Table 3.

9. T. Williams, *The Cocaine Kids: The Inside Story of a Teenage Drug Ring* (Reading, Massachusetts: Addison-Wesley Publishing, 1989), 36.

10. Williams, *The Cocaine Kids*, 47.

11. J. Skolnick, *The Social Structure of Street Drug Dealing* (BCS FORUM, Office of the Attorney General, State of California, undated).

12. D. Waldorf and D. Lauderback, ADon=t Be Your Own Best CustomerC Drug Use of San Francisco Ethnic Gang Drug Sellers,@ *Crime, Law and Social ChangeC An International Journal*, 19 (1993): 1-15. The published article was based on a population of 300; however, an updated version surveyed 568 gang members.

13. K. Chin, AChinese Triad Societies, Tongs, Organized Crime and Street Gangs in Asia and the United States,@ unpublished Ph.D. dissertation, University of Pennsylvania, Philadelphia, Pennsylvania, 1986.

14. J. Vigil, *Barrio Gangs: Street Life and Identity in Southern California* (Austin, Texas: University of Texas Press, 1988).

15. T. Mieczkowski, "Crack Distribution in Detroit," *Contemporary Drug Problems*, (Spring 1990): 23-24.

16. An analogy helps make this point. Suppose that a grocery store clerk were to ring 1,000 $1 candy bars individually on his register. Suppose that he was inaccurate but unbiased as he occasionally registered too many or too few zeros: 100 bars were priced at $0.10, 800 were priced at $1, and 100 were priced at $10. The total expenditure on candy bars would be $1,810, or an average of $1.81 per candy bar. Here the clerk's random errors do not balance out.

17. B. Johnson et al., *Taking Care of Business: The Economics of Crime by Heroin Abusers* (Lexington, Massachusetts: Lexington Books, 1985).

18. B. Johnson and E. Wish, "The Robbery-Hard Drug Connection: Do Robbers and Robberies Influence Criminal Returns and Cocaine-Heroin Purchases," paper presented at the Criminology Section of the American Sociological Association, August 17, 1987.

19. P. Reuter et al., *Money from Crime: A Study of the Economics of Drug Dealing in Washington, D.C.* (Santa Monica, California: Rand Corporation, 1990) Rand Publication R-3894-RF, p.61.

20. T. Mieczkowski, Understanding Life in the Crack Culture: The Investigative Utility of the Drug Use Forecasting System (National Institute of Justice, Research in Action, November–December 1989).

21. T. Mieczkowski, "Crack Distribution in Detroit," *Contemporary Drug Problems*, (Spring 1990): 18-20.

22. Crack is made by heating powdered cocaine until it crystallizes. "Rocks" are then broken off the chunk of crack produced. Crack is often bought by the rock. Although this purchase unit varies in weight and size, rocks tend to be fairly small and inexpensive.

23. R. Simeone, W. Rhodes and D. Hunt, A Plan for Estimating the Number of "Hardcore" Drug Users in the United States: Preliminary Findings, January 1997. Estimates reported above were based on previously unreported tabulations from that study.

24. This average comes from multiplying the average number of days per week that the subject used heroin times the average expenditure per day for each heroin users, and then taking the average over all users. This is not the same as multiplying the average expenditure per day for all users by the average number of days used heroin for all users. Thus, the reader cannot confirm the weekly expenditure estimate from the number cited above. The tabulations were weighted to reflect the population of hardcore drug users in Cook County.

25. J. Fagan, Drug Selling and Licit Income in Distressed Neighborhoods: The Economic Lives of Street-

Level Drug Users and Dealers, in Drugs, Crime and Social Isolation, edited by A. Harrell and G. Peterson (The Urban Institute Press, Washington, D.C., 1992): 99-146.

26.   A. Rocheleau and D. Boyum, Measuring Heroin Availability in Three Cities (Office of National Drug Control Policy, Washington, D.C., November 1994).

27.   T. Mieczkowski, AThe Economic Dimensions of Crack Use and Distribution: Some Preliminary Data,@ paper presented to the American Society of Criminology Annual Meetings, Reno, Nevada, November 1989.

