What America's Users Spend on Illegal Drugs: 2000 through 2006

Reconciliation of Demand- and Supply-Based Drug Estimate Reports

June 2012

Acknowledgements

This publication was sponsored by the Executive Office of the President, Office of National Drug Control Policy (ONDCP). William Rhodes, Ph.D., Christina Dyous, M.A., Dana Hunt, Ph.D., Jeremy Luallen, Ph.D., Myfanwy Callahan, and Rajen Subramanian, Ph.D., and other members of Abt Associates produced this publication. Michael A. Cala, Ph.D., served as the ONDCP Project Manager for this publication.

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Originating Office

Executive Office of the President
Office of National Drug Control Policy
Washington, DC 20503
Printed in June 2012

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Foreword

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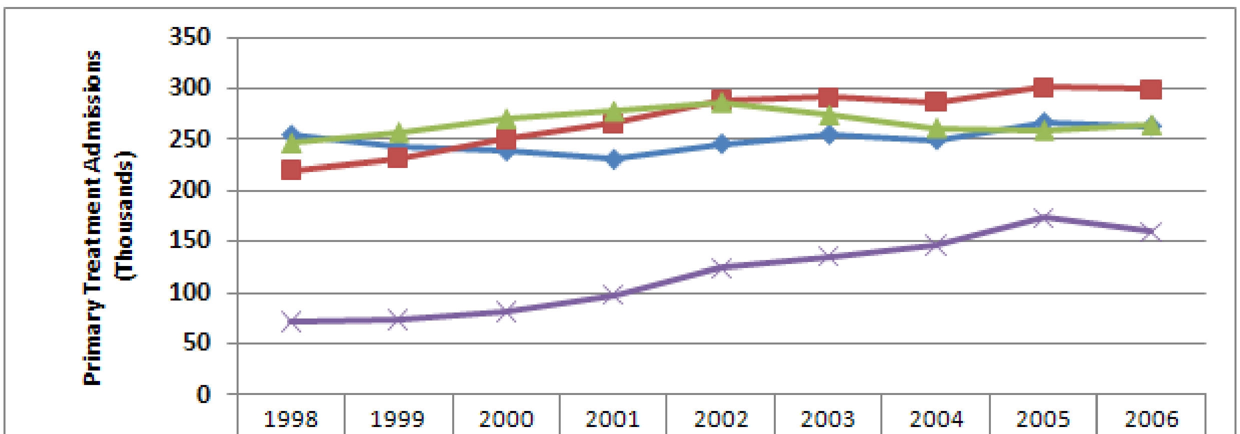
The Office of National Drug Control Policy sponsored research to update previously published estimates of illegal drug availability on the streets of the United States based on both demand and supply data indicators. The demand-based methodology, published as What America's Users Spend on Illegal Drugs (WAUSID), estimates the magnitude of drugs in the United States by calculating consumption based on surveys of drug use prevalence and frequency. The supply-based methodology, published as Drug Availability Estimates in the United States (DAEUS), estimates the magnitude of drugs in the United States based on supply indicators such as production estimates and seizures. This foreword integrates results of these updates.

Trends in the demand and supply-based availability should correlate to trends in the drug consequences (e.g., drug poisonings, drug treatment) in the United States. Figure FW.1 shows the number of reported primary drug treatment admissions for cocaine, heroin, marijuana, and stimulants (which includes methamphetamine) from 1998 through 2006. Cocaine admissions reached a low in 2001, then rose slightly to 263,000 in 2006. Heroin admissions peaked in 2002, then fell slightly in 2006. Marijuana admissions rose steadily from 1998 to 2002, then plateaued through 2006. Treatment admissions for stimulants rose from 1998, until peaking in 2005, then dropped slightly in 2006. Where differences occur between trends in the availability estimates and consequences, potential explanations will be discussed. Based on this evidence, expectations are that methamphetamine availability and use increased over most of 2001 through 2006. For the other drugs, availability and use were relatively constant, although cocaine use may have increased and heroin use may have decreased. Expected changes are not large.

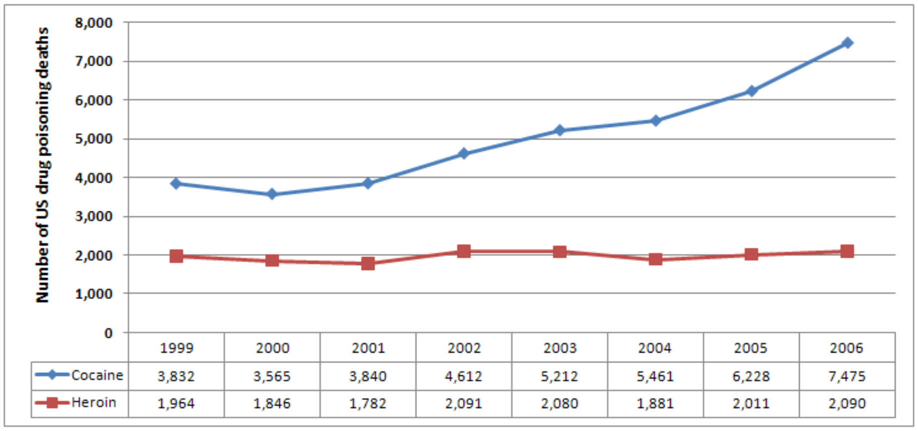
Figure FW.1: Trends in Primary Drug Treatment Admissions in the United States: 1998–2006 (TEDS)



	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cocaine	254	242	239	231	246	255	249	266	263
Marijuana	220	232	251	266	289	292	287	301	300
Heroin	247	258	270	278	286	274	262	259	265
Stimulants	71	74	81	98	124	135	147	173	160

Figure FW. 2 shows the trends in drug poisoning deaths for cocaine and heroin. Heroin deaths were flat at about 2,000 annually from 1999 through 2006. Annual cocaine poisoning deaths averaged 3,750 from 1999 to 2001, then rose annually to over 7,000 by 2006. Again, the implication is that heroin's availability and use has been stable, but cocaine's availability and use appears to have increased.

Figure FW. 2: Trends in Number of Poisoning Deaths Involving Cocaine or Heroin in the United States: 1999–2006 (NCHS)



The demand and supply-based availability estimates should be equivalent, assuming that the amount of drugs supplied to U.S. streets each year is all consumed, with no net accumulation. However, it is unlikely that demand-based and supply-based estimates will be equivalent given the complexities and uncertainties of the covert activities of producing, distributing, and consuming illegal drugs. Accurate measurement of drug use is a challenge to surveys seeking valid and reliable information on drug use frequency and expenditures for drug purchase. Resource limitations result in gaps in data collection: for example, the Arrestee Drug Abuse Monitoring (ADAM) project, a key data source on chronic drug use, had no data collection from 2004 through 2006. On the supply side, remote sensing of illicit drug cultivation is challenged by dispersed and hidden crops, and adaptations to aerial and manual eradication techniques. Given the dearth of information regarding the quantity of chemicals traded on the black market or diverted to synthetic drug manufacture, quantifying the amount of illegal synthetics produced each year is a challenge. Furthermore, all of these indicators have a temporal component that is difficult to gauge. For example, drugs departing source areas may be delayed in shipment due to consolidation, changes between conveyances, and delays in delivery to avoid law enforcement suspicion. Therefore, the models often depend on averages or assumptions that add to the uncertainty of the estimates.

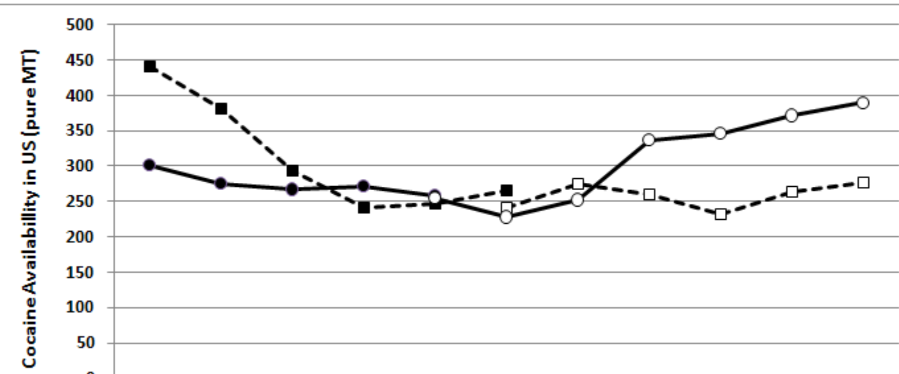
These challenges are worth confronting because estimates are of benefit to decision-makers in putting various indicators, counter-drug program performance data, and trends in perspective. For example, the value of a reduction of 10 metric tons of a drug depends on whether the total street availability is 100 or 1,000 metric tons. The estimated trends are also useful as a general indicator of whether the problem is getting better or worse. Although the current estimates only extend through calendar year 2006, they provide a more mature baseline for follow-on estimates (i.e., the most recent prior estimates extend only through 2000–2001).

Cocaine

Annual cocaine consumption was determined by estimating the number of occasional and chronic users, multiplying their estimated numbers by their average weekly expenditures for cocaine, and then converting total expenditures to a pure amount by dividing by the price per pure gram of cocaine. The consumption figures from WAUSID (2000 to 2006) connect seamlessly with the previously published estimates (see Figure FW.1).

The supply-based cocaine availability estimates covered by DAEUS (2001-2006) also connect smoothly with the previously published supply-based availability estimates. These were calculated by beginning with the potential cocaine production estimate (calculated separately each year by UN and U.S. analysts), subtracting seizures, then assuming a market split between the United States and the rest of the world. The remainder, after subtracting the rest-of-the-world consumption is what is available for consumption in the United States. Figure FW.3 shows that the demand and supply-based cocaine availability estimates remained at 250 to 275 pure metric tons until 2003, when they diverged: the demand-based estimates rose in subsequent years, while the supply-based availability estimates remained fairly steady. The rise in the demand-based estimates does correlate to the rise in cocaine poisoning deaths shown in Figure FW.2, but other indicators will also be considered.

Figure FW. 3: Trends in the Estimated Availability of Cocaine in the United States: 1996-2006



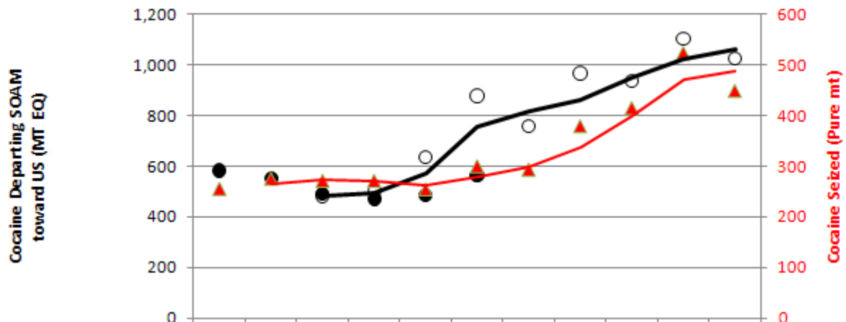
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
DAEUS 2002 (table 1-1)	441	380	294	242	246	266					
Supply-method						241	275	260	231	264	277
WAUSID 2001 (table 2)	301	275	267	271	259						
Consumption					254.6	228	252.5	336.6	346.2	371.7	389.6

Observed movements of cocaine and seizures are other indicators of cocaine availability that can be compared with the demand and supply-based estimates of availability. The Consolidated Counterdrug Data Base (CCDB) tabulates observed (through detection or intelligence) cocaine load movement departing South America. Figure FW.4 compares these CCDB amounts with the corresponding amounts calculated by the previously published DAEUS,[1] and shows an increase in the amount of cocaine departing South America toward the United States after 2001. The amount of cocaine seized worldwide (shown in red in Figure FW.3) rose after 2003. With stable law enforcement resources, increasing

[1] These corresponding values are calculated by assuming that 2/3 of cocaine departing South America (line 7 in Table 1-1 of the DAEUS, 2002) heads toward U.S. markets. The 2/3 figure was used by the Interagency Assessment of Cocaine Movement (IACM) between 2002 and 2007.

seizures could be a surrogate measure of flow. Thus, the cocaine movements from South America and the seizure data both point to increasing cocaine supply from 2003 to 2006.

Figure FW. 4: Comparison of Trends in Cocaine Flow toward the United States and Seizures: 1996-2006



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
○ CCDB			483	501	637	878	760	968	939	1,104	1,025
● DAEUS 2002	583	552	492	471	486	562					
▲ World-wide seizures	256	276	272	272	255	301	294	380	416	525	450

To understand these divergent trends between availability estimates, an understanding of the events during 2000 to 2003 is important. Two significant operations occurred during this period affecting the amount of cocaine departing South America: Plan Colombia and Operation Purple. Plan Colombia was developed as a six-year plan to end Colombia's internal conflict, eliminate drug trafficking, and promote economic and social development. U.S. assistance to Plan Colombia from FY 2000 through FY 2005 included expansion of coca spray operations. Operation Purple was a voluntary initiative launched in 1999 to track shipments over 100 kilograms of the key cocaine precursor chemical potassium permanganate to reduce its use in cocaine production. Both of these programs reduced cocaine production in Colombia below levels that would otherwise have been observed from 2000 to 2003.

Plan Colombia increased coca spraying 160 percent from 2000 to 2003, as shown in Figure FW.5. Coca spraying disrupted the equilibrium of both coca harvesting by farmers and the process for estimating coca cultivation and cocaine production. This rapid rise in spraying caused a farmer response of replacing their sprayed coca crops: seedbeds were readied for replanting, cultivated areas were expanded outside traditional areas, new plantings increased with smaller fields, and crop concealment increased through plantings under canopy or among licit cultivation. Fortunately, cultivation and field productivity decreased in sprayed areas, but unfortunately, farmer adaptation to hide crops may have caused surveys to understate the actual amount of production. Operation Purple was the other significant activity over the 2000–2003 timeframe that affected Colombian cocaine. That 1999 operation restricted the availability in Colombia of potassium permanganate, which is used for oxidation during the production of cocaine. Potassium permanganate reacts (oxidizes) with yellowish-brown colored impurities in coca paste, which then precipitate out of solution. Highly oxidized cocaine is very white and fluffy. Failure to remove these impurities results in a final product (i.e., cocaine hydrochloride) of poorer quality with respect to cocaine content and especially color and appearance (Casale & Klein, 1993).

Figure FW. 5: Area Sprayed in Colombia: 1996-2006 (Thousands of Hectares)

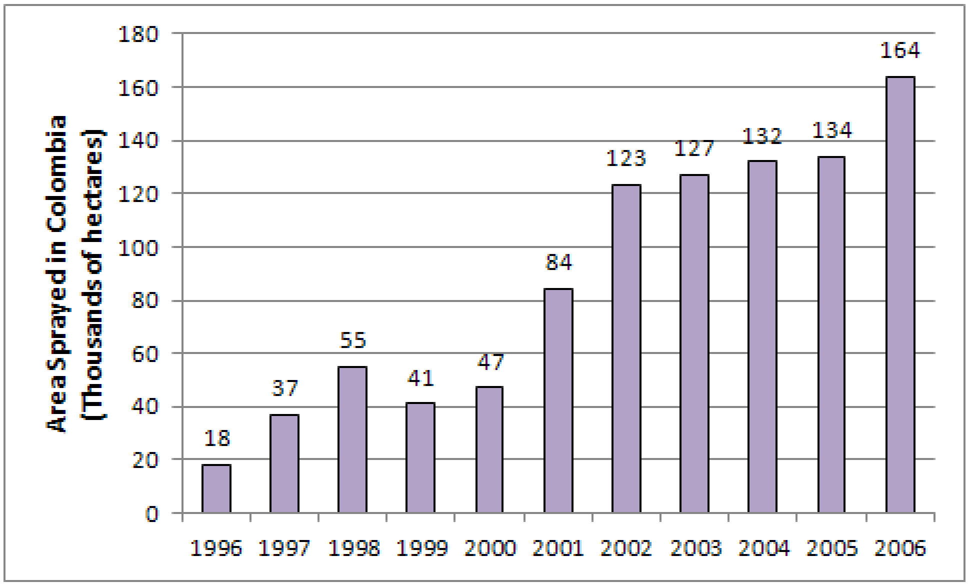
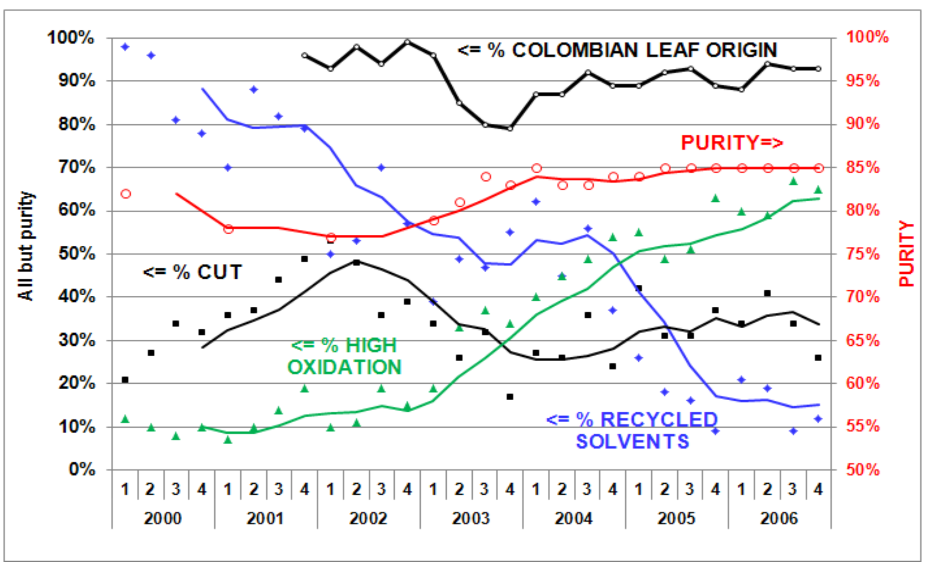


Figure FW.6 shows that from 2000 through 2003, less than 20 percent of the cocaine seizure specimens analyzed by DEA's Special Testing Laboratory were highly oxidized. Lower oxidation results in a dark, lumpy and less attractive product. Purity during that period dropped as the less oxidized cocaine was cut, predominately with white crystalline chemicals (caffeine and lactose). At the time, DEA linked the decline in purity to the restriction of potassium permanganate used for oxidation.[2] By 2003, the effects of Operation Purple dissipated as shown in Figure FW.6: the fraction of highly oxidized specimens began increasing, the fraction of cut specimens declined, and purity rose.

Figure FW. 6: Forensic Trends in Large Cocaine Seizures (>10kg): 2000-2006



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2 Declining Cocaine Purity Levels Are a Step in the Right Direction, DEA website, http://www.justice.gov/dea/ongoing/cokepurity.html

This rise in purity had a dramatic impact on the calculated demand-based availability, which is computed by dividing total expenditures by price per pure gram. Total expenditures were flat from 2000 to 2006 ($35B to $40B), so as purity rose from 2003 to 2006, the price per pure gram declined ($136/pure gram in 2000 to $97/pure gram in 2006), resulting in a rise in the estimated availability of pure cocaine.

Over the period covered by this report, 2000 to 2006, the number of cocaine users and their expenditures were stable, thus leading to an expectation of a stable consumption estimate. However, the demand-based measure of availability was calculated to be rising. This was because the demand-based estimate of availability is a measure of pure cocaine consumed. It appears that the bulk volume consumed was stable, but the pure volume rose as less of the product was cut.

In summary, the cocaine availability estimates calculated for this latest update connect smoothly with the previously published estimates, and are fairly stable at 240–275 pure metric tons over the period 2000 through 2003. Disruption of coca cultivation and cocaine production by the Colombian government affected the availability estimates from 2003 through 2006. The purity rise resulted in a calculated rise in the demand-based estimate of cocaine availability in the United States. Supply-based availability estimates remained steady, but were subject to much uncertainty due to increased difficulty in estimating coca cultivation when spray activities increased.