28.   S. Schnoll et al., ACharacteristics of Cocaine Abusers Presenting for Treatment,@ in *Cocaine Use in America: Epidemiological and Chemical Perspectives*, ed. N. Kozel and E. Adams (Rockville, Maryland: National Institute on Drug Abuse, 1985), NIDA Research Monograph 61, 171-181.

29.   F. Gawin and H. Kleber. ACocaine Use in a Treatment Population: Patterns and Diagnostic Distinctions,@ in *Cocaine Use in America: Epidemiological and Chemical Perspectives*, ed. N. Kozel and E. Adams, (Rockville, MD: National Institute on Drug Abuse, 1985), NIDA Research Monograph 61, 182-192.

30.   J. Collins, R. Hubbard, and J. Rachal, AExpensive Drug Use and Illegal Income: A Test of Explanatory Hypotheses, *Criminology@* 23, no. 4. (1985): 743-763.

31.   D. Waldorf et al., *Cocaine Changes: The Experiences of Using and Quitting* (Philadelphia: Temple University Press, 1991).

32.   Kahn reports an average of three fixes a day for 453 clients before their participation in a methadone maintenance program. Only 16 percent of his clients reported more than four fixes daily. Anglin reports that during the 12 months before entering criminal justice supervision, 279 heroin addicts (who had been identified through a methadone maintenance program in the early 1970s) had injected heroin an average of 2.7 times a day. R. Kahn, AThe Frequency of Narcotic Use Before and After Admission to a Methadone Maintenance Program,@ *International Journal of the Addictions*, 14, no. 8. (1979): 1157. M. Anglin et al., *Effects of Legal Supervision on Narcotics Use and Criminal Behavior over the Addiction Career* (Los Angeles, CA: UCLA Drug Abuse Research Group, December 1988).

33.   National Institute on Drug Abuse, Heroin Addict Habit Size in Three Cities: Context and Variation (NIDA, Rockville, Maryland, downloaded from the Internet, March, 1996).

34.   B. Johnson et al., *Taking Care of Business: The Economics of Crime by Heroin Abusers* (Lexington, Massachusetts: Lexington Books, 1985).

35.   M.D. Anglin et al., Effects of Legal Supervision on Narcotics Use and Criminal Behavior Over the Addiction Career (Los Angeles, CA: UCLA Drug Abuse Research Group, December 1988); and

Table 3.

36.   P. Reuter et al., *Money from Crime: A Study of the Economics of Drug Dealing in Washington, D.C.* (Santa Monica, California: Rand Corporation, 1990), Rand Publication R-3894-RF, p. 61.

Appendix C

Drug Prices

Several sources report prices paid for illegal drugs.[1] The problem with those sources, for present purposes, is that they report prices as broad ranges, unsuitable for the calculations used in this report.

Recent studies provide a method for estimating prices within a narrower range.[2] Basically, this methodology is to estimate the price paid during market transactions (completed by police as undercover agents, and hence reported to a data source) using regression analysis to control for the quantity and quality (purity is the measure of quality) of drugs sold. Results from the regression are then used to estimate the price paid on average at a given time and place for a given quantity and quality of drugs.

For this report, we analyzed data from the System to Retrieve Drug Evidence (STRIDE), which were available from January 1981 through September 1996. The data and our basic approach are described elsewhere.[3] We have updated that method for present purposes, and we will report full results at a later date.

One problem when using regression analysis to estimate illicit drug prices is that the typical quantity and quality of drug entering a retail transaction is unknown. As others have noted,[4] retail transactions take so many forms that an average retail price is hard to identify. Nevertheless, the calculations used in this report required one.