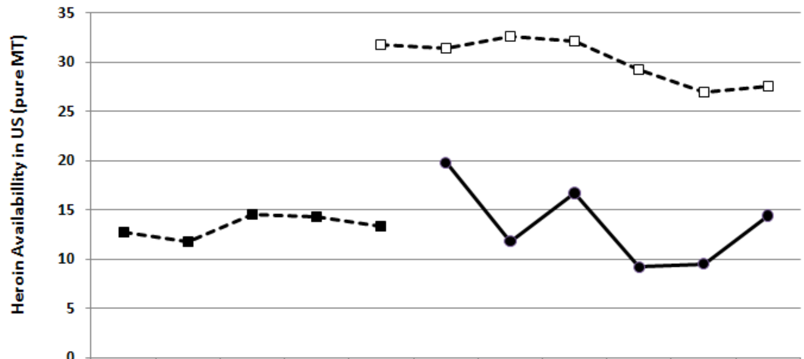
Heroin

The demand and supply-based methodologies for measuring heroin availability were similar to those used for cocaine. Demand-based availability was calculated by multiplying the number of heroin users by their annual expenditures, then dividing by the unit retail price of pure heroin. Supply-based availability estimates were calculated by beginning with potential production from foreign sources, then subtracting seizure losses.

Forensic signature analyses of heroin purchases and seizures in the United States indicated that the majority of heroin consumed in the United States comes from source areas in South America (primarily Colombia) and Mexico. From 2001 to 2006, Mexican potential heroin production was fairly level, averaging 10 pure metric tons, while Colombian potential heroin production averaged 10 pure metric tons annually in 2000–2001, but dropped to half that by the middle of the decade. After reducing the production amount by seizures, the supply availability estimates in the United States showed a declining trend of 10–20 pure metric tons of heroin, as shown in Figure FW.7.

Colombian potential heroin production has been difficult to consistently estimate. Because of the difficulty in obtaining clear imagery in the “cloud forest” where Colombia’s poppy crop grows, the estimate generally has greater uncertainty than other cultivation estimates (CNC, 2003). Persistent cloud cover in 2000 and 2005 prevented the completion of cultivation surveys. Backcasting adjustments to prior production estimates, based on updated yield surveys, were made. For example, the Colombian potential heroin production estimate in 2001 was 4.3 pure metric tons. The 2001 estimate was adjusted to 15.1 pure metric tons two years later, then to 11.4 pure metric tons by August 2006.

Figure FW. 7: Trends in the Estimated Availability of Heroin in the United States: 1996-2006



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
WAUSID 2001 (table 2)	12.8	11.8	14.5	14.3	13.3						
Consumption					31.8	31.4	32.6	32.1	29.2	26.9	27.6
Supply-method						19.8	11.8	16.7	9.2	9.5	14.4

The methodology for calculating the demand-based availability estimate (consumption) was similar to that for cocaine. Total expenditures (about $12B) were divided by the average price per pure gram of heroin (about $400 per pure gram) to yield approximately 30 pure metric tons of heroin. Figure FW.7 shows the results and shows a slightly declining trend. In comparison with the previously published WAUSID, expenditures were stable and equivalent. However, the average purchase price per gram in 2000 was adjusted from $839 per pure gram (in WAUSID, 2001) to $461 per pure gram. This caused a doubling of the heroin consumption estimate.

The heroin price estimated for 2000 changed from the earlier version of WAUSID to this current version. There are two reasons. Prices have always been based on a statistical model that was estimated using data from the System to Retrieve Drug Evidence (STRIDE). However, using that statistical model to predict retail prices requires knowledge of the distribution of expenditures per purchase (e.g., 20 percent of purchases were for $20, 50 percent were for $40, etc.). This distribution was unknown when the earlier version of WAUSID was prepared and had to be estimated from crude data. The ADAM survey provided the distribution for this current version of WAUSID. The second reason is that STRIDE data were unavailable for 2000 when preparing the earlier version of WAUSID. Therefore the price reported for 2000 was a projection that, in retrospect, was too high.

When the improved price estimates are taken into account, estimates of heroin use from the earlier version of WAUSID are broadly consistent with estimates from this current version. The discrepancy between the demand-based and supply-based estimates is disconcerting, but the report argues that the differences are not large if Colombian poppy cultivation is understated because of cloud cover.

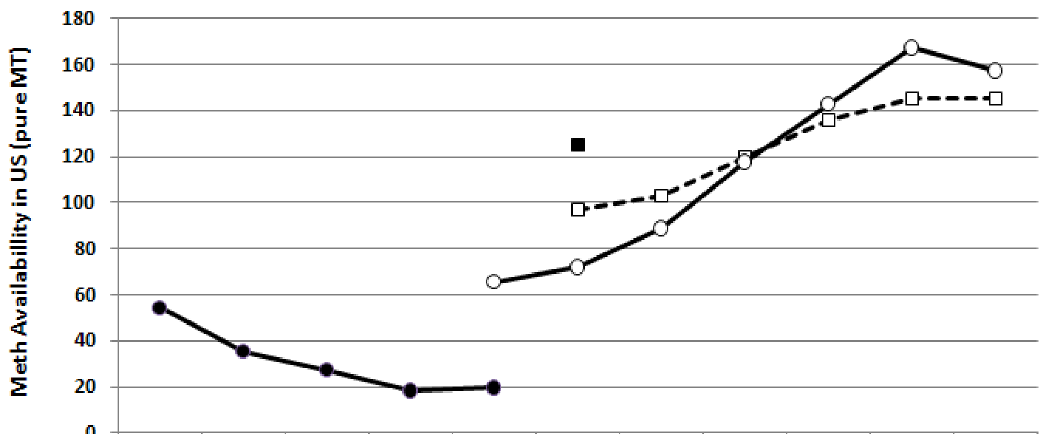
Methamphetamine

The demand-based methodology for measuring methamphetamine availability was similar to that used for cocaine. Demand-based availability (consumption) was calculated by multiplying the number of meth users by their annual expenditures, then dividing by the unit retail price of pure meth. The results, shown in Figure FW.8, show an estimated meth consumption of 66 pure metric tons in 2000, peaking at 165 pure metric tons in 2005. The previously published WAUSID estimated meth consumption as 20 pure metric tons in 2000.

The large difference in the meth consumption estimate between this WAUSID version and the prior version was due to improved information from the ADAM survey. As explained for heroin, ADAM provided knowledge of the distribution of expenditures per purchase, which was input to a statistical model that predicted retail prices. ADAM also provided improved data for estimating the number of chronic meth users and their expenditures.

The data and methodologies for calculating the supply-based estimates of methamphetamine availability improved substantially since the last published WAUSID in 2001. Information on meth lab seizure incidents, black market pseudoephedrine, and Southwest Border meth seizures was combined to develop supply-based meth estimates that were close to the consumption estimates. Figure FW.8 shows the close correlation.

Figure FW.8: Trends in the Estimated Availability of Methamphetamine in the United States: 1996-2006



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
DAEUS 2002 (table 1-1)						125					
Supply-method						96.6	102.6	119.9	135.9	145.1	144.9
WAUSID 2001 (table 2)	54	35	27	18	20						
Consumption					66	72	89	118	143	167	157

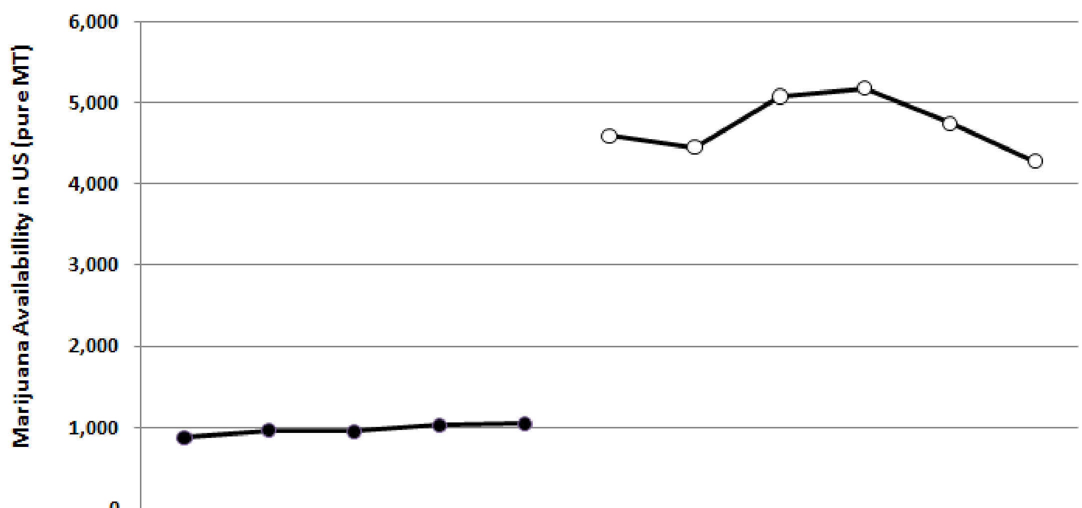
Marijuana

The calculations for marijuana users and expenditures were based exclusively on the National Survey on Drug Use and Health (NSDUH) data. Separate estimates were computed for chronic users (4+ days of use in the last month) and occasional users (1–3 days of use in the last month). The amount of marijuana use reported in this version of WAUSID is much larger than the amount of marijuana use reported in the previous version of WAUSID. Prior to 2000, estimation was based on a combination of Drug Use Forecasting (DUF) data, the National Household Survey on Drug Abuse (NHSDA), and the Monitoring the Future Survey. None of these surveys asked questions about expenditures on marijuana; DUF provided uncertain coverage of marijuana use; and there were no credible adjustment factors for underreporting in the NHSDA. This changed in 2000 when the Arrestee Drug Abuse Monitoring (ADAM) survey, which provided a battery of market questions, replaced DUF. It changed again in 2001 when the NSDUH, which asks a series of questions about marijuana market behavior, replaced the NHSDA. Current estimates are based on the NSDUH starting in 2001; complementary estimates come from ADAM for 2000 through 2003.

Figure FW.9 shows the estimates for marijuana consumption over the period 2001 to 2006 have been between 4,200 and 5,200 metric tons. Marijuana supply estimates are more difficult to calculate due to the uncertainty in marijuana yield, both domestically and from foreign sources. The National Drug Intelligence Center (2010) has concluded:

> No reliable estimates are available regarding the amount of domestically cultivated or processed marijuana. The amount of marijuana available in the United States—including marijuana produced both domestically and internationally—is unknown. Moreover estimates as to the extent of domestic cannabis cultivation are not feasible because of significant variability in or nonexistence of data regarding the number of cannabis plants not eradicated during eradication seasons, cannabis eradication effectiveness, and plant yield estimates. (Note 16, p. 36.)

Figure FW.9: Trends in the Estimated Availability of Marijuana in the United States: 1996-2006



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
WAUSID 2001 (table 2)	874	960	952	1,028	1,047						
Consumption						4,595	4,453	5,082	5,182	4,750	4,285

Executive Summary

This version of *What America's Users Spend on Illegal Drugs* (WAUSID) provides estimates of three aspects of the illegal drug world: prevalence of drug use, expenditures on drugs, and consumption of drugs. It provides prevalence estimates of the number of chronic and occasional users for each of the four major illegal drugs (cocaine, heroin, marijuana and methamphetamine) from 2000 through 2006. Based on those prevalence estimates and drug users' self-reports of drug market behaviors, this study provides estimates of what Americans spent on each of the four major illegal drugs. It draws on the best available estimates of illegal drug prices paid at the retail level to convert the expenditure estimates into quantity estimates—metric tons of cocaine, heroin, marijuana and methamphetamine. Finally, it contributes to the substance abuse literature by examining self-report validity for the use of tobacco and alcohol.

Why Are Expenditure Estimates Important?

There is no mystery that millions of Americans use illegal drugs. Those users endanger themselves and others, and they place a heavy burden on the public to support enforcement, prevention and treatment programs. Drug users spend billions of dollars, which enter an underground economy, disrupting both domestic and international economic intercourse, and funding organized crime and even terrorism. The magnitude of the problem is manifest on the nightly news and on many urban street corners. The scope of this problem, while apparent, is difficult to document.

This report is the most recent version of a series of studies that for two decades has provided empirically based estimates of the number of users, how much they spend on illegal drugs, and the amount of drugs that they use (Office of National Drug Control Policy [ONDCP], 2001). Estimates of chronic drug use reported in WAUSID complement prevalence estimates derived from the National Survey on Drug Use and Health (NSDUH). The national survey provides indispensable survey-based estimates of the prevalence and trends of domestic drug use, but the NSDUH has limitations. Chronic drug users frequently live outside of households, are homeless or are periodically institutionalized. If they do live in households, their lifestyles often make them unavailable to interviewers; or, if they are interviewed, they frequently deny drug use when questioned. Many critics conclude that the NSDUH greatly underestimates the number of chronic drug users in the United States.

WAUSID estimates the prevalence of chronic drug users based on data collected at jails and booking facilities where chronic drug users frequently appear. Interviewing chronic drug users in these locations has two advantages. First, chronic drug users have some estimable probability of being included in the sample regardless of whether or not they are stable household members. Second, chronic drug users seem more willing to self-report their substance abuse when questioned outside of households, and even when they are untruthful, objective tests (bioassay of urine specimens) provide a means to adjust estimates based on self-reports for truthful reporting.

Nevertheless, there is a distinct disadvantage in using survey data that are not population-based. Drug users interviewed in jails and booking facilities cannot be considered a random sample of the general population of drug users. Consequently, while prevalence and trend estimates based on NSDUH data are derived from straightforward calculations that are familiar to survey statisticians, prevalence and trend estimates based on jail samples require additional assumptions and statistical modeling.

Performing the considerable effort required for statistical modeling is worthwhile for those who believe that empirically based estimates of prevalence and trends in chronic drug use are valuable metrics for public policy makers, implementers and monitors. To increase the value of these estimates, this version of WAUSID introduces *uncertainty estimates* where practical. An uncertainty estimate for prevalence is a range providing credible upper and lower limits on true prevalence. WAUSID strives to place these limits on a probability basis, but the range actually results from a combination of statistical theory and judgment.

WAUSID also provides estimates of how much users pay for their illegal drug use. According to the assumptions, methodology and calculations reported in this study, drug users spent about $100 billion for the four major illegal drugs during 2006. To put this into context, Americans spent about $116 billion on alcoholic beverages (1999) and about $87 billion on tobacco products (2003).[3] Drug sales are big business.

This big business funnels its earnings into both domestic and international criminal enterprises. The U.S. Government considers funds flowing to transnational criminal organizations and terrorist groups involved in drug trafficking to be a major threat to the stability of some foreign economies and governments. Arguably, money laundered from drug sales accounts for the majority of funds flowing through money laundering channels. Inarguably, drug money that finds its way into international commerce creates an environment that fosters corruption and facilitates violence and weapons acquisition by criminals that is detrimental to the well-being of America and its allies.

For many purposes, dollar expenditures provide the most useful metric for gauging the scope of the threat that drug trafficking poses to the United States and its allies. However, many anti-drug programs focus on the *amount* of drugs that get bought and used. For example, the U.S. Government is duly concerned with the amount of coca grown in Peru and the amount of poppy produced in Mexico. Federal and other foreign-nation authorities seized about 122 metric tons of cocaine in the source zone, 244 metric tons in the transit zone and another 126 metric tons within the United States and at the arrival zone in 2006.[4] The significance of those seizures depends on whether Americans use 100, 300 or 600 metric tons of cocaine. WAUSID is the best consumption-based reference for assessing whether drug seizures make a minor dent or an appreciable gouge in the commerce of drug trafficking.

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[3] The estimate for tobacco products came from a U.S. Department of Agriculture website: www.ers.usda.gov/Briefing/Tobacco/Data/table07.pdf. The table is labeled "Table 21 – Expenditures for tobacco products and disposable personal income, 1993–2003." The original source is cited as "reports from the Department of Commerce, Bureau of Economic Analysis." Downloaded from the Internet on September 22, 2004. The estimate for alcohol was reported in Foster, Vaughan, Foster & Califano (2003).

[4] After completion of the analysis phase of this work, the Government revised some cocaine seizure estimates. These revised estimates were not incorporated into the current report; they are not substantial and would not have significantly altered the findings.

To address the need for estimates of the number of users, their expenditures on drugs, and the amount they use, this report provides:

- Estimates of the number of chronic and occasional users of cocaine, heroin, marijuana and methamphetamine for 2000 through 2006.
- Estimates of expenditures on the four major drugs for 2000 through 2006.
- Estimates of the amount of consumption in pure metric tons for 2000 through 2006.

Estimates: A Summary

Throughout this report, drug users are classified into two categories—chronic and occasional—based on frequency of use during a 30-day period. The "30-day period" refers to the 30 days before the interview. A chronic user is one who used the specified drug once a week or more. An occasional user is one who used the specified drug less frequently. Choosing once-per-week as a criterion for bifurcating users into two groups is purely an accounting convenience. There is no implication that weekly users need treatment. Furthermore, this report uses multiple data sources, and they do not all report use according to the same metric. Sometimes it is necessary to approximate weekly use as use on four or more days during a month, and sometimes calculations require other approximations.

Table ES.1 reports estimates for the number of chronic drug users in the United States.

Table ES.1: Chronic Users of Cocaine, Heroin and Methamphetamine (Thousands)

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Cocaine	2,578	2,661	2,634	2,812	2,823	2,775	2,777
Heroin	961	939	975	946	900	844	841
Methamphetamine	823	850	887	1,017	1,165	1,272	1,334
Marijuana	10,200	10,200	12,800	12,700	12,400	12,800	13,000

Source: See the discussion accompanying Table 2.1 and 3.1

During 2006, there were about 2.8 million chronic users of cocaine, 0.8 million chronic heroin users, 1.3 million chronic methamphetamine users, and 13 million chronic users of marijuana. As mentioned earlier, uncertainty surrounds these estimates. For example, the number of chronic cocaine users might be between 2.3 and 3.2 million for 2003. These uncertainty estimates are detailed in the main text.

The previous version of WAUSID (Office of National Drug Control Policy, 2001) estimated 2.7 million chronic users of cocaine and 898 thousand chronic users of heroin for 2000 (Table 3 in WAUSID). It estimated 595 thousand chronic users of methamphetamine for 2000 (Table 8 in WAUSID). It did not provide an estimate for chronic users of marijuana. Although current estimates and previous estimates are similar for 2000, the methodology is different. As explained in this report, current estimates rest heavily on data from the Arrestee Drug Abuse Monitoring survey (ADAM). Previous estimates rested heavily on data from the Drug Use Forecasting program, the National Household Survey on Drug Abuse (NHSDA), and other sources.

Estimates of the number of occasional users come directly from unadjusted tabulations of NSDUH. Because of methodological changes to the NSDUH, the 2001 and 2002 estimates cannot be compared, rendering confidence intervals and trends of little value. Furthermore, underreporting is appreciable in the NSDUH, but the extent of underreporting is unknown. For reasons explained in Chapter 3, this report assumes that self-reports of occasional cocaine, heroin and methamphetamine use derived from NSDUH should be inflated by a factor of 4; as explained in Chapter 2, self-reports of occasional marijuana use should be inflated by a factor of 1.333. In Table ES.2, the row *total* is the raw total from the NSDUH (weighted by the NSDUH sampling weights) and the *adjusted total* applies the inflation factors.

Table ES.2: Occasional Users of Drugs 2002–2006 (Thousands of Users per Month)

	Year					
	2002	***2003***	***2004***	***2005***	***2006***	***Average***
Cocaine						
Total	1,094	1,423	932	1,263	1,206	1,184
Adjusted	4,377	5,692	3,728	5,052	4,823	4,734
Heroin						
Total	51	27	30	31	84	45
Adjusted	205	108	120	126	338	179
Methamphetamine						
Total	134	162	120	174	142	146
Adjusted	537	647	480	697	567	586
Marijuana						
Total	4,496	4,816	4,957	4,534	4,686	4,698
Adjusted	5,995	6,422	6,609	6,046	6,248	6,264

Notes: The average is the five-year average for cocaine, heroin, methamphetamine and marijuana. The adjustment is 4 for cocaine, heroin and methamphetamine; it is 1.333 for marijuana.
Source: See the discussion accompanying Figure 2.1 and Table 3.12.