Estimating the street price for heroin was relatively straightforward. Rocheleau and Boyum[5] reported that hardcore heroin users bought about 1.7 bags of heroin per purchase in New York, 1.9 bags per purchase in Chicago, and 2.0 bags per purchase in San Diego. They also reported that a bag contained about 25 milligrams of pure heroinᏟsuggesting that a typical purchase comprised roughly 50 milligrams of pure heroin. They do not explain how they determined that a typical bag contained 25 milligrams of pure heroin, but Rhodes and Pittayathikhun[6] report a similar figureᏟ80 pure milligrams per purchasedᏟbased on an analysis of data from the domestic monitoring system (1987-1992). They also reported that a typical purchase was 20 percent pure over this period. More recent estimates, also based on the domestic monitoring program data, suggest that purity was closer to 40 percent in 1996.[7] For purposes of estimating the regression, then, we assumed that a typical purchase was of two to four bags, containing a total of 80

milligrams of pure heroin from 1988 to 1992, and a total of 100 milligrams of pure heroin from 1993 to 1995. These assumptions were used to estimate the average price paid for heroin, based on regression predictions, for each year 1988 through 1995. Results are reported in the text.

Because similar information is not available for cocaine purchases, we use a different approach: Let $P = F(Am, Pu)$ be a functional representation of the relationship between price paid (P) and the amount (Am) and purity (Pu) of drugs purchased. This functional relationship was determined by regression analysis as explained earlier.

Let \$D represent the average dollar amount that a hardcore cocaine user spends per week on cocaine. This number was reported in Table 2 of the main report. Setting Pu equal to the average purity of drugs sold at the retail level, and assuming that the user buys drugs once per week, the typical amount of drugs in a weekly purchase must be the solution to the equation:

$$\$D = Am \cdot F(Am, Pu)$$

If Am* is the solution to this equation, then one estimate of retail prices is F(Am*, Pu).

Similarly, assuming that the user buys drugs at T separate times during the week, the purchase amount must be the solution to the equation

$$\$D = T \cdot Am \cdot F(Am, Pu)$$

If Am** is the solution to this equation, another estimate of retail price is F(Am**, Pu).

Now, if few hardcore users buy drugs less frequently than once per week, and if few heavy users buy drugs more frequently than T times per week, then F(Am*, Pu) and F(Am**, Pu) provide low and high prices, respectively. The average of these is reported in the text.

This price range does not encompass all prices paid at retail. Many hardcore drug users undoubtedly pay much more. Others probably pay much less. These limits are intended to encompass the price that is typically paid at retail. That is, it is a range that seems likely to include the price that hardcore drug users pay on average for retail-level drug transactions. Prices are reported in Table 3 of the main report.

Endnotes

1.   For example: Drug Enforcement Administration, *Illegal Drug Price/Purity Report United States: January 1992-December 1995*, August 1996; National Institute on Drug Abuse, *Epidemiologic Trends in Drug Abuse, Volume II Proceedings*, December 1995.

2.   G. Brown and L. Silvermen, "The Retail Price of Heroin: Estimation and Applications," *Journal of the American Statistical Association*, 69, no. 347 (1974):595-606; J. Caulkins and R. Padman, "Quantity Discounts and Quality Premia for Illicit Drugs," *Journal of the American Statistical Association*,88, no. 423 (1994):748-57; W. Rhodes, R. Hyatt and P. Scheiman, "The Price of Cocaine, Heroin and Marijuana, 1981-1993," *The Journal of Drug Issues*, 24, no. 3 (1994):383-402; J. Caulkins, *Developing Price Series for Cocaine*, MR-317-DPRC (Santa Monica, CA, Rand).

3.   W. Rhodes, R. Hyatt and P. Scheiman, "The Price of Cocaine, Heroin and Marijuana, 1981-1993," *The Journal of Drug Issues*, 24 no. 3 (1994):383-402.

4.   J. Caulkins, "What is the Average Price of An Illicit Drug?" *Addiction*, 89, no. 7 (July 1994): pp. 815-19.

5.   A. Rocheleau and D. Boyum, *Measuring Heroin Availability in Three Cities* (Office of National Drug Control Policy, Washington, D.C.: 1994): 49.

6.   W. Rhodes and T. Pittayathikhun, *Heroin Prices and New Addicts: 1981-1994* (report submitted to the National Institute of Justice, Washington, D.C.: April, 1995).

7.   Drug Enforcement Administration, *DEA Briefing Book* (Drug Enforcement Administration, Washington, D.C.: October, 1996).