There are roughly 4.7 million occasional users of cocaine, 179,000 of heroin, 586,000 of methamphetamine and 6.3 million of marijuana. These estimates of occasional drug use have a high but unknown degree of uncertainty. Fortunately for this report, chronic users consume the bulk of illegal drugs, so the uncertainty when estimating occasional users has a relatively minor impact on subsequent estimates of expenditures and amounts used.

Table ES.3 reports estimates of the amount spent on illegal drugs between 2000 and 2006. These estimates do not adjust for inflation, though inflation remained low during this period.[5] In 2006, cocaine accounted for about $38 billion, heroin for about $11 billion, marijuana for about $34 billion and methamphetamine for roughly $18 billion. Again, there is considerable uncertainty in these estimates. For example, an uncertainty range for cocaine is between $29.6 and $43.1 billion for 2003, and this does not account for all uncertainty in these estimates. Chapters 2 and 3 detail these uncertainty ranges.

[5] Because of price inflation, the value of a dollar decreases over time. A common practice when reporting household expenditures is to increase the dollar value of earlier purchases when comparing expenditures over time. The Consumer Price Index (CPI) is typically used for this purpose because the CPI is adjusted to reflect the price increase in the mix of goods purchased by the average urban dweller. This practice may not apply to chronic drug users and their purchases, because a large proportion of their market basket (as the mix of goods is known) comprises illegal drug purchases—which are not an ingredient of the CPI. Table E.3 reports expenditures in terms of nominal dollars.

Table ES.3: Total Expenditures on Cocaine, Heroin, Methamphetamine and Marijuana ($ Billions)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	$34.6	$35.0	$35.9	$40.1	$37.2	$37.9	$37.8
Heroin	$11.9	$12.3	$12.7	$12.1	$11.5	$10.8	$11.0
Methamphetamine	$11.7	$11.6	$12.5	$13.4	$15.7	$17.4	$17.9
Marijuana	$25.2	$25.2	$35.7	$36.9	$30.3	$33.5	$33.7
Total	**$83.40**	**$84.10**	**$96.80**	**$102.50**	**$94.70**	**$99.60**	**$100.40**

Source: See the discussion accompanying Figure 2.5 and Table 3.17. Estimates are not adjusted for inflation.

The previous report (Office of National Drug Control Policy, 2001) estimated that Americans spent $35.3 billion on cocaine and $10.0 billion on heroin (Table 5). It estimated that Americans spent $5.4 billion on methamphetamine (Table ES.8) and $10.5 billion on marijuana (Table ES.9). Except for marijuana expenditures, these differences are attributable to different use prevalence estimates (discussed earlier) and to the availability of data from the ADAM survey that, for the first time, provided detail about expenditures. For marijuana estimates, the difference is due to the NSDUH (which replaced the NHSDA) introducing a module on marijuana users' purchasing behavior. Note that in Table ES.3 the 2000 estimate is equated to the 2001 estimate because the module was introduced in 2001.

The retail price of drugs varies widely both across the country and from purchase to purchase. Dividing total expenditures by the best available prices, roughly 390 metric tons of cocaine, 28 metric tons of heroin, 157 metric tons of methamphetamine and 4,285 metric tons of marijuana were used during 2006 in the United States (Table ES.4). (Those figures are all in pure metric tons.) The uncertainty surrounding the number of users, the amount they spent on drugs, and the price of drugs, all affect the estimates of the amount of drug use in the United States.

Table ES.4: Drug Consumption: 2000 through 2006 (in Pure Metric Tons Except Marijuana)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	254.6	228.0	252.5	336.6	346.2	371.7	389.6
Heroin	31.8	31.4	32.6	32.1	29.2	26.9	27.6
Methamphetamine	65.5	72.1	88.8	117.7	142.8	167.4	157.3
Marijuana	4,594.7	4,594.7	4,452.7	5,081.8	5,182.0	4,749.9	4,285.1

Source: See the discussion accompanying Figure 2.2 and Table 3.20.

The previous version of WAUSID (Office of National Drug Control Policy, 2001) reported that 259 metric tons of pure cocaine were used in 2000, an estimate that agrees broadly with that reported in Table ES.4. However, the previous version (Table ES.7 from WAUSID) reported an estimated 13.3 metric tons of heroin, which is lower than that reported in Table ES.4. The difference arises largely from differences in estimated retail-level prices for heroin. Previous estimates were 19.7 metric tons for pure methamphetamine (Table ES.8 of WAUSID) and 1,047 metric tons of marijuana (Table ES.9 of WAUSID). These differences in metric tons of use are largely explained by increases in prevalence and expenditures for methamphetamine (due to use of data from the ADAM survey) and increase in the prevalence and expenditures on marijuana use (due to the marijuana market module in the NSDUH).

For reasons explained in the report, the dramatic trend in apparent cocaine use comes from a large estimated decrease in the retail price of cocaine. The apparent trend may be an artifact of questionable purchase data. The level of heroin use is surprisingly high and may be a function of unreasonably low estimates for retail-level heroin prices.

Comments on the Prospect for Future Estimates

Availability of data from the ADAM survey for 2000 through 2003 was instrumental for the estimates appearing in Tables E.1 through E.4. This report provides details for the calculation of these estimates. The National Institute of Justice ceased funding ADAM following 2003, so estimates from 2004 through 2006 rest on a shakier foundation of assumptions and incomplete data.

However, price estimates will remain a challenge. Currently, the most comprehensive source of illicit drug price and purity data is DEA's System To Retrieve Information from Drug Evidence (STRIDE). STRIDE is a database of drug exhibits sent to DEA forensic laboratories from the DEA, FBI, CBP, ICE, USCG, and Washington Metropolitan Police Department. STRIDE is not a representative sample of drugs available in the United States, but reflects all evidence submitted to DEA laboratories for analysis. STRIDE data are not collected to reflect national market trends. Nonetheless, STRIDE data reflect the best information currently available on changes in cocaine, methamphetamine and heroin price and purity. The National Research Council (Manski, Pepper, & Petrie, 2001) and researchers funded by the NRC (Horowitz, 2001) have argued that price data derived from STRIDE are unreliable. While others have countered that the NRC position is overstated (Arkes, Pacula, Paddock, Caulkins, & Reuter, 2008), the best available price estimates (Fries, Anthony, Cseko, Gaither, & Schulman, 2008) show trends that contrast dramatically with other indications of the availability and use of illegal drugs in the United States. Improved price estimates may be the missing link when estimating tonnage of drug use by Americans.

Chapter 1:
Introduction to the Methodology

This report provides estimates of the number of Americans who use illegal drugs, the amount they spend on illegal drug use, and the amount of drugs they use. To develop these estimates the researchers use general population surveys and a number of other sources. The Substance Abuse Mental Health Services Administration (SAMHSA) sponsors a premier survey on illegal drug use in the general population, the National Survey on Drug Use and Health (NSDUH), and the National Institute on Drug Abuse (NIDA) sponsors a highly regarded survey on illegal drug use by youth, the Monitoring the Future (MTF) survey. The researchers use other sources to complement these surveys because general population surveys miss a large proportion of heavy drug users, users reached by conventional surveys often deny their use (Fendrich, Johnson, Sudman, Wislar, & Spiehler, 1999; Harrison, Martin, Enev, & Harrington, 2007) and with a few exceptions, the surveys do not question respondents about expenditures on illegal drug use or the amount of drugs used. Consequently, the surveys alone do not provide adequate answers to important policy questions about prevalence and trends in illegal drug use and expenditures.

An attempt to estimate trends in illegal drug use may not seem feasible. If the nation's best surveys cannot answer the requisite policy questions, how could estimates based on a patchwork of survey responses and other indicator data answer the policy questions? This report describes a method that has evolved over the last 20 years, and prevalence and trend estimates based on that methodology. The methodology may not satisfy all critics because validity and reliability challenges remain. Nevertheless, this report provides details about the methodology and a discussion of strengths and weaknesses; readers can decide if the findings are supported by this methodology.

There is no best methodology for deriving estimates of prevalence and trends in drug use, and suggestions for improvements are welcome as they provide a basis for modifying and improving WAUSID.

The introductory chapter provides the reader with an overview of the study's approach to estimating marijuana, cocaine, heroin and methamphetamine usage in the United States. Greater detail for each of the drugs appears in subsequent chapters. Section 1.1 of this chapter defines key measures used in this report. Section 1.2 provides an overview of the approach for estimating marijuana use. A different approach is used to estimate cocaine, heroin and methamphetamine use. This different approach is summarized in section 1.3. Section 1.4 explains how this report deals with uncertainty in the estimates. The last section (section 1.5) provides an outline of this report.

1.1 Definitions

This report provides estimates for marijuana, cocaine, heroin and methamphetamine usage. ***Prevalence*** refers to the number of Americans who use an illegal drug on average during any month of the calendar year. The report distinguishes between *chronic drug use* and *occasional drug use*. Chronic use means that a person used the illegal drug one or more times per week over the prior month; occasional use means that a person used the illegal drug less frequently.

This division between chronic and occasional use is a distinction adopted as a rule necessary to support the calculations. Adopting some other convention would be possible; justification for the once-per-week rule is that (1) it has been used for previous versions of WAUSID and (2) it is suitable for the calculations.

The distinction between chronic and occasional use does not imply a sharp division between the most and the least problematic users; nor is it intended to approximate any clinical decision rule for who does and who does not need treatment. Furthermore, while some data sets distinguish once-per-week users, other data sets do not. Calculations in this report attempt to be consistent in the definition when distinguishing between chronic and occasional use but approximations are sometimes necessary.[6]

Trends are defined as changes in prevalence over time. Prevalence is measured with considerable imprecision or error, some of which is measurable, most of which is not.[7] Given the size of the total measurement error for prevalence estimation, statistical testing for year-to-year changes is impractical and this report takes a longer-term view of trends. It imposes an assumption that trends are linear or at most a quadratic function of time,[8] and tests the null hypothesis[9] that there has been no significant trend. Adopting this approach provides a more powerful test of changes over time and addresses what is typically the more important policy question: Has drug use increased or decreased over time?[10]

1.2 Approach for Estimating Marijuana Use

For nearly a decade, SAMHSA has supported a marijuana market module as a component of the NSDUH. "Market" refers to questions about the amount of a drug purchased and the price paid. As a result, the NSDUH can support calculations of the number of chronic and occasional users, the amount they spend on marijuana purchases, and the amount of marijuana that they acquire. The NSDUH also provides good coverage of marijuana users (most of who appear to live in conventional households that are

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6 Some surveys ask the respondent if he or she used a drug on a weekly basis, so the definition is easily met. Some surveys ask the respondent how frequently he or she used in the last month, so some translation is required. For this report the translation was that use on four or more days during the month was equivalent to weekly use.

7 When SAMHSA reports statistics from the NSDUH, it reports measurement error that arises because of sampling. That kind of error is measurable and SAMHSA routinely reports a standard error. When a researcher wants to adjust reports from the NSDUH for underreporting, the amount of underreporting is not measurable, or at least, has not been measured except for special population or narrow timeframes.

8 The trend in a linear function is based on the variable "year." The trend in a quadratic function is based on the variables "year" and "year squared."

9 A null hypothesis is a statement about fact. A null hypothesis can be refuted or rejected using the data and standard rules for statistical testing. In the present context, the null hypothesis is that there is no trend in drug use. One might reject this mull hypothesis in favor of an alternative conclusion such as "there is a negative linear trend in drug use."

10 Estimating year-to-year changes is important to judge whether some intervention (such as changes in a media campaign) has had its intended short-term effect. Focusing on longer-term trends is pragmatic. Typically data cannot support reliable estimates of year-to-year changes, but data can support reliable estimates of long-term changes.

within the NSDUH sampling frame) and SAMHSA has supported studies of truthful reporting by marijuana users (Harrison et al., 2007). Therefore, there is considerable justification for basing prevalence and trend estimates of marijuana use on NSDUH data; and that is the approach taken in this study.

1.3 Approach for Estimating Cocaine, Heroin and Methamphetamine Use: Prevalence, Expenditures and Tonnage of Use

Except for marijuana use, the NSDUH cannot serve as a sound basis for estimating chronic drug use. The survey's coverage appears to miss many chronic users, who often live outside of conventional households, and there is ample evidence that chronic users and even occasional users frequently deny or understate their use (Fendrich et al., 1999; Harrison et al., 2007).

As a result, this report relies heavily on the Arrestee Drug Abuse Monitoring (ADAM) survey for deriving prevalence and trend estimates for cocaine, heroin and methamphetamine. ADAM is a probability survey of arrestees in a convenience sample of 40 U.S. counties. This report discusses procedures for generalizing from the sample of ADAM arrestees to the population of chronic drug users in the county, and for generalizing from the population of chronic drug users in the ADAM counties to chronic drug users in the nation. Details appear in chapters 2 and 3. A summary appears below. Subsection 1.3.1 explains the method for estimating drug use prevalence and drug expenditures. Subsection 1.3.2 explains the method for estimating drug price/purity and translating expenditures into metric tonnage of use.

1.3.1 Estimating Prevalence and Expenditures

Using ADAM data to derive prevalence and trend estimates for cocaine, heroin and methamphetamine is advantageous for the following reasons:

- ADAM carefully questions a probability sample of arrestees about their drug use and market behaviors, so the first advantage of using ADAM data is that the ADAM surveys ask the correct questions.
- Arrestees frequently deny or understate their drug use, but truthfulness appears to be much higher in ADAM than in the NSDUH (Office of National Drug Control Policy, 2010), and ADAM provides an objective means (based on urine testing) for adjusting for underreporting.

Using ADAM data also has some disadvantages but the methodology applies solutions. These disadvantages and solutions are summarized below:

- One disadvantage is that ADAM is a probability sample of arrestees, not drug users, so ADAM weights do not sum to the population of interest. The solution is to treat the arrest process as a sampling process, so that if the arrest rate is 0.5, the ADAM sampling weight is adjusted by 2 = 1/0.5.
- Another problem is that ADAM comprises a non-probability sample of arrests in 40 counties, and there is no simple way to convert estimates from the 40 counties into a national

estimate. The solution is to use a ratio estimator that uses data regarding treatment entry to infer a national estimate of drug use.

- A third problem is that ADAM is a statistical sample of male arrestees, so it is necessary to make assumptions—with some supporting data—to convert prevalence estimates for male arrestees into estimates for all arrestees.
- A fourth problem is that ADAM is limited to adults and the ADAM-based estimation methodology is limited to chronic drug users. Therefore, the approach complements estimates of chronic adult drug use based on ADAM with estimates of occasional drug use by adults using the NSDUH and juvenile drug use using the MTF survey.

For the analyses in this report, ADAM data were only available from 2000 through 2003 since the National Institute of Justice halted its sponsorship of the ADAM program in 2004. The Office of National Drug Control Policy revived ADAM in ten counties as of 2007, but those recent data are not part of the time period covered by this report.

Finally, using the method summarized here leads to estimates of the number of Americans who use cocaine, heroin and methamphetamine and the amount that they spend on those drugs, but the method does not provide an estimate of the metric tons of drugs used (i.e., consumed). To derive estimates of metric tons of use requires dividing expenditures by prevailing retail prices.

1.3.2 Estimating Prices and Tonnage of Use

While survey respondents can report the price that they paid for drugs, they cannot reliably report the amount purchased. First, drugs come in non-standard units such as bags and capsules, making the amount purchased highly variable. A "bag" of heroin can be 0.2 grams at one time or place and 0.4 in another. More importantly, drug purity in each unit varies, and respondents cannot reliably report pure amounts, the purchase amount required to estimate total tonnage of pure drugs used.

To overcome this problem, estimation starts with total expenditures, which can be estimated from survey responses, and then divides total expenditures by the *average purchase prices per pure gram*. The price per pure gram is a theoretical measure calculated by dividing the bulk price (impure) by the purity.

This shifts the problem to estimating the average purchase price per pure gram. The Institute for Defense Analysis (IDA) (Fries et al., 2008) provides a series of retail prices paid conditional on pure purchase amount, but while these estimates have a firm statistical justification, they cannot be used in estimating tonnage of drug use. A stylized example explains why and provides the foundation for deriving price estimates that more useful for present purposes than those standard published price series.

Suppose there are 1,000 purchases of crack cocaine during a period of interest. Sixty percent (n=600) of the purchases are for one-half gram and the purchase price is $160 per pure gram. Thirty percent (n=300) of the purchases are for 8 grams and the purchase price is $70 per pure gram. Ten percent (n=100) of the purchases are for 20 grams and the purchase price is $45 per pure gram.

During the period of interest, buyers spend \$306,000 = (600x0.5x\$160) + (300x8x\$70) + (100x20x\$45). The researcher can observe this total expenditure amount. They purchase 4,700 grams = (600x0.5) + (300x8) + (100x20). This total purchase amount of 4,700 grams is not observable by the researcher. Therefore, the purpose is to estimate the 4,700 grams. Estimation requires knowing the average price per gram purchased. This must be \$65.11 = \$306,000/4,700 because dividing the amount paid (\$306,000) by this average purchase price (\$65.11) gives the correct estimate of 4,700 grams.

Although \$65.11 is the correct average price paid for the above calculation, there is another way to think about the average price paid—namely, the average price paid over the 1,000 purchases. This is \$121.50 = [(600/1000)x\$160] + [(300/1000)x\$70] + [(100/1000)x\$45]. The standard published price series reports this type of average. Dividing this version of the average retail price into the \$306,000 expenditure yields an estimate of 2,519 grams, an estimate that is only 54 percent of the correct amount. Therefore, although the standard published price series estimates are good for other purposes, the latter example illustrates that they do not perform well for present purposes.

This report provides an estimate of retail prices that comes closer to what is highlighted by the stylized illustration. (Details are explained in Appendix H and a summary is presented here.)

The correct price requires weighting the purchase prices by the amount purchased, but that solution is not possible because the distribution of purchase amounts is unknown. Provided quantity discounts are not very large at the retail level the total amount paid is a good proxy for amount purchased. Therefore, instead of weighting purchase price by the distribution of purchase amounts, an estimate comes from weighting by the distribution of amount paid at retail. In the stylized illustration above, where there is a large quantity discount, the estimated price paid per grams purchased is nevertheless \$76.76, close to the correct \$65.11 and distinct from the incorrect \$121.50.[11]

While the standard published price series estimates are not used directly in the estimation, they are used indirectly as a check. If one is willing to believe that purchases by DEA and other enforcement agencies that send samples to the System to Retrieve Information from Drug Evidence (STRIDE) are representative of the purchases made by non-enforcement drug buyers, then one can approximate the above calculations using standard published price series tables.

1.4 Comments on Estimating Uncertainty

Estimates are always measured with uncertainty. Uncertainty takes two forms. Some parts of the estimation are based on statistical analysis that leads to probability-based confidence intervals. The NSDUH is an illustration. For example, the NSDUH leads to a probability-based confidence interval implying that a reader can be 95 percent certain that the number of Americans who would self-report recent marijuana use if all Americans had been questioned would fall between an estimated upper and lower limit.

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[11] In the illustration, buyers who pay \$160 per purchase pay \$48,000 (600x0.5x\$160) in total; those who pay \$70 pay \$168,000 (300x8x\$70) in total; and those who pay \$45 pay \$90,000 (100x20x\$45) in total. Total expenditures are \$306,000. Therefore the weighted price is 76.76 = [(48,000/306,000)\$160] + [(168,000/306,000)\$70] + [(90,000/306,000)\$45].

Other parts of the estimation methodology are based on assumptions. For example, the estimation will assume that 75 of every 100 marijuana users will truthfully report their recent use of marijuana. Typically some evidence will support such an assumption, but seldom is there a basis for placing a probability-based bound on the assumption. Judgment necessarily enters and, consequently, probability-based confidence intervals disappear. They are replaced by what this report will call uncertainty intervals. The problem with an uncertainty interval is that it is based on judgments, and different readers will undoubtedly assert—based on the reader's judgment—that the *uncertainty interval* should be narrower or wider.