Appendix D

Imputations for Missing Data on Marijuana Use

Calculations of the amount of marijuana used by household members was straightforward. We multiplied the number of marijuana users per month, by the average number of joints smoked per user, by the average weight of a joint. The result was then multiplied by twelve months to give a year=s estimate. The principal problems when making this calculation are dealing with missing data and with responses that represent a range. The latter presents a problem because the ranges are not suitable for our calculations. Because the Substance Abuse and Mental Health Services Administration had already imputed responses when there was missing data about recent use, this was not a problem. This appendix explains how we imputed responses when either the number of joints smoked or the amount of marijuana smoked were missing or were reported as a range.

Imputing the Number of Joints Smoked

From the National Household Survey for 1991, analysts selected respondents who said they used marijuana in the past month and who gave valid responses to three related questions. The first question was the number of days they smoked marijuana in the past month (DAYS). Valid responses were 1-30 days. The second question was the number of marijuana cigarettes smoked per day in the past month (JOINTS). From the responses to these two questions, analysts created a variable

$$\text{TOTAL JOINTS} = \text{DAYS} * \text{JOINTS}.$$

The third question was the amount of marijuana used during the last month (AMOUNT). This is exactly the question that the analysts sought to answer, but the AMOUNT question was not directly useful for this purpose because it was specified as a range. The acceptable answers to AMOUNT were:
- 1-10 joints
- 11-20 joints
- 1 ounce
- 2 ounces
- 3-4 ounces
- 5-6 ounces

The analysts=problem was to infer the amount of marijuana used by people who said they used marijuana in the last month based on the variables TOTAL JOINTS and AMOUNT.

D- 1

As short-hand, let *J* represent TOTAL JOINTS, let *A* represent AMOUNT, and let *W* equal the weight of marijuana used in ounces. The analysts wanted to estimate *W*.

$$W = \lambda J + \varepsilon$$

Now, *W* is unknown, but it might be represented as:

where λ is the weight per joint and ε is a random error term, which will be discussed below. Equation [1] says that, on average, a person who smokes *J* joints will use *W* ounces of marijuana, because λ is the average weight of a single joint. Of course, some people who smoke *J* joints use a little less; some use a little more. This variation about what is typical is reflected in the term ε.

Assume that ε is distributed normally with a mean of zero, a standard deviation of σ, and that the error terms are independently and identically distributed. It turns out that these assumptions about the distribution of ε are hard to justify, and alternative assumptions are adopted later. However, this simple, if somewhat unrealistic, specification is useful for explaining the approach.

Although *W* is unknown to the analysts, it is known to the respondent, and by assumption the value of *W* determines the respondent=s answer for AMOUNT. Specifically, the respondent will say that he used

1-10 joints when
$W \leq \alpha_1$
10-20 joints when
$\alpha_1 < W \leq \alpha_2$
1 ounce when
$\alpha_2 < W \leq 1.5$
2 ounces when
$1.5 < W \leq 2.5$
3-4 ounces when
$2.5 < W \leq 4.5$
5-6 ounces when
$4.5 < W$

The logic here is that the respondent will select the usage category that most closely describes his use, although it seems reasonable to suppose that he makes errors when making this translation. Two terms are unknown, α_1 and α_2. The first, α_1, is presumably the weight of 10.5 joints. The second is harder to interpret, but α_2 is some value that distinguishes the response "10 to 2" joints from "1 ounce," at least in the eyes of the respondent.

There are four parameters to be estimated here: λ, σ, $\propto_1$ and $\propto_2$. These parameters can be estimated by

$$P_1 = P(1\text{-}10 \; joints) = \emptyset\left(\frac{\propto_1 - \lambda J}{\sigma}\right)$$

maximum likelihood once a probability has been assigned to every response. Specifically,

$$P_2 = P(11\text{-}20 \; joints) = \emptyset\left(\frac{\propto_2 - \lambda J}{\sigma}\right) - P_1$$

$$P_3 = P(1 \; ounce) = \emptyset\left(\frac{1.5 - \lambda J}{\sigma}\right) - P_1 - P_2$$

$$P_4 = P(2 \; ounces) = \emptyset\left(\frac{2.5 - \lambda J}{\sigma}\right) - P_1 - P_2 - P_3$$

$$P_5 = P(3\text{-}4 \; ounces) = \emptyset\left(\frac{4.5 - \lambda J}{\sigma}\right) - P_1 - P_2 - P_3 - P_4$$
$$P_6 = P(5\text{-}6 \; ounces \; or \; more) = 1 - P_1 - P_2 - P_3 - P_4 - P_5$$

where ϕ is the standard normal distribution function.