1.4.1 Prevalence vs. Trends

There are two kinds of measurement error. One type of error is constant from one year to the next. To continue an earlier illustration, some evidence supports an assumption that 75 percent of marijuana users will truthfully report their current use. Assuming that 75 percent is correct, after accumulating self-reports of marijuana use to conclude that 10 million Americans admit to marijuana use during the month, an analyst might divide the 10 million by 1/0.75 to conclude that 13.3 million Americans probably used marijuana during the month. The assumption may be wrong. If 80 percent report truthfully, then 12.5 million Americans are users; if 60 percent report truthfully, then 16.7 million Americans are users; and so on. Uncertainty about the level of truthful reporting adds uncertainty to prevalence estimation.

Suppose, however, that while the level of truthfulness is uncertain, a reader would be willing to assume that the rate of truthfulness has not changed much over time. (That assumption is maintained in the report.[12]) Then trends can be estimated with greater precision than can prevalence. That is, any factor (such as the level of self-reporting) that does not change over time will not add uncertainty to the estimation of trends.

This report uses linear and sometime quadratic regressions to estimate trends. Often the prevalence estimates for each year are used as data points, and the regression estimates whether there appears to be a trend. Estimation of the regression parameters is not affected by measurement errors that do not vary from year to year.[13]

A regression does more than ignore measurement errors that do not vary from year to year. The regression imposes order on the data—in this case, a linear trend. Given this imposition of order, the distribution of prevalence estimates about the regression line reflects pure measurement error. That is, if there were no measurement error, all the prevalence estimates would fall exactly on the trend line. The precision of the estimated trend depends on the inverse of the square root of the number of time points. For example, the standard error for a six-year trend is about 0.58 times the size of the standard

[12] The assumption would be testable with a longer time-series of ADAM data. The question is whether willingness to report drug use changes over time in ADAM. Four years of ADAM data are insufficient to test the null of no change in reporting behaviors, but the addition of additional ADAM data through the ADAM II survey would allow those tests.

[13] Consider a simple linear regression with prevalence as the dependent variable, a constant, and time as the independent variable. Measurement error that is constant at each time point will affect the constant. It will not affect the slope and hence the estimate of the trend.

error when comparing the prevalence for one year with the prevalence for any other year. This is a great advantage of examining long-term trends in contrast to year-to-year changes in prevalence.

1.4.2 Comparisons

While statistical analysis provides a good way to estimate confidence intervals, often uncertainty intervals are the best that can be done. Another way to assess the goodness of the estimates is to compare them with estimates from other researchers and trends in other drug use indicators. This report introduces three comparisons to assess the credibility of the estimates.

The report offers comparisons with estimates provided by other researchers, but there are two problems. The first is that there are few other estimates, so there is little to compare. The second is that other estimates are often crude and it is unclear whether these crude calculations should have comparable standing to a more sophisticated approach.

A second comparison is between trends in prevalence and other indicators of drug use. For example, although there is evidence that the NSDUH underestimates the prevalence of chronic drug use, trends based on NSDUH data should be consistent with trends based on the methods used for this study.

A third comparison is between demand-based estimates (reported here) and supply-based estimates reported separately (ONDCP, 2011). Americans cannot consume more foreign-produced drugs than enter the country, so a comparison of demand and supply is logical, especially when that comparison is based on trends. One problem is that supply-based estimates are measured with considerable uncertainty. In addition, some of the supply-based estimates depend partly on data about demand, so to some extent the reasoning is circular.

1.5 Outline of the Report

The above summary provides the reader with an overview of the methodology. The report is structured to make findings accessible to different readers. Chapters 2 through 4 provide details at a level for a general reader. Technical appendices are intended for readers with training in statistical analysis and for readers who are searching for details. When applicable, readers are referred to other published reports.

Exclusive of the executive summary and this brief introduction to the methodological issues, the body of this report has four chapters. Chapter 2 addresses marijuana and provides prevalence and trend estimates for the number of users, the amount they spend on marijuana, and the tonnage of marijuana they use. Chapter 3 addresses cocaine, heroin and methamphetamine. It also provides prevalence and trend estimates for the number of users, the amount they spend on illegal drugs, and the tonnage use of cocaine, heroin, and methamphetamine. Marijuana is separated from the other illicit drugs because the methodology used to estimate prevalence and trends in marijuana use differs from that used for the other drugs. Chapter 4 presents estimates for alcohol and tobacco use. Chapter 5 provides concluding remarks.

Chapter 2: Marijuana

More Americans use marijuana than any other drug. This is one reason why the data about marijuana use are richer than the data about the use of cocaine, heroin and methamphetamine. Using these rich data, this chapter takes two approaches to estimating prevalence and trends in marijuana users, dollar expenditures and metric tons of use. The first approach is based primarily on data from the National Survey on Drug Use and Health (NSDUH). This approach is applicable for 2001 through 2006. It is considered the preferred approach because the NSDUH is so carefully done, it provides good coverage for marijuana use, there are credible estimates for adjusting self-reports for underreporting, and the data are currently available for six years. The second approach mixes data from the Arrestee Drug Abuse Monitoring (ADAM) survey with data from the NSDUH. This approach only yields estimates for 2000 through 2003, but these are useful for comparison with the preferred estimates. This chapter critically assesses the methodology to identify weaknesses and compares its estimates with estimates provided by other sources. It also contrasts trends reported here with trends in other drug use indicators.

Table 2.1 summarizes findings from the rest of the chapter. For the purpose of the estimates, a *chronic user* is defined as someone who consumes marijuana on four or more days per month. An *occasional user* is defined as someone who consumes marijuana on three or fewer days per month. Discounting 2001 because of changes in the NSDUH protocol, the number of chronic users has remained constant at about 13 million and the number of occasional users has remained constant at between 6 to 6.5 million users. This is the number of users *per month*; there are more users per year. *Expenditures* are more difficult to estimate, so the expenditure estimates have larger measurement error. Nevertheless, expenditures have been near $30 billion per year over the six year period. *Tonnage of use* is even more difficult to estimate because it requires dividing uncertain expenditure estimates by uncertain price estimates. Nevertheless, tonnage used appears to be approximately 5,000 metric tons per year.

Table 2.1: Marijuana Users, Expenditures and Tonnage of Use

	2001	*2002*	*2003*	*2004*	*2005*	*2006*
Chronic users (millions/per month)	10.2	12.8	12.7	12.4	12.8	13.0
Occasional users (millions/per month)	5.4	6.0	6.4	6.6	6.0	6.2
Expenditures (billions/per year)	$25.2	$35.7	$36.9	$30.3	$33.5	$33.7
Tonnage of use (metric tons/per year)	4,594.7	4,452.7	5,081.8	5,182.0	4,749.9	4,285.1

Source: Chronic and occasional user estimates are from Figure 2.1. Tonnage is from Figure 2.2 and expenditures are from Figure 2.3.

2.1 Estimates Based on the National Survey on Drug Use and Health

The NSDUH is a good source of data on marijuana use for several reasons. First, these data are likely representative of the general population of marijuana users. Marijuana use is prevalent so there is less worry than with other drugs that a population missed by the NSDUH (because its members live outside of conventional households) could account for a proportionately large amount of marijuana use. Also, as discussed subsequently, there are studies that support the accuracy of self-reports of marijuana use.

Finally, the survey data report the amount paid for purchases of marijuana and the amount purchased; although using those data requires some modeling and statistical manipulation, the modeling/manipulation leads to credible estimates of marijuana use.

2.1.1 Prevalence of Marijuana Use

Respondents of the NSDUH are asked to report the number of days during the last 30 days when they used marijuana or hashish.[14] After applying the NSDUH sampling weights and making several adjustments, these data are used to estimate the number of Americans who use marijuana in a typical month. These adjustments are described below.

There is ample evidence that respondents to the NSDUH frequently understate their drug use, so estimation requires an upward adjustment to reduce reporting bias. The size of the required adjustment is unclear. According to a recent study (Harrison et al., 2007), 61 percent of respondents who tested positive for marijuana admitted to marijuana use in the last 30 days.[15] Only 81 percent of respondents provided a specimen for testing, and while there are many reasons for refusing to provide a specimen, respondents' knowledge of recent drug use would seem to provide some motivation. Consequently the rate of truthful reporting could be lower.

The picture is even more complicated. Most respondents (89 percent) tested negative for marijuana use, but nevertheless, 6.5 percent of those who tested negative admitted use in the last month. Presuming that these respondents were not overstating their use, they may have been light users whose marijuana use was not detected because it was too little to meet test thresholds. Presumably few respondents would say they used marijuana when they had not.[16]

Given this information, what is a justifiable adjustment factor to prevalence based on self-reports? To answer this question, the population is divided into five groups, A through E, as defined below:

A. Tested positive and truthful *(6.8 percent of respondents[17])*
B. Tested positive and not truthful *(4.3 percent of respondents)*
C. Tested negative, used and truthful *(5.8 percent of respondents)*
D. Tested negative, used and not truthful *(Unknown—no estimate)*

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14 Other authorities prefer to report use during the year. Obviously, more Americans use marijuana during the year than during the month. Monthly use is preferred for this report because (1) estimates of truthful reporting are known for the month but not for the year; and (2) monthly reporting translates into the definition of chronic drug use, here defined as use on four or more days during the month. Multiplying monthly use by 12 equates to yearly use.

15 Recent use of marijuana is detectable for one month or more for heavy users and the window of detection is shorter for less frequent users. See Harrison et al. (2007, p. 62).

16 The NSDUH is careful to focus respondents on the last 30 days, but it seems likely that some respondents would report marijuana use that occurred earlier than the 30 day window because it is difficult to be accurate. Of course respondents who report use outside the window should be discarded from the calculations, but they cannot be identified.

17 Estimates reflect the percent of respondents who provided a specimen for testing.

E. Tested negative, did not use and truthful *(Unknown—no estimate)*

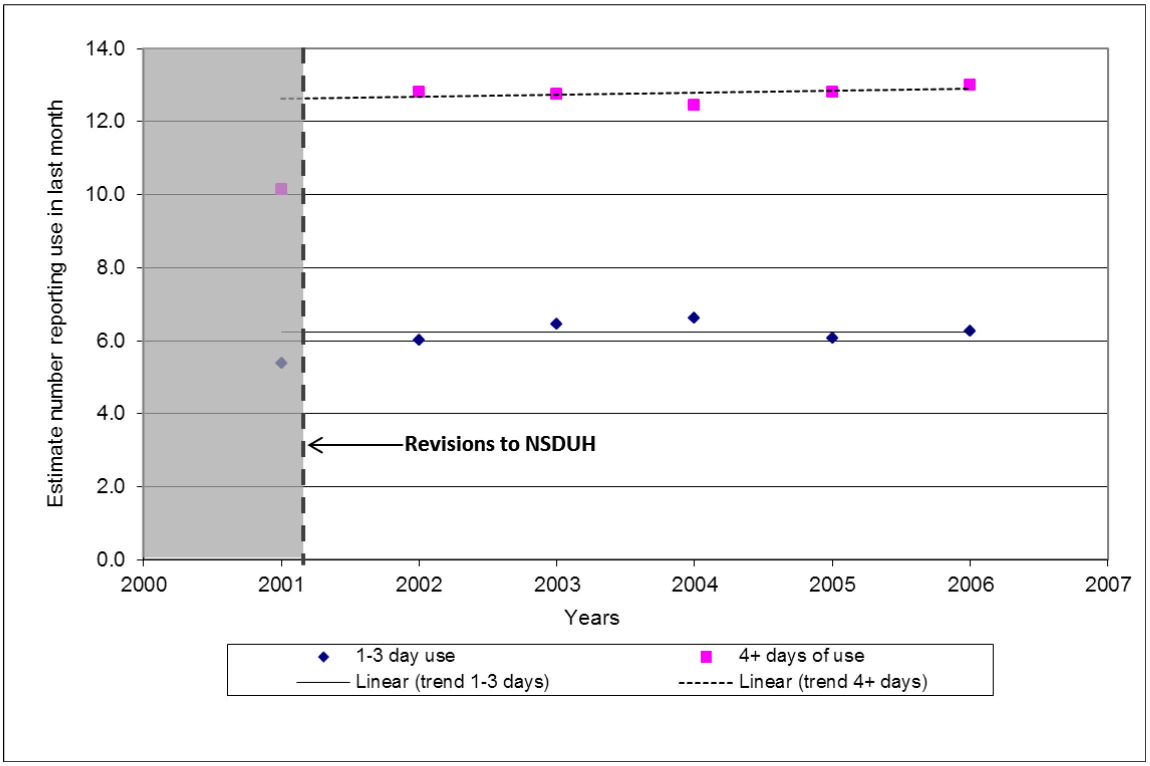
This classification assumes that there is no class of non-users who would nevertheless admit to use. Correcting self-reports to account for underreporting requires an adjustment factor equal to the ratio of Americans who used marijuana (i.e., A, B, C and D) relative to the number of respondents who reported using marijuana (i.e., A and C):

$$ADJUSTMENT = \frac{A+B+C+D}{A+C}$$

Harrison et al. (2007, p. 202) report estimates for A, B and C but there is no estimate for D. There are two approaches to dealing with this problem. One is to assume that D is zero. This implies that the truthfulness rate is 0.74 and the adjustment is 1.35. Another approach is to assume that the ratio of C/D (testing negative) is the same as the ratio of A/B (testing positive). This implies a truthfulness rate of 0.79 and the adjustment is 1.27.

There is a large percent of respondents (19 percent) who did not provide a urine sample and these individuals could decrease the estimated truthful reporting rate. The approach taken here is to assume an estimated 75 percent truthful reporting rate but recognize that truthfulness could be higher or lower. Following that rule, Figure 2.1 shows trends in the weighted number of NSDUH respondents who said that they used marijuana or hashish during the 30 days prior to the survey. All data came from the 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website. The figure distinguishes between those who said that they used between 1 and 3 days and those who said that they used more frequently. The numbers behind this figure were reported in the introduction to this chapter.

Figure 2.1: Prevalence of Marijuana/Hashish Use during the Month Prior to the Survey (Millions)



Source: 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website.

The 2001 estimate seems mysterious because it is substantially lower than the estimates for subsequent years. This is an artifact of changes to the NSDUH survey protocol that were intended (apparently, successfully) to improve the reporting rate. Dismissing 2001 as an artifact of these improvements to the methodology, there appears to be no strong trend in the number of Americans who report using marijuana in the month before the survey.[18] About 19.1 million Americans appear to use marijuana during any given month. About 6.3 million used three or fewer times during the month; the remaining 12.8 million used four or more times during the month. The standard deviation for the total is 264,000.[19] The estimate of truthful reporting is only approximate and likely comprises the largest component of the uncertainty for prevalence.

2.1.2 Expenditures on Marijuana

Since 2001, the NSDUH has asked respondents about marijuana market participation including questions about the amount paid for the last purchase and the amount purchased. In theory, one could use these data to estimate total expenditures on marijuana and the tonnage of marijuana purchased. In fact,

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18 Linear regressions fit using data for chronic users, for occasional users and for all users are not statistically significant at conventional levels of confidence when the estimates are based on data available for this analysis. Changes are statistically significant for the total when 2001 is included in the estimates.

19 This is the standard error about the regression line. Adjusting for underreporting would increase this to 365,000.

respondents appear to have considerable difficulty reporting the amount purchased. For this chapter, the approach was to estimate total expenditures and then estimate tonnage used by dividing expenditures by estimates of marijuana prices. Nevertheless, estimates of grams purchased are used in a secondary role as explained below.

All data came from the 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website. To be included in the analysis, a respondent had to say that he or she had purchased marijuana during the last month (31,751 respondents).

The Basic Calculation

The basic calculations are straightforward. Respondents are asked to report how much they spent on the last purchase. This calculation is not an estimate of marijuana purchased during the month, because it is limited to the amount acquired during the last purchase. Estimation of expenditures during the month requires an adjustment for the frequency of purchasing. The survey asks a direct question about the number of purchases made during the month, and this was used to convert the last purchase into total purchases for the month. Respondents are also asked to report their last purchase amount during the month before the survey in units of joints, grams, ounces or pounds. Assuming that a joint is 0.4 gram, it is simple to convert the responses into gram equivalents, to weight the responses by the survey's sampling weights, and to sum to derive an estimate of the amount bought during the last purchase. The following eight steps provide more details on the basic calculation.

The **first step** was to estimate the size of the most recent purchase. Respondents are allowed to report their last units as joints, grams, ounces or pounds. A few respondents refused[20] to answer so estimation imputed responses for an additional category of unknown units.[21] When respondents said they purchased joints, they also reported the number of joints, which were converted to gram equivalents by assuming that a joint was 0.4 grams. Getting this conversion correct was unimportant, because joint purchases contributed very little to the totals. When respondents said they purchased grams, ounces or pounds, they also reported the weight in categories.[22] By assumption the weight equaled the midpoint of the category for all categories except the highest, which was set at its lower limit because this high-end category had no upper limit.

The **second step** was to estimate the amount paid for the purchase. Respondents are asked how much they paid for their purchase and responses are given in categories. By assumption the dollar amount equaled the midpoint for the category, or $1000 for the highest category for which the lower limit was $1000.99 and there was no upper limit. Very few responses fell into that category.

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[20] As the term is used here, refusal includes outright refusal, inability to answer the question, and blank answers.

[21] The imputation was based on number of days of use during the year.

[22] Grams are reported as gram amounts, rather than categories, above a threshold level.

Respondents appeared to have difficulty when reporting amounts acquired. That is, very large amounts of marijuana were sometimes purchased for very low prices, and small amounts of marijuana were purchased for very high prices. The **third step** was to trim the extremes.[23]

The NSDUH asks respondents how often they purchased during the last month. The **fourth step** was to multiply this variable by the last purchase amount and the last price paid to estimate total purchased during the month and total amount paid.

The **fifth step** was to weight the results from step four by sampling weights and to sum over the respondents who said that they purchased during the last month. The tonnage purchased appeared unreasonable. That is, dividing total expenditures by tonnage implied prices that were much lower than prices commonly observed for marijuana purchases. Assuming that price paid was reported more accurately than grams purchased, the approach was to base calculations on expenditures. Nevertheless, the distribution of grams purchased is used in the next step.

The **sixth step** was to estimate the average price per gram paid for marijuana. The standard published price series reports marijuana prices conditional on the amount purchased (0.1 to 10 grams, 10 grams to 100 grams, and more than 100 grams). Analysts estimated the average price paid as a weighted average of the estimates provided by standard published price series where the weights were determined from the distribution of purchase amounts reported in the NSDUH.[24] By year the estimated average price paid per gram was $5.48 (2001), $8.03 (2002), $7.27 (2003), $5.84 (2004), $7.05 (2005) and $7.87 (2006).

The **seventh step** was to divide the total expenditures by the average purchase price. This yielded a provisional estimate of tonnage, but the provisional estimate required adjustments to account for bias; these adjustments **(step eight)** are described next.

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[23] The estimation methodology regressed the logarithm of the gram equivalent amounts on price, price-squared and year. The methodology then predicted the log-amounts based on price and year, converted the predicted log amounts into gram units by exponentiating the predictions, and substituting the predictions for extreme reports of amount purchased. This required four steps. The first step was to estimate the regression described above. The second step was to discard observations that fell plus or minus three standard deviations from the regression line. These were considered to be extreme values. The third step was to eliminate the extreme values and estimate the regression again. The fourth step was to replace the extreme values with the regression predictions.

[24] IDA (Fries et al., 2008) reports estimates for three categories of purchases: 0.1 to 10 grams, 10 grams to 100 grams, and more than 100 grams. To be useful for this report, the prices reported by IDA needed to be converted into the average price per gram purchased over all purchases, so that large purchase amount received larger weights. The weights were based on the tonnage calculations reported in the text after adjustments for bias. That is, the calculations determined the proportion of purchases the resulted from buys between 0.1 and 10 grams, the proportion that resulted from purchases between 10 and 100 grams, and the proportion of larger purchases. Although the price varied over time, the average between 2001 and 2006 was $6.92. This is considerably lower than the price per gram for purchases between 0.1 and 1.0 grams ($15.50), somewhat lower than the price for purchases between 10 and 100 grams ($9.02), but considerably higher than the price paid for purchases above 100 grams ($2.01).

A Discussion of Bias

The approach seems credible. Still, there are reasons to suspect bias among respondents of the NSDUH.

The Estimates are Biased Downward. There exists ample evidence that respondents to the NSDUH frequently understate their drug use, so estimation of purchases requires an upward adjustment to reduce reporting bias. Previously the calculations for prevalence of use assumed that 75 percent of people who used during the last month would admit to that use. This is not altogether the correct criterion. There may be greater reluctance to report purchasing than there is to report use, so this estimate for truthful reporting may be too high.[25] Nevertheless, adopting an estimate that 75 percent of respondents tell interviewers about their purchases, and that their reports are accurate, suggests that the amount purchased should be increased by 1/0.75=1.333. This adjustment is applied subsequently.[26]

The Estimates are Biased Upward. About 9 percent of the respondents said that they had sold some of the marijuana after purchasing it. This is a serious problem because the NSDUH does not ask respondents to estimate the proportion that they resold and this raises the problem with double counting. Suppose respondent A bought one ounce of marijuana, retained one-half of an ounce, and sold the other one-half of an ounce to respondent B. Respondent A would report one ounce and respondent B would report one-half ounce. This would double count the one-half ounce.

An expedient approach is to discard all respondents who said that they had sold some of the marijuana. An alternative approach uses a regression-based adjustment to account for dealing.[27] This report adopts the regression-based adjustment as the best approach, identifies the unadjusted estimate as a high estimate in the uncertainty range, and identifies the estimate after eliminating dealers (e.g., respondent A) from the calculations as the low estimate of the uncertainty range. Readers should appreciate that the low range is certainly too low because users frequently sell some of their marijuana.

2.1.3 The Best Estimates

The best estimate is that Americans spent about $36 billion per year on average between 2002 and 2006 and about 5,000 metric tons per year on average during that same period. Likely this estimate is biased downward principally because (1) it does not account for users who acquire marijuana by barter or by cultivation and (2) it does not account for use by people who live outside of conventional households, but as noted this bias is probably not a large part of the overall uncertainty.

Figure 2.2 shows year-by-year trends for estimates that adjust both for underreporting and for dealing.

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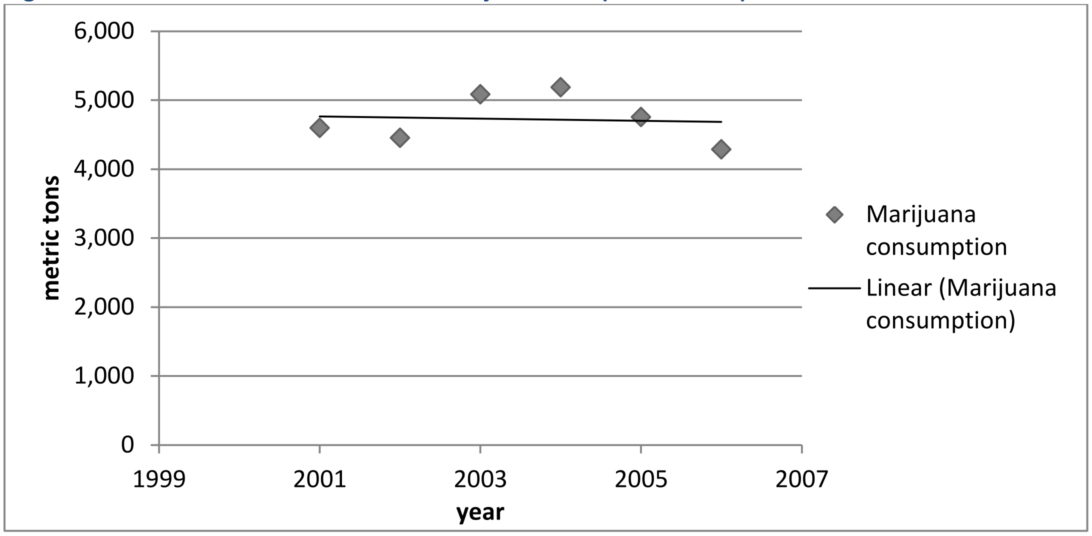
25 Marijuana is often shared so that there are many more users than there are buyers. The buyers may be more or less truthful than the users.

26 Some respondents traded for marijuana or they grew it themselves. They should be included in the calculations for tonnage used. However, they are a small proportion of respondents, and given that estimating prices and gram-equivalents is complicated for this group, they are not included.

27 The dependent variable is the amount purchased. The independent variables are a constant, the number of times used in the last year, a dummy variable denoting that some was sold, and an interaction term between the dummy variable and the frequency of use variable. Predictions were based on the estimated constant and the estimated parameters for use in the last year. These predictions were substituted for self-reports when the respondent said that he or she sold some of the marijuana.

Figure 2.2: Best Estimates of Trends in Marijuana Use (Metric Tons)

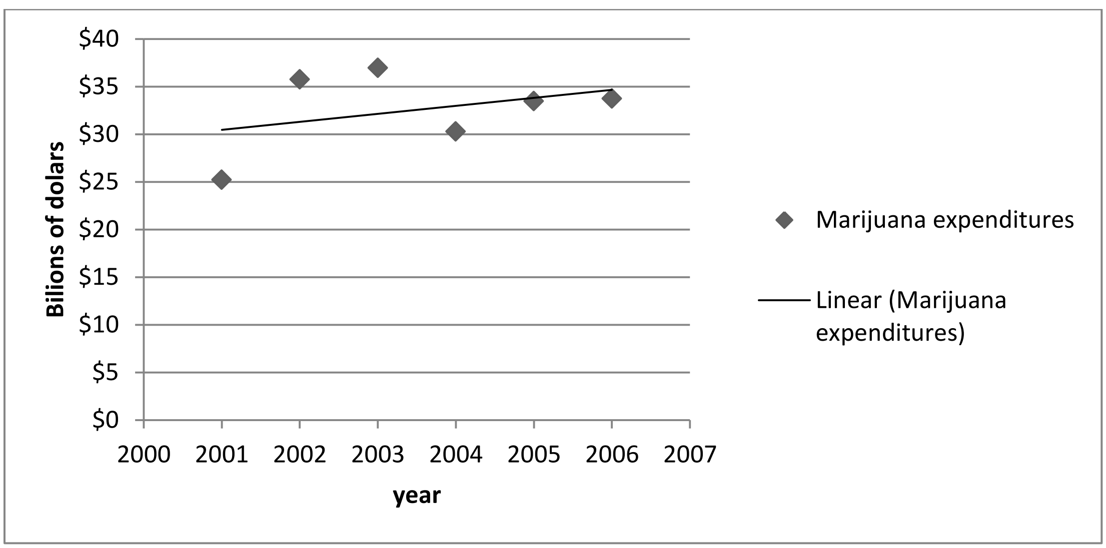


Source: 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website.

A regression suggests no trend, but caution is required. The low estimate for 2001 is an artifact of changes to the NSDUH design. The standard error about this regression line is 935, implying that there is considerable error in each yearly estimate. Given this, there is little justification for comparing year-to-year variation in these estimates, but concluding that there are no long-term trends seems justified.

Figure 2.3 is the counterpart to Figure 2.2 and represents dollar expenditures in billions.

Figure 2.3: Best Estimate of Trends in Marijuana Expenditures ($ Billions)

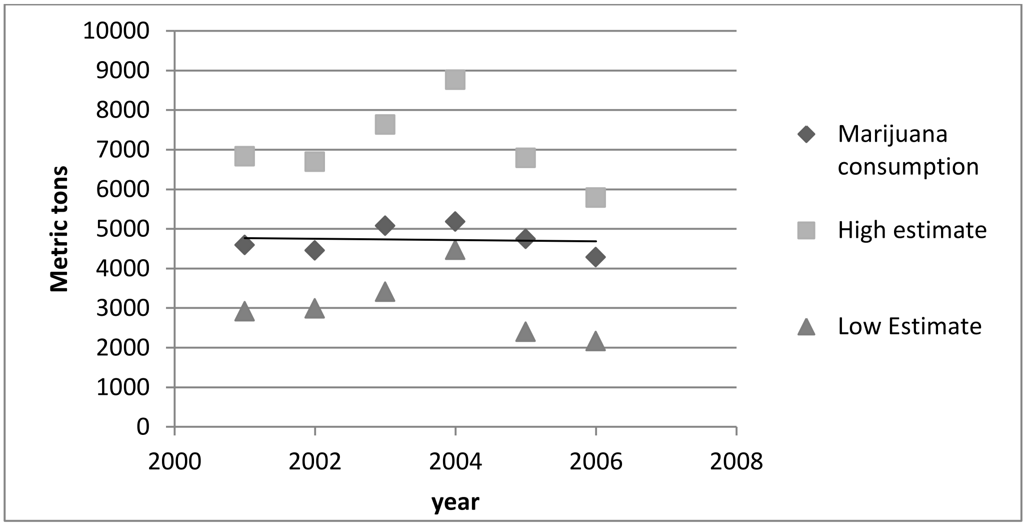


Source: 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website.

The line drawn in Figure 2.3 suggests an upward trend, but this seems unlikely. As already noted, the 2001 estimate is likely low relative to other estimates because of changes to the design of the NSDUH.

Figure 2.4 expresses a measure of uncertainty for tonnage. The figure shows high estimates (represented by squares in the figure), which are the estimates that make no allowance for dealing but account for underreporting. The figure also shows low estimates (represented by triangles), which are estimates that discard observations from any respondent who said that he sold some of what he bought.

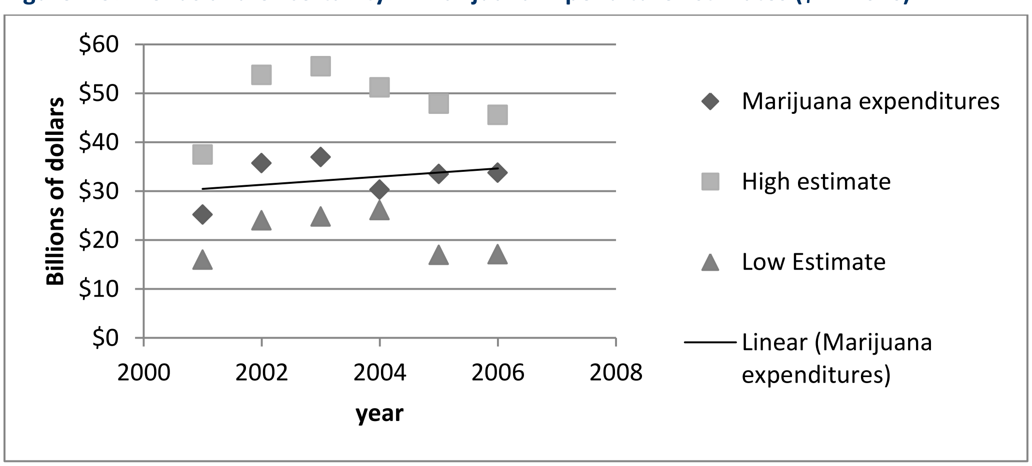
Figure 2.4: Trends and Uncertainty in Marijuana Use Estimates (Metric Tons)



Source: 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website.

Figure 2.5 is the counterpart to Figure 2.4, representing dollar expenditures rather than tonnage of purchases.

Figure 2.5: Trends and Uncertainty in Marijuana Expenditure Estimates ($ Billions)



Source: 2001–2006 NSDUH survey results downloaded from the Substance Abuse Mental Health Services Administration/Office of Applied Studies website.

Neither range between the low estimates and the high estimates are confidence intervals, but they do reflect some uncertainty in these estimates, and can be compared with estimates provided by others. A reader should remember, however, the uncertainty does not reflect any uncertainty about the truthful reporting rate.

2.2 Estimates Based on the Arrestee Drug Abuse Monitoring Survey

Appendix A provides detailed calculations for an alternative approach to estimating the prevalence of marijuana use, expenditures on marijuana use, and the tonnage of use. (Also see chapter 3, which uses the same approach for estimating users and use of cocaine, heroin and marijuana.) A summary appears here.

2.2.1 Prevalence of Marijuana Use

ADAM-based estimation assumes that chronic users (those who use on a weekly basis) have an appreciable probability of being arrested and booked for drug use, for drug selling or for other charges. This does not mean that all or even most are booked during the year. The assumption is testable because the NSDUH asks respondents to report if they have been arrested during the last year and how often they have been arrested in the last year. About 33 percent of those who used 1–3 days said they had been arrested and booked; about 41 percent of those who used 4–10 days said they had been arrested and booked; and about 48 percent of those who said they used more on more than 10 days said they had been arrested and booked. Chronic users in the NSDUH are arrested on average every other year. Therefore the assumption of *an appreciable probability* is justified.[28]

The ADAM-based estimates require seven steps. The **first step** requires estimating the number of arrests for chronic marijuana users during a year. This necessitates applying ADAM's sampling weights for the 8 weeks when ADAM was in the field and prorating this estimate to account for the remaining 44 weeks when ADAM was not in the field.

The **second step** is to adjust self-reports for underreporting. This is done using ADAM's drug test results. The **third step** is to adjust for the fact that ADAM is limited to males. The adjustment is approximate: essentially, male-based statistics are inflated to account for the proportion of males in the total arrestee population based on Uniform Crime Report statistics.

Steps one through three lead to estimates of the number of chronic marijuana users booked in a county during a year. Estimating the number of chronic marijuana users in the county population requires dividing by the arrest rate. Therefore **step four** requires computing the respondent's arrest rate. This is done using the ADAM calendar, a listing of significant events—including bookings—that occurred during the year prior to the interview. Dividing by the arrest rate converts a statistic for chronic marijuana users in the booking population into a statistic for chronic marijuana use in the general population. Technical details of this step are reported elsewhere (Rhodes, Kling, & Johnston, 2007).

Steps one through four lead to estimates of chronic marijuana use among adults in the general population but only for those counties that participated in the ADAM survey. **Step five** assumes a proportionality between chronic marijuana use and entry into treatment for marijuana use (e.g., application of a ratio estimator) to build an estimate of chronic drug use in the nation.

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[28] Being arrested and booked is stigmatized behavior in most societies. Likely the arrest rates based on the NSDUH are understated.

ADAM-based estimation is also limited to adult users. To account for chronic use among youth, **step six** uses tabulations of chronic use based on the Monitoring the Future (MTF) survey. To capture use by occasional users, **step seven** uses data from the NSDUH. Thus, adult chronic use comes from ADAM, juvenile chronic use comes from the MTF, and adult and juvenile occasional use comes from the NSDUH.

ADAM-based estimates for chronic drug use are available for 2000–2003 for 35 counties (since ADAM data were not available for all sites after those years). By year (with uncertainty intervals in parentheses) the estimates are 7.9 million for 2000 (6.5 to 9.2 million), 7.9 million for 2001 (6.5 to 9.2 million), 8.2 million for 2002 (6.9 to 9.6 million) and 8.6 million for 2003 (7.3 to 10.0 million). Adding chronic use by juveniles leads to estimate of 10.0 million for 2000, 10.0 million for 2001, 10.1 million for 2002 and 10.5 million for 2003. Although these estimates are lower than NSDUH estimates for chronic marijuana use, the estimates are not greatly different and findings agree that there are no strong trends over these years.

2.2.2 Expenditures on Marijuana

The ADAM survey carefully asks a battery of questions about market behaviors. The following provides a summary; technical details are provided in Appendix A. The survey asks the respondent to report how much he paid for his last purchase, the number of purchases made during the day, and the number of days he purchased marijuana during the month. Monthly expenditure is the product of these three self-reports; i.e., the average across these reports is multiplied by the total number of marijuana users (e.g., the prevalence computed in 2.1.1). However, there are complications with this approach. The following describes the procedures applied to deal with these complications.

One complication is that respondents sometimes say that they bartered for the marijuana. To deal with this problem, the methodology imputes a dollar-equivalent expenditure based on the amount involved in the transaction and the average price paid for the same amount by those who purchased marijuana.

A second complication is that some respondents resold some of the marijuana. The survey is not sufficiently precise to be able to estimate the proportion that was resold, so the methodology uses a procedure similar to that applied to the NSDUH data. Using regression analysis, it estimates the amount purchased for own use as a function of frequency of use, and it then imputes expenditures for everybody who said that they resold or gave the marijuana as a gift. Details appear in section A.2 of Appendix A.

Sometimes estimates for any individual were so large that they were deemed unreasonable and were trimmed to prevent the overall average from being unduly affected by extreme values. After trimming, total marijuana expenditures were estimated as $34.0 billion for 2000, $34.0 billion for 2001, $34.5 billion for 2002 and $35.8 billion for 2003.

These estimates are remarkably close to their counterparts based on the NSDUH. The 2001 ADAM-based estimate is much higher than its NSDUH counterpart, but changes in the NSDUH survey’s design may account for that difference.

2.2.3 Tonnage of Marijuana Use

Estimating tonnage of use comes from dividing expenditure by price per gram. For this report, prices come from an ONDCP-sponsored study (Fries et al., 2008, p. B-35). As noted earlier, the report does not actually report marijuana prices. Rather, it reports prices for purchase categories (0.1 to 10 grams, 10 grams to 100 grams, and more than 100 grams). To derive a price estimate, one needs to know the distribution of purchase amounts. However, as explained above that information is unavailable.

Therefore, for this study, analysts performed independent analyses of the Systems to Retrieve Information from Drug Evidence (STRIDE) data, distributing the prices over the purchase categories observed among arrestees. By year the price estimates were $6.40 per gram (2000), $7.06 per gram (2001), $9.30 per gram (2002) and $8.53 per gram (2003). These estimates are similar to the estimates applied to the NSDUH data, so the estimates seem credible.

Dividing these price estimates into the expenditure estimates leads to estimates of metric tons of use between 2000 and 2003. The estimates by year (uncertainty intervals in parentheses) are 5,113 (3,862–6,364) for 2000; 4,824 (3,723–5,925) for 2001; 3,751 (2,813–4,688) for 2002; and 4,130 (3,083–5,117) for 2003. These estimates are in the same range (about 5,000 metric tons) as estimates from the NSDUH.

2.2.4 Comments: NSDUH-Based Estimates vs. ADAM-Based Estimates

The NSDUH-based estimates and the ADAM-based estimates are remarkably similar for 2001–2003, the only years for which comparisons are possible. They are based on different data and used different estimation procedures. The fact that they are close leads to a conclusion that Americans probably spend somewhere near $30 billion per year and purchase close to 5,000 metric tons of marijuana per year. Given the variation about the regression lines as reported in these figures, it surely would not be surprising if the true number were 4,000 to 6,000 metric tons and $25 billion to $35 billion dollars. Indeed, the uncertainly interval could be stretched beyond those confines.

2.3 Other Estimates

Others have provided estimates of marijuana use from both the demand-based (the method used in this report) and the supply-based perspective. This section cites some of that literature and compares those findings to the estimates above.

2.3.1 Other Demand-Based Studies

Using the NSDUH, but applying an entirely different estimation methodology, Kilmer and Pacula (2009) estimated that Americans used between 1,317 and 6,134 metric tons of marijuana during 2005. Their best estimate was 2,948. Using a procedure suggested by researchers at Rand (Kilmer, Caulkins, Pacula, MacCoun, & Reuter, 2010, p. 18) leads to estimates that Americans used about 3,300 metric tons of marijuana during 2006–2007. These estimates are lower than those reported in this study.

2.3.2 Supply-Based Estimates

The National Drug Intelligence Center (2010) has concluded (from note 16 on page 36): “No reliable estimates are available regarding the amount of domestically cultivated or processed marijuana. The amount of marijuana available in the United States—including marijuana produced both domestically and internationally—is unknown. Moreover estimates as to the extent of domestic cannabis cultivation are not feasible because of significant variability in or nonexistence of data regarding the number of cannabis plants not eradicated during eradication seasons, cannabis eradication effectiveness, and plant yield estimates." A companion report to this current study reaches the same conclusion (*Drug Availability Estimates in the United States*, ONDCP, 2011).