This approach is similar to an ordered probit model. There is an important difference between this approach and a traditional probit model, however. Specifically, the threshold values of 1.5, 2.5, and 4.5 are known although $\propto_1$ and $\propto_2$ are unknown. This allows the parameter σ to be identified and estimated. In turn, this allows λ to be identified and interpreted as the weight of a marijuana cigarette.

One further extension is to assume that:

$$\propto_1 = \lambda \bullet 10.5$$

That is, the parameter $\propto_1$ equals the weight of 10.5 joints, because the weight of 10.5 joints is the threshold value between the responses "1-10 joints" and "11-20 joints." There are only three remaining parameters to estimate: $\propto_2$, λ, and σ.

D- 3

As stated, this model is an unacceptable representation of the relationship between the number of joints smoked and the amount of marijuana smoked. A more convincing model is:

$$W = (\overline{\lambda} + \varepsilon_1) J + \varepsilon = \overline{\lambda} J + J \varepsilon_1 + \varepsilon = \overline{\lambda} J + \varepsilon_2$$

This implies that the average joint weighs $\underline{\ \ }$ ounces, but that the weight varies across users. This variation is represented by the distribution of ε_1. The model would be complete once the distribution of ε_2 is specified.

The distribution of ε_2 has to satisfy some a priori constraints. First, W must be positive, so ε_2 has a lower limit that depends on $\underline{\ }J$. Second, the distribution of ε_2 should account for an apparent upward skew: inspection of the data shows that some users seem to use much more than the average amount of marijuana, but nobody can use much less because zero is a lower limit. Third, the error term is heteroscedastic.

$$W = \lambda J = e^{\varepsilon_3} J$$

A new specification is more useful, given these a priori constraints:

where $\varepsilon_3 \sim N(\mu,\sigma)$. Here, λ has a lognormal distribution, and thus λJ is always positive and λ is skewed

$$E (\lambda) = e^{\mu + 0.5\sigma^2}$$

$$VAR (\lambda) = e^{2\mu + \sigma^2} (e^{\sigma^2} - 1)$$

upward. In this specification:

Taking logarithms on both sides of [3], we have

$$\ln W = \ln J + \varepsilon_3$$

$$\ln W = \ln J + \mu + \varepsilon_4$$

where $\varepsilon_4 \sim N(0,\sigma)$. As with the earlier, less realistic model, the parameters can be estimated using maximum likelihood. A simple extension is to let $\mu = \beta_0 + \beta_1 J/100$. The "100" is just a scale factor that has no effect on analysis. This specification allows frequent smokers to smoke larger or smaller joints than average smokers.

The most important estimate is $E(\lambda)$, the average weight of a marijuana cigarette. An estimate of W, then, is:

$$W = E(\lambda)J$$

This tells us that if a respondent says he smoked J joints during the month (TOTAL JOINTS), then $E(\lambda)J$ is the best estimate of the quantity (in ounces) of marijuana smoked.

Table D presents parameter estimates based on an analysis of 1623 smokers who reported DAYS, JOINTS, and AMOUNT. Before estimating these parameters, the analysts changed some of the data

Table D-1

Regression Results: The Total Amount of Marijuana Smoked in the Past Month

Parameter	Parameter Estimate	Standard Error	Probability
β_0	-4.95	0.24	.0000
β_1	0.13	0.11	.0000
α_2	1.50	0.39	.0001
σ	1.08	0.013	.0000

Sources: NHSDA 1991

Before calculating TOTAL JOINTS, responses of more than 30 for JOINTS (number of marijuana cigarettes smoked per day in the past month) were truncated to 30. These extreme responses represented only about 0.1% of the total number of monthly users.