2.4 Conclusions

The National Survey on Drug Use and Health provides an excellent source of data for estimating use and expenditures on marijuana. Using the NSDUH to directly estimate tonnage is questionable because users appear to have difficulty reporting grams purchased. Reports of dollar expenditure appear to be more reliable and can be converted into tonnage with suitable retail price estimates. Deriving suitable price estimates is a problem, however, because there is no probability-based survey of prices and using the best available data from the System to Retrieve Information from Drug Evidence raises validity and reliability challenges (Manski et al., 2001). Estimation has to adjust self-reports for underreporting, and this is uncertain, both because available estimates of underreporting are uncertain (Harrison et al., 2007) and because underreporting may vary over time with the social acceptability of marijuana use (Manski et al., 2001), while adjustments must be based on a point estimate from a single point in time.

It is, therefore, comforting that estimates based on the NSDUH agree broadly with estimates based on data from the ADAM survey. This agreement is especially important for reasons clarified in the next chapter. That chapter provides estimates for cocaine, heroin and methamphetamine that are primarily based on ADAM data. There are few good alternative estimates of cocaine, heroin and methamphetamine use, so there is no direct way to investigate the validity of using ADAM data to estimate cocaine, heroin and methamphetamine use. An indirect way is to argue that the same estimation procedure appears to work for estimating marijuana use, providing some reassurance that ADAM-based estimation procedures work for cocaine, heroin and methamphetamine as well. The next chapter turns to estimating the prevalence of users, the expenditures they make, and the tonnage they use for these three illicit drugs.

Chapter 3:
Cocaine, Heroin and Methamphetamine

The previous chapter provided estimates of the number of Americans who use marijuana, their expenditures on marijuana, and the tonnage of marijuana that they use. This chapter provides comparable estimates for cocaine, heroin and methamphetamine. Putting these three drugs together is convenient because the estimation methodology is the same for all three.

As a preview, Table 3.1 provides estimates of the number of Americans who used cocaine, heroin and methamphetamine once per week or more often. This chapter will report considerable uncertainty surrounding prevalence estimates for chronic users[29] but there are discernible trends: There is a small but statistically significant increase in chronic cocaine users. This conclusion is based on a linear trend from 2000 through 2006. Most of this increase appears to occur early in the seven-year period and the estimates seem to remain near 2.8 million for the last four years. There is a small but statistically significant linear decrease in chronic heroin use. There is a large, statistically significant linear increase in methamphetamine use. Trends in occasional users (not shown in the table) are more difficult to judge, but occasional users account for a small proportion of expenditures.

Table 3.1: Chronic Users of Cocaine, Heroin and Methamphetamine: 2000–2006 (Thousands)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	2,578	2,661	2,634	2,812	2,823	2,775	2,777
Heroin	961	939	975	946	900	844	841
Methamphetamine	823	850	887	1,017	1,165	1,272	1,334

Source: Table 3.11.

Table 3.2 reports estimates of expenditures on cocaine, heroin and methamphetamine. Considerable uncertainty surrounds these estimates.[30] Trends in expenditures are parallel to trends in chronic drug use because chronic drug users account for most of illegal drug sales.

Table 3.2: Total Expenditures on Cocaine, Heroin, and Methamphetamine: 2000–2006 ($ Billions)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	$34.6	$35.0	$35.9	$40.1	$37.2	$37.9	$37.8
Heroin	$11.9	$12.3	$12.7	$12.1	$11.5	$10.8	$11.0
Methamphetamine	$11.7	$11.6	$12.5	$13.4	$15.7	$17.4	$17.9

Source: Table 3.17.

Table 3.3 provides estimates of tonnage of use. Consistent with trends in chronic drug use, tonnage use of heroin has remained fairly constant while tonnage use of methamphetamine has increased.

29 The standard error for chronic cocaine users is about 220,000. For heroin, the standard error is about 130,000 and for methamphetamine it is about 60,000.

30 The standard errors for expenditures are roughly $7.1 billion for cocaine, $1.8 billion for heroin, and $1.4 billion for methamphetamine.

Inconsistent with trends in chronic cocaine users, the estimated tonnage use of cocaine has increased markedly. This increase in tonnage of use is consistent with (and in fact caused by) a decrease in the price per pure gram for cocaine over much of this seven-year period. That is, by spending the same amount of money, users were able to purchase more pure cocaine. A companion report (*Drug Availability Estimates in the United States*, ONDCP, 2011) shows that cocaine seizures have increased over this period. If seizures are roughly proportional to the amount of cocaine shipped to the United States, then increased seizures imply increased shipments, which would partly explain decreasing real prices (e.g., price per pure gram). However, the companion reports will also show that cocaine production estimates are not increasing over this period, so in this regard product estimates are inconsistent with production estimates.

The tonnage of heroin use is surprisingly high given estimates of the apparent supply of heroin to the United States. However, all the tonnage estimates have considerable uncertainty.[31] Furthermore, the companion report shows that trends in production are broadly consistent with trends in consumption over this seven-year period. The companion report shows that both levels and trends in methamphetamine use are broadly consistent with supply-based estimates.

Table 3.3: Drug Consumption: 2000 through 2006 (Metric Tons Pure)

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Cocaine	254.6	228.0	252.5	336.6	346.2	371.7	389.6
Heroin	31.8	31.4	32.6	32.1	29.2	26.9	27.6
Methamphetamine	65.5	72.1	88.8	117.7	142.8	167.4	157.3

Source: Table 3.20.

The rest of this chapter is organized by the major steps required to construct Tables 3.1 through 3.3. Section 3.1 explains estimates of the number of chronic and occasional drug users. Section 3.2 explains estimates of expenditures on cocaine, heroin and methamphetamine. Section 3.3 explains how expenditure estimates were converted into tonnage of use. The final section concludes.

3.1 Drug User Prevalence in the United States 2000–2006

This section estimates the prevalence of drug use for three populations: adult chronic users (3.1.1), juvenile chronic users (3.1.2) and occasional users (3.1.4). Detailed calculations appear in appendices.

3.1.1 Adult Chronic Drug Use

Adult drug use and juvenile drug use are estimated with different methodologies due to different data sources. The Monitoring the Future survey (MTF) provides data about drug use by juveniles (8^{th}–12^{th} grade) while several sources are used to estimate adult drug use. The Arrestee Drug Abuse Monitoring (ADAM) survey provides data for the period 2000 through 2003. Data from the Treatment Episode Data Set (TEDS) is used to supplement ADAM data when ADAM data are incomplete or unavailable.

31 The standard error for cocaine is about 70 metric tons. For heroin it is about 5 metric tons and for methamphetamine it is about 12 metric tons. These estimates do not take into account uncertainty about price estimates, a component part of the tonnage estimates.

Using ADAM Data to Estimate Adult Chronic Drug Use: 2000–2003

The methodology for estimating the number of chronic drug users in a county is based on data from the ADAM survey. The ADAM survey asks questions that can identify an arrestee as an adult male chronic drug user. Because ADAM is a probability sample of male arrestees, ADAM leads to probability-based estimates of the number of arrests of adult male chronic drug users during a specified year in a specific county, and Abt researchers have developed a procedure for generalizing the ADAM sample from the population of arrestees to the population of heavy drug users in the county.

The methodology for estimating chronic drug users in the county uses the ADAM 12-month calendar to estimate the rate at which chronic drug users in the county get arrested and booked into jails where they are eligible for ADAM interviews. The calendar is a month-by-month retrospective synopsis of major events occurring during the most recent year in the life of the respondent: arrests, treatment admissions, homelessness, level of drug use, etc. To show how the calendar leads to estimates of chronic drug use in the county, let A be the number of arrests of chronic drug users; let R_A be the rate at which chronic drug users are arrested; let C be the number of chronic drug users in the community. Then if C chronic drug users generate an average of R_A arrests per year, they will cause A arrests:

$$A = CxR_A$$

Given estimates of A based on the ADAM sample and R_A based on the ADAM calendar, an estimate of C is:

[3.1] $$\hat{C} = \frac{\hat{A}}{\hat{R}_A}$$

where the "^" denotes an estimate.

ADAM is based on self-reports and confirmatory urine testing, and estimation requires adjustment for underreporting. Furthermore, estimates based on male arrestees require extrapolation to females. Finally, the Abt team used **ratio estimation** to extend estimates for the ADAM sites to estimates for the rest of the country for 2000 through 2003. Although calculations are complex, the logic is simple. Let C_{ADAM} represent the number of chronic users in counties with ADAM programs, and let $C_{NOT\ ADAM}$ represent the number of chronic users in counties without ADAM programs. Let T_{ADAM} represent the number of treatment admissions in counties that have ADAM programs and let $T_{NOT\ ADAM}$ represent treatment admissions in counties that lack ADAM programs. Based on procedures described above, estimates are available for C_{ADAM}, and based on data from the National Survey of Substance Abuse Treatment Services, estimates are available for T_{ADAM} and $T_{NOT\ ADAM}$. Therefore, a national estimate of chronic drug use for 2000 through 2003 comes from:

[3.2] $$\hat{C}_{NO\ ADAM} = \frac{\hat{T}_{NO\ ADAM}}{\hat{T}_{ADAM}} \hat{C}_{ADAM}$$

By applying this methodology to ADAM data for 2000 through 2003, the Abt Associates researchers produced estimates of adult chronic drug users. Details appear in a series of appendices.

Section A.1 of Appendix A explains how the ADAM data lead to estimates of the number of chronic drug users in the ADAM sites (C_{ADAM}). Appendix B provides details about data assembly and data cleaning to derive T_{ADAM} and $T_{NO\ ADAM}$. Appendix C identifies the precise formula used for ratio estimation (formula [3.2]). Estimates for adult chronic drug users are reported in Table 3.4 for 2000 through 2003.

Table 3.4: Adult Chronic Users of Cocaine, Heroin, Methamphetamine and Marijuana: 2000–2003 (Thousands)

		2000		**2001**		**2002**		**2003**	
Cocaine		2,433		2,516		2,466		2,614	
	range	1,997	2,869	2,080	2,951	2,030	2,902	2,179	3,050
Heroin		816		794		807		748	
	range	569	1,062	547	1,042	560	1,054	501	994
Methamphetamine		690		717		754		907	
	range	581	800	608	825	645	863	797	1,016

Note: Uncertainty intervals equal plus or minus two standard errors.

Even at this stage in the estimation, the estimates reflect considerable uncertainty. The standard error for estimates of chronic cocaine users is about 218,000. For chronic heroin users it is about 123,000 and for chronic methamphetamine users it is about 55,000.

Using TEDS Data to Estimate Adult Chronic Drug Use in 2004–2006

A limitation of the ADAM-based methodology is that the collection of ADAM data stopped in 2003 and the collection of ADAM II data only restarted in ten counties during 2007. Developing estimates for 2004 through 2006 requires projecting the 2000–2003 adult chronic user estimates forward. This section describes that methodology, which uses both the ADAM data and the Treatment Episode Data Set (TEDS) data. Appendix D provides details.

Presuming that only serious or chronic users enter substance abuse treatment, the number of adult chronic drug users can be counted as they enter treatment using the TEDS data. If C adult chronic drug users generate an average of R_T treatment admissions per year, then during a year there will be:

$$T = CxR_T$$

treatment admissions. Estimates of T and R_T, then, lead to estimates of the number of adult chronic drug users according to the formula:

$$\hat{C} = \frac{\hat{T}}{\hat{R}_T} \qquad [3.3]$$

Formula [3.3] provides the estimation approach used for this report because credible estimates of T and R_T are available. The source is identified below.

Adult Treatment Admissions According to TEDS: Estimating T

TEDS provides counts of the number of adult users (18 and older) who enter substance abuse treatment for 2000 through 2006. These counts probably underestimate treatment admissions because TEDS' coverage is not comprehensive of all treatment programs, although it does include those that received public funding for providing treatment services. Consequently, TEDS-based estimates are likely to underestimate the number of chronic drug users who enter treatment. Somewhat offsetting this downward bias, at least some and perhaps many treatment admissions are sequential (detoxification to outpatient and inpatient to outpatient), but counted as two entries (two people) in TEDS. Although the TEDS data collection protocol attempts to minimize such double counting, some undoubtedly still exists. It is unlikely that these two biases perfectly offset each other.

TEDS allows separate tabulations of outpatient and inpatient treatment episodes. For reasons explained in Appendix D, this study derives admissions rates R_T for outpatient treatment for chronic users and formula [3.3] uses outpatient treatment admissions.

TEDS also provides separate tabulations of treatment admissions for males and females. Therefore, a further refinement of formula [3.3] comes from distinguishing between treatment admissions for men and women, an important step because most ADAM sites also collected questions about entering substance abuse treatment from a non-probability sample of woman arrestees. For study purposes, the survey of woman arrestees is treated as if it were a simple random sample.[32]

Finally, TEDS allows separate tabulations by drug of abuse. TEDS identifies the primary, secondary and tertiary drug of abuse reported by the client at the time of admission. This study distinguishes admissions for cocaine, heroin and methamphetamine. An admission is for cocaine if cocaine is identified as the primary or secondary drug.[33] Similar rules apply for heroin and methamphetamine.

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[32] The ADAM sampling procedures for males assure that the sample is reasonably balanced, so that weighted and unweighted estimates are similar. This is not necessarily true for the female sample. One justification for believing that an unweighted sample of females, nevertheless, provides estimates with small bias is that the female samples are essentially take-every samples. Unfortunately, they are only take-every samples during the periods when interviewers are stationed at the jails, so they may be unrepresentative for women booked into jail at other times.

[33] The justification is that using the primary and secondary drug of abuse leads to TEDS-based estimates that were closest to the ADAM-based estimates for 2000–2003. When the tabulations included tertiary drug of abuse, the TEDS-based estimates were higher than the ADAM-based estimates. The differences are not large, however, as most treatment admissions for the drugs of interest are primary or secondary.

Table 3.5 shows a tabulation of the number of adult outpatient treatment admissions by year for three drugs and by sex.[34] This table provides estimates of T that enter the numerator of a refined version of equation [3.3].

Table 3.5: Number of Adult Outpatient Treatment Admissions by Drug, Gender and Year (Drug either Primary or Secondary at Admission)

Outpatient	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Cocaine							
Male	144,053	141,220	151,989	155,448	157,215	155,498	155,376
Female	99,343	96,342	100,113	102,128	105,528	104,558	103,223
Totals	243,396	237,562	252,102	257,576	262,743	260,056	258,599
Heroin							
Male	104,377	105,621	107,144	100,510	96,965	92,258	89,904
Female	57,546	57,262	58,263	56,267	54,091	51,682	49,570
Totals	161,923	162,883	165,407	156,777	151,056	143,940	139,474
Methamphetamine							
Male	28,848	36,816	50,363	54,502	58,976	65,505	70,631
Female	26,055	30,677	37,472	41,599	47,087	53,988	56,534
Totals	54,903	67,493	87,835	96,101	106,063	119,493	127,165

Reviewing outpatient treatment admissions shows trends for each of these drugs. Treatment admissions for cocaine have remained relatively constant during this seven-year period. Treatment admissions for heroin have fallen slightly toward the end of the period. Treatment admissions for methamphetamine have grown markedly and almost continuously over the seven years, although the proportionate increase was smallest for 2006 (6 percent vs. an average of 17 percent for earlier years). If treatment admissions are roughly proportional to chronic drug use, these trends imply that cocaine use has remained roughly constant, that heroin use may have decreased, and that methamphetamine use has increased. Of course a shortcoming of these trends is that they do not account for changes in the availability of treatment, so the trends may mask a change in the ratio of treatment admissions to chronic drug users. This issue is discussed later, where the conclusion is that treatment availability has remained constant over this period.

[34] These are treatment admissions not drug users because a single user may have entered treatment more than once during the year. A single user may be represented in more than one row, for example if he or she had cocaine as the primary drug of admission and heroin as the secondary drug. The estimation methodology requires that T be treatment admissions not a count of admitted drug users; it requires that chronic drug users be counted for each drug they use. Thus the methodology used to tabulate these data is consistent with the methodology used to estimate chronic users.

Admission Frequency According to ADAM: Estimating R_T

Data from the ADAM calendar lead to estimates of the rate at which users in the adult arrestee population generate treatment admissions, the denominator of equation [3.3].[35] Using weights developed in a separate study, these estimates generalize the rate of treatment admissions for adult male arrestees to the general population of drug users. For females, the estimates are assumed to approximate the admission rates for chronic drug users in the general population, because the separate study did not develop weights for females. ADAM counties provided estimates of outpatient treatment admission rates for males and for females for each of three drug types: cocaine, heroin and methamphetamine. The study estimated a national average for each of these three county-specific estimates using as weights the distribution of chronic adult male drug users across the ADAM sites.[36] The rates required some adjustments because the admission rates across ADAM sites sometimes appeared to be higher and sometimes appeared to be lower than admission rates across non-ADAM sites. Appendix D explains the adjustment. Table 3.6 reports adjusted estimates. For example, on average a chronic male cocaine user generates 0.118 outpatient treatment admissions per year.

Table 3.6: Estimated National Rate of Treatment Admissions per Year for Adult Chronic Drug Users Based on ADAM Calendar Data Adjusted Using TEDS Data

	Outpatient
Cocaine	
Male	0.118
Female	0.114
Heroin	
Male	0.156
Female	0.299
Methamphetamine	
Male	0.069
Female	0.098

ADAM data are unavailable for 2004 through 2006. In order to develop estimates for those years, this study must either assume a constant treatment admission rate for those years or estimate a trend. Treatment admission rates are assumed to remain constant, with the following evidence supporting this assumption. Though ADAM data are unavailable for this time period, the NSDUH provides evidence of trends. (See Appendix E.) From the NSDUH, the study estimated the rate at which chronic drug users

35 The base includes all arrestees who said they had used cocaine, heroin or methamphetamine sometime during the year before being arrested; that is, for cocaine treatment admission rates, data pertained to offenders who said they had used cocaine during the last year. Similar selection rules applied to heroin and methamphetamine users. The definition of chronic users for these calculations differs from the earlier definition, because treatment admissions apply to the last year and thus a definition of chronic use as frequent use during the last month will not work. Instead, for this narrow purpose, chronic users are defined as individuals who used a drug two or more times per week in any of the last 11 months in the ADAM calendar. This definition is driven by the way that ADAM records data.

36 If site A had twice as many chronic drug users as site B, then site A received a weight that was twice as large as that of site B.

report entering substance abuse treatment during the year of the survey. For this purpose, a chronic drug user is someone who used the specified drug on four or more days during the month before the interview. The results of these tabulations are shown in Table 3.7. After averaging 2002 and 2003 for cocaine (to account for changes in survey methodology), there is no evidence that treatment admissions for cocaine changed materially between 2002 and 2006. The picture is less clear for heroin, but the confidence intervals (not shown in the figure) are sufficiently wide that year-to-year variations in the estimates are not significantly different from each other. Data are too sparse for methamphetamine treatment admissions to provide any useful inferences.

Table 3.7: NSDUH Calculations of Chronic Drug Users and Treatment Entry

	2002	2003	2004	2005	2006
Cocaine					
Treated	157,346	57,309	128,801	120,496	137,512
Number chronic	790,440	758,451	895,454	807,761	925,631
Proportion treated	0.199	0.076	0.144	0.149	0.149
Heroin					
Treated	36,624	22,799	51,619	26,818	132,696
Number chronic	114,316	91,031	118,041	84,214	229,121
Proportion treated	0.320	0.250	0.437	0.318	0.579

Note: All estimates are computed using NSDUH sample weights.

There is another way to check that admission rates have remained constant. TEDS reports the number of all prior treatment admissions for individuals entering treatment facilities.[37] If there were trends in admission rates, the average number of prior treatment admissions should change slowly over time. That does not appear to happen.

Finally, ADAM data are available for 2007 for ten ADAM II sites. Have treatment admission rates changed across time over those ten sites? Over these ten ADAM II sites, adult male drug users generated 0.0717 outpatient treatment admissions per year during 2007 and about 0.0852 outpatient treatment admissions per year during the period 2000 through 2003. The same group generated 0.197 inpatient treatment admissions per year during 2007 and about 0.142 inpatient treatment admissions per year between 2000 and 2003. Both of these differences in treatment admissions are within the 95 percent confidence interval and thus are not statistically significant.

Combining TEDS and ADAM Data to Estimate Chronic Drug Use

All the elements are now in place to calculate the number of adult chronic drug users as described in equation [3.3]. The number of chronic users is calculated by dividing the number of adult treatment admissions by the rate at which chronic users are admitted. This calculation was repeated for each of the three drugs: heroin, cocaine and methamphetamine. Estimates based on outpatient treatment

[37] This study experimented with using the prior admission variable for the denominator of equation [3.3]. There are two principal problems. The first is TEDS provides no way of estimating the length of the drug use career, so there is no credible way to convert the number of treatment admissions into rates of treatment admissions. Second, even if that conversion were possible, estimation requires an estimate of the current (last year) rate of admissions not the lifetime rate. The study abandoned an attempt at estimating treatment admission rates using TEDS data.

admissions are reported in Table 3.8. Estimates based on inpatient treatment admissions differ from those based on outpatient treatment admissions. Appendix D explains why estimates based on inpatient treatment admissions are less credible than estimates based on outpatient treatment admissions.

Table 3.8: Estimates of the Number of Chronic Drug Users

	2000	2001	2002	2003	2004	2005	2006
Cocaine							
Male	1,221,791	1,197,763	1,289,101	1,318,438	1,333,425	1,318,862	1,317,828
Female	873,930	847,530	880,703	898,430	928,340	919,807	908,062
Totals	2,095,721	2,045,293	2,169,804	2,216,868	2,261,765	2,238,669	2,225,890
Heroin							
Male	668,584	676,552	686,308	643,814	621,107	590,956	575,877
Female	192,418	191,468	194,815	188,141	180,865	172,810	165,748
Totals	861,002	868,020	881,123	831,955	801,972	763,766	741,626
Methamphetamine							
Male	415,618	530,415	725,588	785,220	849,677	943,742	1,017,593
Female	266,013	313,202	382,577	424,712	480,742	551,199	577,193
Totals	681,631	843,616	1,108,165	1,209,932	1,330,420	1,494,941	1,594,786

Table 3.9 compares the original adult chronic user estimates from Table 3.4 with the chronic user estimates based on outpatient treatment admissions from Table 3.8. It also reports an "adjusted trend," explained below.

Table 3.9: Final Estimates of Adult Chronic Drug Users of Cocaine, Heroin and Methamphetamine (Thousands)

	2000	2001	2002	2003	2004	2005	2006
Cocaine							
ADAM-based	2,433	2,516	2,466	2,614			
TEDS-based	2,096	2,045	2,170	2,217	2,262	2,239	2,226
Adjusted	2,433	2,516	2,466	2,614	2,660	2,633	2,618
Heroin							
ADAM-based	816	794	807	748			
TEDS-based	861	868	881	832	802	764	742
Adjusted	816	794	807	748	737	702	682
Methamphetamine							
ADAM-based	690	717	754	907			
TEDS-based	682	844	1,108	1,210	1,330	1,495	1,595
Adjusted	690	717	754	907	1,062	1,193	1,273

The ADAM-based estimates are the same as those reported in Table 3.4. These estimates have also been carried forward without adjustment into the row called *Adjusted*. The TEDS-based estimates are the same as those reported in Table 3.8 based on admissions to outpatient treatment. The TEDS-based estimates are multiplied by an adjustment factor and then carried into the adjusted rows for 2004 through 2006. The adjustment factor is 1.18 for cocaine, 0.92 for heroin, and 0.80 for methamphetamine. The adjustment factors were selected to assure that on average the ADAM-based and the TEDS-based estimates would agree for 2000–2003. These adjusted values are used as a best-estimate throughout the rest of this report.

The ADAM-based and TEDS-based estimates are remarkably close. While this is gratifying, it is also perplexing. Treatment admissions are underreported given the coverage of TEDS, so TEDS-based estimates should be smaller than ADAM-based estimates, but this is only true for cocaine. The closeness of these estimates is also surprising because the ADAM-based estimates for 2000–2003 define a chronic drug user as someone who used cocaine, heroin or methamphetamine on four or more days per month.[38] Presumably the TEDS-based estimates implicitly define a chronic drug user as someone who uses at a level sufficient to lead to treatment. The two definitions may identify a similar set of drug users, but the definitions are not the same.

Table 3.9 does not show uncertainty ranges. However, the uncertainty ranges for 2000 through 2003, as reported in Table 3.4, carry forward into Table 3.9. The uncertainty range for 2004 through 2006 cannot be smaller than the uncertainty range for 2000 through 2003, because no ADAM estimates are available for 2004 through 2006.

Comments

The number of chronic drug users is based principally on ADAM data for 2000 through 2003, as those data provide the most justifiable estimates of chronic drug users. The credibility of the 2004 through 2006 estimates depends on two specific assumptions. First, whatever underreporting occurs in TEDS, underreporting must remain a constant proportion of TEDS reports from 2000 through 2006. There is no independent way of verifying that assumption, but the number of treatment admissions has remained fairly constant during that period, so the assumption seems reasonable. Second, the rate at which chronic users enter treatment has remained constant. Based on the best available evidence—cited above—this assumption also appears reasonable.

The credibility of the 2004 through 2006 trend estimates does not depend on the ratio of treatment admissions to chronic users being correct because the consequences of small errors will be eliminated by adjustments that were made to ensure that ADAM-based and TEDS-based estimates are approximately the same between 2000 and 2003. As noted, it is gratifying that the original ADAM-based estimates and the TEDS-based estimates broadly agree. If that had not been true, one might question whether or not the TEDS-based methodology was adequate for the overall exercise. Nevertheless, the credibility of the 2004 through 2006 estimates depends on getting the trends correct, even if the levels of the TEDS-based estimates are biased.

3.1.2 Chronic Drug Use—Non-Adults

The previous section provided an estimate of the total number of chronic adult drug users in the United States. The next step is to estimate the number of chronic non-adult drug users in the United States. Because ADAM only includes adult users, this study turned to the Monitoring the Future (MTF) survey to estimate chronic drug use for youth. MTF understates drug use for older youth because the survey does not account for youth who leave school. It may also understate drug use for those who remain in school if chronic users are more likely to be absent on the day that the survey is administered. Although these problems are absent in the NSDUH, which also surveys 12–17-year-olds, youth appear to be more willing to report drug use on the MTF survey than on the NSDUH, likely due to the greater anonymity afforded

[38] Many chronic users never go to treatment, but this does not affect the estimates for the same reasons that ADAM-based estimates are not affected by the fact that many chronic drug users avoid arrest.

respondents in MTF (group administered in a school setting) compared with the NSDUH (individually administered in the youth's home).[39] Estimates are reported by drug and by year. The source data are published reports from the Monitoring the Future Study.[40]

The MTF survey reports drug use in categories: no use during the month, 1–2 occasions during the month, 3–5 occasions, and so on. Because the survey does not otherwise distinguish the threshold of 4 or more times per month, this study assumed that two thirds of reports in the 3–5 occasion category were for chronic use, i.e., 4 or more times per month as defined earlier in this report. The MTF survey reports drug use by 8th, 10th and 12th grade students. This study computed a simple average of the proportion of children in each grade who reported using a specified drug on 4 or more occasions per month. It multiplied that simple average by 21 million, roughly the number of youth between the ages of 15 and 19 according to the U.S. Census Bureau.[41]

The study estimated an approximate sampling variance for these prevalence estimates. Let P be the proportion of juveniles who were estimated to be chronic drug users, let N be the sample size, and let DEFF be the estimated design effect. This study set the design effect at 3, which is conservative according to MTF documentation. Given that there are 21 million juveniles, the sampling variance is estimated at (212)x((Px(1-P))/(N/3)). Although the design effect is conservative, the estimate is approximate, especially because it does not reflect any of the uncertainty about dividing the 3–5 days users into 3-day users and 4- to 5-day users, and it does not account for underreporting.

An illustrative calculation is provided in Appendix F. Table 3.10 shows estimates of the estimated number of youth (in thousands) who were chronic users by drug and by year.

Table 3.10: Number of Juvenile Chronic Users (Thousands)

Years	*Cocaine*	*Heroin*	*Methamphetamine*
2001	145	42	133
2002	168	49	133
2003	198	35	110
2004	163	44	103
2005	142	49	79
2006	159	35	61

[39] Youth between 13 and 14 report three to five times as much marijuana use on the Monitoring the Future survey as they do on the NSDUH; youth between the ages of 15 and 17 report about twice as much marijuana use on the MTF survey as they do on the NSDUH.

[40] These reports can be found at http://www.monitoringthefuture.org.

[41] The source is the U.S. Census: http://www.census.gov/popest/national/asrh/NC-EST2006/NC-EST2006-01.xls The actual number of 21,324,186 for children between the age of 15 and 19 in 2006.

3.1.3 Total Chronic Users

The final step for estimating chronic drug users adds the adjusted estimates from Table 3.9 to the estimates from Table 3.10. Results appear in Table 3.11. An uncertainty range appears in a table note.

Table 3.11: Chronic Users of Cocaine, Heroin and Methamphetamine (Thousands)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	2,578	2,661	2,634	2,812	2,823	2,775	2,777
Heroin	961	939	975	946	900	844	841
Methamphetamine	823	850	887	1,017	1,165	1,272	1,334

Note: Extending the procedures discussed regarding Table A.1, a rough uncertainty range for chronic user estimates is ±437,000 for cocaine, ±247,000 for heroin and ±55,000 for methamphetamine. Uncertainty about juvenile consumption is not included. Uncertainty may be larger for the later years.

Ordinary least squares (OLS) regression leads to confidence intervals for trends. OLS seems like an appropriate estimator because the variance in the residual is about the same from year to year. Based on OLS regression, there has been a statistically significant linear trend in cocaine use from 2000 through 2006 ($p < 0.01$). There has been a statistically significant decrease in heroin use over the same period ($p < 0.01$). And there has been a statistically significant increase in methamphetamine use ($p < 0.01$).[42]

3.1.4 Methodology for Estimating Occasional Drug Use

Estimates of the number of occasional users come from the NSDUH. Here an occasional drug user is someone who said that he or she used cocaine or heroin 1 to 3 days during the month before being interviewed. For methamphetamine, the question asks about the frequency of use per week during the previous year. These different definitions are necessitated by the NSDUH wording.

As mentioned earlier, the Office of Applied Studies (OAS) of the Substance Abuse Mental Health Services Administration (SAMHSA) warns that changes to the NSDUH in 2001 and 2002 resulted in a break in the time-series. SAMHSA/OAS provides no adjustment, so prevalence estimates from 2001 and 2002–2006 NSDUH data are not directly comparable.

It is likely that occasional users underreport to the NSDUH, but the level of that underreporting is uncertain. Excluding marijuana use, estimates for underreporting comes from Fendrich et al. (1999) in a study of populations in selected Chicago neighborhoods. Based on hair bioassay, the authors report that "…toxicological results were nearly five times the survey-based estimates for past month use ..." for cocaine. Although they reported that respondents were more willing to report heroin use, their heroin sample was small. The Fendrich estimates presumably include chronic and occasional users. Since the Fendrich estimates come from a single study in a specific sample, they may not generalize.

[42] One must be concerned about applying inferential statistics to seven data points. One problem is that ordinary least squares regression has known asymptotic properties, but the use of only seven data points requires assumptions about small sample properties. These are only known if the distribution of the error terms is normal and spherical. There is no guarantee that the error terms are distributed as normal, or that they are homoscedastic, nor that they are independent over time.

A more recent study by Harrison et al. (2007) estimated truthful reporting by conducting a survey experiment using data from the SAMHSA Validity Study of the NSDUH's predecessor: the National Household Survey on Drug Abuse (NHSDA). Among those who tested positive for the specified drug, 21 percent said they used cocaine in the last 30 days (p. 84), 8 percent said they used opiates in the last 30 days (p. 90), and 10 percent said they had used amphetamines (p. 96).

Table 3.12 reports results by number of days of use because later calculations will use this breakdown. The total rows are the simple total using NSDUH weights. The adjusted rows attempt to account for underreporting by assuming that 25 percent of occasional users will report their use.

Table 3.12: Occasional Users of Drugs 2002–2006 (Thousands of Users per Month)

	Year					
	2002	**2003**	**2004**	**2005**	**2006**	**Average**
Cocaine						
1 day	622	631	504	714	629	620
2 days	298	496	256	293	341	337
3 days	174	296	172	256	236	227
Total	1,094	1,423	932	1,263	1,206	1,184
Adjusted	4,377	5,692	3,728	5,052	4,823	4,734
Heroin						
1 day	21	11	16	13	32	19
2 days	26	14	11	18	24	19
3 days	4	2	3	1	28	7
Total	51	27	30	31	84	45
Adjusted	205	108	120	126	338	179
Methamphetamine						
1 day	52	44	42	51	49	48
2 days	29	83	40	67	66	57
3 days	54	35	38	57	26	42
Total	134	162	120	174	142	146
Adjusted	537	647	480	697	567	585

Notes: The average is the five-year average for cocaine, heroin and methamphetamine. The adjustment weight is 4.

Thus, there were roughly 4.7 million occasional users of cocaine, 179 thousand of heroin, and 585 thousand of methamphetamine. These estimates of occasional drug use have a high but unknown degree of uncertainty because while the NSDUH is a probability sample, there are no confidence intervals for estimates of the truthful reporting rates. Fortunately for this report, chronic users consume the bulk of illegal drugs, so the uncertainty when estimating occasional users has a relatively minor impact on subsequent estimates of expenditures and amounts used.

3.2 Expenditures on Illicit Drugs 2001–2006

Few surveys ask drug users about expenditures on illegal drugs. A notable exception is the ADAM survey, which asked a probability sample of arrestees in 40 counties about buying cocaine, heroin and methamphetamine between 2000 and 2003. This study combines the ADAM responses with estimates of the prevalence of illegal drug use (from section 3.1) to estimate expenditures for 2000 through 2003 and then projects those estimates though 2006. Making projections requires a method for estimating average expenditures for 2004 through 2006 when ADAM data are unavailable.

This section explains the methodology and reports estimates. Technical material appears in Appendix G.

3.2.1 Definition of Expenditures

Throughout this chapter, *expenditures* on illicit drugs means *dollar-equivalent expenditure* on those drugs. Drugs are typically acquired by money exchange, and when that is the case, the dollar expenditure is obvious. At other times drugs are acquired through bartering (trading goods or services for all or part of the drugs acquired), and when that is the case, the dollar-equivalent expenditure for those transactions is less obvious. The approach taken in this chapter is to impute a dollar-equivalent value for bartered transactions based on the dollar price paid for an equivalent quantity of purchased drugs.

Because of price inflation, the value of a dollar decreases over time. A common practice when reporting household expenditures is to increase the dollar value of earlier purchases when comparing expenditures over time. The Consumer Price Index (CPI) is typically used for this purpose because the CPI is adjusted to reflect the price increase in the mix of goods purchased by the average urban dweller. This practice may not apply to chronic drug users and their purchases, because a large proportion of their market basket (as the mix of goods is known) comprises illegal drug purchases—which are not an ingredient of the CPI. This section reports expenditures in terms of *nominal* dollars, although it comments on real dollar expenditures where appropriate.

The next section estimates the amount of drugs used as total expenditures divided by average price paid per pure gram purchased. Provided both expenditures and price are reported in nominal terms, the calculation is appropriate without adjusting for inflation. Therefore, in the next chapter, prices per pure gram purchased are also reported in nominal dollars. An alternative approach would have been to inflate both expenditures and prices by the same amount, but this would have had no effect on the estimated amount of drugs consumed.

3.2.2 Methodology for Estimating Expenditures—Cocaine, Heroin and Methamphetamine

ADAM data are important for developing these estimates because ADAM asks respondents a battery of questions about recent purchasing and bartering for cocaine, heroin and methamphetamine. This study develops a computing algorithm to convert answers to those questions into estimates of monthly expenditures by individual chronic users. It then converts those monthly estimates into national estimates of average expenditures per month for chronic users. Finally, it derives estimates of total expenditures by chronic users during the year by multiplying the estimated average expenditures (reported later in this section) by the estimated number of chronic users by 12 months. Appendix G provides technical details.

The NSDUH asks no questions about expenditures on cocaine, heroin or methamphetamine. Presuming that that average expenditures by household members are equivalent to average expenditures by arrestees conditional on the frequency of drug use, this study uses ADAM to estimate the average expenditure per day by occasional users for cocaine, heroin and methamphetamine. It applies that daily estimate to all occasional users who reported frequency of use to the NSDUH. It then estimates average expenditures for occasional users. This approach probably overstates expenditures by occasional users, but the bias for total expenditures should not be great given that chronic users account for most expenditures.

Estimating Monthly and Daily Expenditures Using ADAM Data

ADAM interviewers ask arrestees if they have purchased or otherwise acquired cocaine, heroin, or methamphetamine during the last month. If the arrestee admits to a recent acquisition, he is asked a series of follow-up questions.

If he says that he *purchased* the specific drug, the interviewer asks him about the price he paid for the last purchase. The interviewer also asks him to estimate the amount of that drug that he received as a result of that purchase. Then the interviewer asks him how many times he purchased that day and on how many days he purchased during the last month. He is also asked whether he used the entire purchase himself or whether he gave some away or sold some.

If he says that he *bartered* to cover some or the entire drug's price, the interviewer asks him to estimate how much he received as a result of the transaction. This study imputes a dollar equivalent value for that reported amount. The imputation is based on the empirical relationship between the price paid and amount purchased given reports by those respondents who actually made cash purchases. For example, if a respondent said that he bartered for 1 gram of cocaine, the imputation might assign a dollar value of $100 for that 1 gram, because respondents who made dollar purchases paid $100 on average per gram. Additionally, the interviewer asks the respondent how many times he bartered during the same day and during the last month, and whether he used the amount himself.

The computing methodology divides respondents into two groups. The *first group* (Own Use) comprised people who said they had purchased or bartered for cocaine (or heroin or methamphetamine) and had used the entire purchase for their own use. The *second group* (Gift/Sold) comprises people who said they had purchased or bartered for cocaine (or heroin or methamphetamine), but had either shared the drug or had sold some. The data are uninformative about the amount given to others and the amount sold, so this study could not use data from the second group directly to estimate how much its members spent on drugs.[43] In some instances, chronic users do not answer the market portion of the ADAM instrument. Those respondents with missing data are also treated as members of the second group.

Using only those respondents from the first group (Own Use), the methodology estimates the dollar value of purchased drugs for the month as the product of price paid for the last purchase times the number of purchases made that same day times the number of days when purchases were made during the last month. The estimated dollar value of bartered drugs is the same except that it substitutes the imputed dollar-equivalent value as the putative purchase price. The dollar-equivalent values for the purchased and bartered drugs are combined for any user who reported both behaviors to yield a *provisional* dollar expenditure estimate for that user. For example, if the respondent said that he paid

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[43] The problem is with sales. Suppose that arrestee A bought $100 worth of cocaine but sold $50 of that purchase to someone else. Then someone else would report a $50 purchase for what is in reality just $100 worth of drugs. Including both purchases would be double counting.

$20 for the last purchase, that he bought 2 times during that day, and that he bought on 10 days during the month, then his provisional monthly purchase is $400 = $20 x 2 x 10.

The provisional estimate is sometimes unbelievably large. The estimation methodology placed an upper limit on expenditures for own use based on the physiological limitations for drug use. If the consumption implied by that expenditure exceeds the physiological limit, that respondent was moved from the first group (Own Use) to the second group (Gift/Sold). The justification for moving a case was that either the respondent misunderstood the question (or was otherwise unable to give a credible answer) or else he actually sold some of the drug, but was unwilling to admit the crime.

Using data for the first group (Own Use), the methodology applies statistical analysis (ordinary least squares regression analysis) to establish the relationship between expenditures on own use and frequency of use during the same month. The dependent variable is the reported expenditure for the month. The independent variable is the number of days of use during the month. The slope is interpreted as the expenditure per day of use. The methodology then uses that estimated relationship to impute the dollar expenditure for everyone in the second group (Gift/Sold) based on the frequency of their drug use.[44]

The methodology repeats the analysis site by site. Methamphetamine use is rare in many ADAM sites east of the Mississippi, and heroin use is rare in other ADAM sites. When there are too few cases for meaningful analysis, ADAM sites are grouped into regional clusters and the analysis is done in clusters. Although grouping probably introduces some inaccuracies, grouping is done where drug use was relatively rare. Consequently, the potential inaccuracies should have little effect on the estimated average expenditure because sites that are grouped contribute little to an estimate that is weighted by the number of drug users in that site.