After calculating TOTAL JOINTS, analysts compared TOTAL JOINTS with AMOUNT and corrected for extreme inconsistencies between (or highly unlikely combinations of) the two variables. If JOINTS

>= 100 and AMOUNT <= 20 joints or if JOINTS >= 200 and AMOUNT <= 2 ounces, then analysts assumed that the respondents had mistakenly given the total number of joints they had smoked in the past month for the question on JOINTS (number of marijuana cigarettes smoked per day in the past month). For these respondents, analysts treated JOINTS as TOTAL JOINTS in calculating the quantity estimates.

Results from the analysis imply that a person who smokes 1 joint per month uses 0.013 ounces (0.37 grams per joint) of marijuana. A person who smokes thirty joints per month uses 0.4 ounces (0.38 grams per joint) of marijuana. A person who smokes 120 joints per month uses 1.79 ounces (0.43 grams per joint) of marijuana. Applying the parameter estimates from Table D-1, Equation [7] was then used to compute the average weight per joint (W/J) for every respondent in each year of the NHSDA. Results, which appear in Table 6 of the main report, are used in the calculations reported in the body of this report.

Imputing Joints

A related problem is that the variable JOINTS was sometimes missing. We could not just substitute the average response when JOINTS were known, because those with missing data seemed to have different usage patterns from those who did not have missing data. Instead, we estimated regressions where JOINTS was the dependent variable and MJFREQ was the independent variable. MJFREQ is "frequency used marijuana in the past 12 months." We used results from these regressions to impute responses when JOINTS was missing.

MJFREQ is coded:

1	--	several times a day;
2	--	daily;
3	--	almost daily (3 to 6 days a week);
4	--	1 or 2 times a week;
5	--	several times a month (about 25 to 51 days a year);
6	--	1 or 2 times a month (12 to 24 days a year);
7	--	every other month or so (6 to 11 days a year);
8	--	3 to 5 days in the past 12 months;
9	--	1 or 2 days in the past 12 months.

We treated this variable as a continuous measure. To capture nonlinearities, we added an additional independent variable $MJFREQ^2 = MJFREQ \cdot MJFREQ$.

The regression had two special features. The first was that the respondent could have said that he used zero joints during the month before the interview. After all, marijuana use during the year (MJFREQ) does not imply marijuana use during the month before the survey (JOINTS). To take this special feature into account, the regression specification was written:

$$Z = \alpha_0 + \alpha_1 \, MJFREQ + \alpha_2 \, MJFREQ^2 + \varepsilon$$

$$JOINTS = Z \text{ when } Z \geq 0$$

$$JOINTS = 0 \text{ otherwise}$$

where

$$\varepsilon \sim N(0,\sigma)$$

$$\sigma = \beta_0 + \beta_1 Z$$

Note that in this specification the error term is heteroscedastic and a linear function of the underlying latent variable Z.

Table D-2 shows regression results.

Table D-2

Regression Results: The Average Number of Joints Smoked in the Past Month

	Model 1		Model 2	
Parameter	Parameter Estimate	Probability	Parameter Estimate	Probability
α_0	81.23	0.00	12.62	0.09
α_1	-20.64	0.00	-1.42	0.24
α_2	1.30	0.00	-0.07	0.30
β_0	12.15	0.00	20.30	0.00
β_1	0.48	0.00	2.18	0.05
N	1418		190	

Sources: NHSDA 1991

The table shows two regressions. Model 1 was estimated for the 1418 respondents who reported use of marijuana in the 1991 NHSDA survey. Model 2 was estimated for the 190 respondents whose use of marijuana was imputed by SAMHSA. We estimated two separate models because specification testing showed that estimates based on the 1418 cases did not work well for the 190 cases and vice versa.

The regressions over predict slightly. Based on the 1418 cases, the regressions predict 23.4 joints on average per month. In reality, respondents said they used an average of 21.6 joints per month. For the 190 cases, the prediction was 10.7 joints on average per month and the actual was 8.5 joints. Because these predictions were only used when responses were missing for the variable JOINTS, we considered them to be close enough for our purposes.