Table 3.13 reports average monthly expenditures by chronic users for cocaine, heroin and methamphetamine.[45] The "average" is the weighted average across the ADAM sites. The "weights" are the estimated number of drug users in those sites. For example, if there are C chronic drug users across the ADAM sites, and if a site has c chronic drugs users, then that site gets a weight of c/C. When a site

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44 The methodology actually predicted expenditures for both groups. It may seem preferable to use the group 1 estimates directly instead of using predictions based on the regression results. However, the group 1 estimates themselves have an unknown amount of sampling variance, so it would be inadvisable to use those estimates as if they were data points known with certainty. As explained in Appendix G, the estimation methodology used predictions from the regression, combined with econometric logic, to estimate the uncertainty in the group 1 estimates.

45 Estimation was done separately for crack and powder cocaine. The two estimates were weighted by the number of chronic users of crack/powder cocaine to derive an estimate for cocaine.

lacks an estimate for one year, the methodology substitutes the estimate from an available year.[46] The table reports an uncertainty interval based on plus or minus two standard errors.[47]

Table 3.13: Monthly Expenditures by Chronic Drug Users: 2000–2003

		2000		2001		2002		2003	
Cocaine		$979		$960		$1,001		$1,005	
	range	$847	$1,110	$819	$1,101	$866	$1,137	$874	$1,136
Heroin		$1,019		$1,077		$1,072		$1,054	
	range	$808	$1,229	$814	$1,340	$915	$1,228	$907	$1,201
Methamphetamine		$1,101		$1,062		$1,101		$1,022	
	range	$915	$1,288	$883	$1,241	$924	$1,278	$841	$1,204

Note: Uncertainty intervals equal plus or minus two standard errors.

In 2003, a chronic user of cocaine spent $1,005 per month, on average, on his cocaine use. Chronic users of other drugs spent $1,054 per month for heroin and $1,022 per month for methamphetamine. The range of uncertainty is between $874 and $1,136 for cocaine based on plus or minus two standard errors. Table 3.13 reports the uncertainty interval for other drugs. There are at least three reasons why this uncertainty interval understates the width of a probability-based confidence interval. One is that the uncertainty interval pertains strictly to the ADAM sites; ADAM sites may not provide representative estimates for other places that are not ADAM sites. A second reason is that the estimates are for men; women may spend a different amount on average. A third reason is that some chronic users are youths, and their expenditure patterns may differ from the patterns of adults. Roughly four of every five chronic users are adult men, however, so the estimates should be reasonably valid as estimates for the entire country.[48]

The estimates in Table 3.13 are central to all the other estimates in this report, so it is useful to ask: Are they credible? Looking at the same period, Golub and Johnson (2004) reported average monthly expenditures for user groups: $747 for those who use powder cocaine, $982 for those who use crack cocaine, $870 for those who use heroin, $1,813 for those who use powder and heroin in combination,

46 If the estimate was missing from 2000, the methodology substituted the year 2001 estimate. If the estimate was missing from 2003, it substituted the year 2002 estimate. If year T and T+2 estimates were available, and if year T+1 estimates were unavailable, the methodology used the averages from T and T+2.

47 As explained in the appendix, the sampling error arises from three sources: (1) The regression parameter estimates have a degree of uncertainty; (2) ADAM is a sample of male arrestees; and (3) ADAM sites are a sample of counties. To estimate standard errors, ADAM sites were treated as if they were a random sample of counties, and because that is not true, the uncertainty interval is not a traditional confidence interval.

48 The ADAM project assembled a non-probability sample of female arrestees in the ADAM sites but due to the non-probability nature of the sample, tabulations are not necessarily representative of the population of female chronic users or female arrestees. The sampling procedure also implies that the sample is most likely skewed and there is no reasonable way to correct this skew. As a result, the methodology uses estimates for males to represent expenditures for females.

and $1,570 for those who use crack and heroin in combination.[49] Anema and colleagues (Anema, Wood, Weiser, Qi, Montaner, & Kerr, 2010) were concerned with hunger among intravenous drug users in Canada, but they reported that nearly two-thirds of those drug users spent over $50 per day on their use. In the early 2000s, Bennet and Holloway (2004) reported that arrestees across the United Kingdom spent about $859 per months on heroin, powder and crack. These users were both occasional and chronic users. Thus the estimates from others are broadly consistent with the estimates that appear in Table 3.13.

Still, one might question whether users could sustain the level of use—especially for cocaine and methamphetamine—over a long period given the debilitating aspects of using stimulants. In fact users drift in and out of the markets. The same user is unlikely to spend this monthly amount over the course of an entire year because substance abuse is a relapsing condition, so a chronic user one month may not be a chronic user in another month. However, a chronic user who stops being a chronic user is replaced by a chronic user who previously used at an occasional level or did not use cocaine. Therefore prorating the monthly expenditures over the course of a year is an appropriate calculation.

The regression analysis described above provided estimates of daily expenditure on drug use for occasional users.[50] Across the ADAM sites, the average expenditure per day of use for powder cocaine was about $46, and the average expenditure per day of use for crack cocaine was about $56. It appears that crack users spend somewhat more on their daily use, but the differences are not great. Averaging the daily rate for powder and crack yields the estimated $51.39 (plus or minus $2) per day spent by chronic users of cocaine. Heroin users spend about $46.54 (plus or minus $2) per day. Methamphetamine users spend about $62.43 (plus or minus $3.20) per day.

These estimates may be too high. Golub and Johnson (2004) estimated daily rates of expenditures between $20 and $30 for occasional users. However, calculations of expenditures are not especially sensitive to accurate estimates of daily expenditures by occasional users because they do not account for a large proportion of total drug use.

Estimating Expenditures for 2004–2006

Table 3.13 provides estimates of monthly expenditures for 2000–2003, but this study requires expenditure estimates for 2004–2006, and these are not available from ADAM data. Absent any additional information, a best estimate may be that monthly expenditures by chronic users have remained constant between 2004 and 2006. Table 3.14 sets expenditures for 2004–2006 at the average of the estimates for 2000 through 2003. A rough uncertainty range appears in a table note.

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49 The estimates come from manipulating statistics reported in Table 5 to limit expenditures to those deemed to be chronic users. In this context, a chronic user uses on five or more days during the month. This change in definition was necessitated by the way that Golub and Johnson reported their tabulations.

50 The regression parameter associated with days of use during the month was taken as an estimate of daily expenditure amounts. The sampling variance for that estimated parameter was taken as a measure of uncertainty.

Table 3.14: Monthly Expenditures by Chronic Drug Users: 2000–2006

	2000	2001	2002	2003	2004	2005	2006
Cocaine	$979	$960	$1,001	$1,005	$986	$986	$986
Heroin	$1,019	$1,077	$1,072	$1,054	$1,055	$1,055	$1,055
Methamphetamine	$1,101	$1,062	$1,101	$1,022	$1,072	$1,072	$1,072

Note: Extending the procedures discussed regarding Table A.4, a rough uncertainty range for monthly expenditures by chronic user estimates is ±$132 for cocaine, ±$194 for heroin and ±$183 for methamphetamine. Uncertainty ranges may be larger for the later years.

Is this reasonable? One counterargument is that the prices of illegal drugs have changed over time (Fries et al., 2008). Economic theory would argue that users might buy more or less drugs in response to price fluctuations. However, one way to think about expenditures by chronic users is that they spend all residual income (after paying for necessities) on drug use. If that were true, then users would always pay the same regardless of the real price of the drugs that they use.

Is there any reason to believe this to be true? Consider that Fries et al. (2008, p. B-32) show that the price of crack has decreased steadily from $252 per pure gram in 2000 to $188 per pure gram in 2003 when buyers purchase 0.1 to 1 pure grams, and the price of crack has decreased steadily from $153 per pure gram in 2000 to $109 per pure gram in 2003 when buyers purchase 1 to 15 pure grams. Despite this large price decrease, average expenditures on crack cocaine have neither increased nor decreased. Fries et al. (2008, p. B-33) show that the price of methamphetamine has decreased steadily from $212 per pure gram in 2000 to $172 per pure gram in 2003 when buyers purchase 0.1 to 10 pure grams, and the price of methamphetamine has decreased steadily from $138 per pure gram in 2000 to $79 per pure gram in 2003 when buyers purchase 10 to 100 pure grams. Despite this large price decrease, average expenditures on methamphetamine have neither increased nor decreased. The price of heroin has remained relatively constant, so it provides no evidence of how prices affect expenditures. These findings are consistent with an assumption that chronic users spend the same amount regardless of the price per pure gram of cocaine, heroin and methamphetamine.

This is not a satisfying estimate and it may be wrong. A crude way to examine the issue is to use ADAM data from the ten sites that report for 2000–2003 and 2007–2010. (Some of these ten sites missed one or more years from 2000 through 2003.) There is some evidence that monthly expenditures on crack cocaine increased slightly from 2000 through 2003 but decreased from 2007 through 2010. The problem is that ADAM data are unavailable for 2004 through 2006, so there is no way of knowing if average monthly expenditures for crack cocaine were decreasing during 2004 through 2006. The analysis described in this paragraph is only suggestive.

Estimating National Expenditures for Chronic Drug Users

Table 3.8 provided best estimates of the number of chronic drug users for 2000 through 2006. Table 3.14 above provided best estimates of monthly expenditure on illegal drugs by chronic users between 2000 and 2003. Annual expenditure estimates follow from multiplying the former by the latter and then annualizing the result.[51] Table 3.15 reports the resulting estimates of expenditures on cocaine, heroin, methamphetamine and marijuana by chronic drug users. A rough uncertainty range appears in a table note.

Table 3.15: Dollar Expenditures on Cocaine, Heroin and Methamphetamine by Chronic Users ($ Billions)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	$30.3	$30.7	$31.6	$33.9	$33.4	$32.8	$32.9
Heroin	$11.7	$12.1	$12.5	$12.0	$11.4	$10.7	$10.6
Methamphetamine	$10.9	$10.8	$11.7	$12.5	$15.0	$16.4	$17.2

Note: Extending the procedures discussed regarding Table A.5, a rough uncertainty range for estimated dollar expenditures on illegal drugs is ±$6.7B for cocaine, ±$3.7B for heroin and ±$2.4B for methamphetamine. Uncertainty may be larger for the later years

The uncertainty ranges are approximated. The expenditures reported in Table 3.15 come from multiplying the number of chronic users from Table 3.8 by 12 times the monthly expenditures reported in Table 3.14. Think of the calculations as requiring the multiplication of A (chronic users) times B (monthly expenditure) times 12. The standard error for this product is roughly:

$$\sqrt{(2A)^2 VAR(B) + (2B)^2 VAR(A)}$$

Estimating National Expenditures for Occasional Drug Users

Estimates of the amount spent per day of drug use were reported above. Assuming that daily expenditure does not change over time, expenditure estimates follow from multiplying those daily expenditure amounts by the number of occasional users by the number of days that they use per year. The missing link—the number of days of use per month—was reported in Table 3.12.

To calculate expenditures by occasional users, the number of occasional users reported in Table 3.12 is multiplied by the number of days they used per month by the average expenditure per day of use by 12 (the number of months in the year). As reported earlier, estimates are that a day of drug use by an occasional user costs:

- $51.39 per day of cocaine use
- $46.54 per day of heroin use
- $62.43 per day of methamphetamine use

Table 3.16 reports the estimated expenditures by occasional users. The estimates begin in 2002 to accommodate methodological changes in the NSDUH that preclude comparing earlier years with the latter years. Subsequent calculations assume that 2000 and 2001 are the same as 2002. As already noted, these estimates are probably too high, because expenditure during a day of use is probably lower for occasional users than for chronic users.

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[51] This is not to say that the same user would sustain his or her use through the year. For example, a chronic user in January may not be a chronic user in February. However, someone who was not a chronic user in January might become a chronic user in February. The steady state is a constant number of chronic users during the year but the composition of that population of chronic users changes over time.

Table 3.16: Estimated Expenditures on Cocaine, Heroin and Methamphetamine by Occasional Users ($ Billions)

	2002	2003	2004	2005	2006
Cocaine	$4.3	$6.2	$3.8	$5.1	$5.0
Heroin	$0.2	$0.1	$0.1	$0.1	$0.4
Methamphetamine	$0.8	$0.9	$0.7	$1.1	$0.8

Total Expenditures

Computing total estimated expenditures is a simple matter of summing the estimates in Table 3.15 and Table 3.16. An approximate uncertainty range is reported in a table note.

Table 3.17: Total Expenditures on Cocaine, Heroin, Methamphetamine and Marijuana ($ Billions)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	$34.6	$35.0	$35.9	$40.1	$37.2	$37.9	$37.8
Heroin	$11.9	$12.3	$12.7	$12.1	$11.5	$10.8	$11.0
Methamphetamine	$11.7	$11.6	$12.5	$13.4	$15.7	$17.4	$17.9

Note Extending the procedures discussed regarding Table A.5, a rough uncertainty range for estimated dollar expenditures on illegal drugs is ±$6.7B for cocaine, ±$3.7B for heroin and ±$2.4B for methamphetamine. This does add uncertainty about expenditures by occasional users. Uncertainty may be larger for the later years.

Given assumptions that monthly expenditures by chronic users have remained constant over time, the trends in total expenditures are attributable principally to trends in the number of chronic users. The estimates for chronic users of cocaine have remained fairly constant, so expenditures have not changed much. Estimates for chronic users of heroin have decreased slightly, so expenditures have declined, but not by much. The trend toward more methamphetamine users has driven expenditures on methamphetamine from $12 billion to $18 billion over this seven-year period.

3.3 Amount Consumed by Weight

Converting the nation's expenditure on an illegal drug into the weight-equivalent amount of drugs consumed is straightforward given the average price paid per pure gram of drug purchased. For example, if Americans spend $30 billion on cocaine, and if cocaine costs $100 per pure gram on average, then Americans must use 300 million pure grams, which is 300 pure metric tons. Because the previous section has provided estimates of total expenditures, the remaining step is to estimate how much Americans typically pay per unit purchase.

This is not a trivial step. First, drug transactions are not readily observed. Surveys might question respondents about how much they pay for, say, a gram of heroin. But this raises a second problem: Nominal prices for bulk quantities of drugs are fixed, while the purity of that bulk quantity varies. The lower the purity, the higher the real price; the higher the purity, the lower the real price. Given that purity is not directly observable, survey respondents cannot reliably report purchase quality. Prices must be estimated from other sources.

This report estimates the average prices paid for cocaine, heroin and methamphetamine using data from the System to Retrieve Information from Drug Evidence (STRIDE) and the Arrestee Drug Abuse

Monitoring (ADAM) survey. Subsection 3.3.1 explains price estimates. Subsection 3.3.2 applies those price estimates to derive tonnage of use. Appendix H provides technical details.

3.3.1 Prices of Cocaine, Heroin and Methamphetamine

Fries et al. (2008) provide estimates of prices for cocaine, heroin and methamphetamine for the period of interest. This discussion is based on their tables: Tables B-11 (powder cocaine), B-12 (crack cocaine), B-13 (heroin) and B-14 (methamphetamine). Each of these tables presents the average price per pure gram based on the amount of drugs purchased. Fries et al. use two methodologies. The first methodology derives the median price conditional on the purchase being within a quantity range. The second methodology uses regression analysis to construct a price estimate based on a theoretical construct—the expected purity hypothesis.

When estimating prices, it is necessary to distinguish between prices for bulk purchases and prices for pure purchases. For example, a street-level buyer might pay $50 for a gram of cocaine that is 50% pure. The price is then $100 per pure gram. This distinction is essential because nominal prices ($50 in this illustration) tend to remain the same as the purity of cocaine increases and decreases, so there are no large trends in bulk prices. Price per pure gram is a more meaningful metric, because it reflects what buyers pay for what they purchase provided that pure grams are the commodity that ultimately interest buyers.

Table B-12 (from Fries et al.; not shown here) provides an illustration. The table reports the average price for crack by year. There are separate prices for purchases of 0.1 to 1 grams, 1 to 15 grams, and more than 15 grams. For each year/quantity, the table reports two prices; one is the median price for that category and the other is the estimated price based on the expected purity hypothesis.

For present purposes, there are two problems with the estimates. The fundamental problem is that while the table provides an estimate of the average price paid for a drug, this is not the average required for the present analysis. To explain, consider a simple stylized illustration. In this illustration, there are 1,000 buyers. A total of 700 people buy 0.5 pure grams each and pay $160 per pure gram. That is, they purchase a total of 350 grams and pay $56,000. The remaining 300 people buy 8 pure grams each and pay $100 per pure gram. That is, they purchase a total of 2,400 grams and pay $240,000. In total these 1000 buyers purchase **2,750** grams of the drug and they pay **$296,000**.

Some simple algebra establishes that:

$$AMOUNT = \frac{EXPENDITURE}{PRICE}$$

$$2750\, grams = \frac{\$296{,}000}{PRICE}$$

The PRICE that solves this equation is **$107.64**. This is not the average price paid, which equals $142 in this illustration (700x$160 + 300x$100)/1,000. Rather it is a weighted average of prices paid where the weights are the amounts purchased (700x0.5x$160 + 300x8x$100). One cannot recover this weighted average price from the Fries et al. estimates. Another procedure is required.

This observation should not be interpreted as a critique of the methodology used by Fries et al. Their methodology is appropriate for their purpose, which is to estimate the average price and purity of illegal drugs conditional on the amount purchased. However, present needs require estimating the pure amount purchased per price paid and then removing that conditioning using the distribution of prices paid at retail.

STRIDE provides data for estimating the price-purity of cocaine, heroin and methamphetamine. Among other things, STRIDE records undercover drug purchases by the Drug Enforcement Administration, other Federal agencies, and some state and local agencies. It records the type of drug, pure and bulk quantity, dollar prices, geographic area where the drug was purchased, and date of the purchase. By reporting the DEA office, STRIDE indirectly identifies the Metropolitan Statistical Area (MSA) where the purchase occurred.

STRIDE data are assembled for enforcement purposes and are used for domestic intelligence analyses. There is no reason to expect STRIDE to represent illicit drug price/purity without making statistical adjustments, because STRIDE is not a random sample of retail-level purchases, and even the adjustments may prove inadequate. Adjustments required a procedure leading to a national estimate of pure grams purchased per dollar price (PGPR) for cocaine, heroin and methamphetamine. That procedure is detailed in Appendix H and is summarized below.

The approach is to estimate the amount of a drug (cocaine, heroin or methamphetamine) that is purchased conditional on the price paid, when the purchase was made, and where it was made. This is done by estimating a regression with the pure amount purchased as the dependent variable. The explanatory variables are: price paid, quarterly dummy variables representing time in quarter years, and dummy variables representing metropolitan statistical areas where the purchase occurred. Predictions are weighted by:

- The price paid weighted by the amount purchased according to data from ADAM.
- Estimates of the distribution of purchases over metropolitan statistical areas.

The weighted averages are done by quarter and then averaged over the four quarters in a year.

Table 3.18 shows the average prices per pure gram (PGPR) for each year that are used in this analysis (see Appendix H for details on development of these estimates) and these are compared to the standard published price series. Before moving to those calculations, compare the estimates used in this report with the standard published price series (Fries et al., 2008) for the same period.

Table 3.18: Adjusted Price ($ per Pure Gram)

		2000	2001	2002	2003	2004	2005	2006
Cocaine powder	0.1g <= AMT <= 2g @ 0.75g*	$186.37	$194.18	$137.13	$147.54	$134.02	$132.28	$130.37
	2g < AMT <= 10g @ 5g*	$113.14	$93.52	$84.36	$85.80	$73.83	$66.74	$59.98
	WAUSID	$106.69	$119.04	$109.24	$95.84	$88.99	$81.39	$75.97
Crack cocaine	0.1g <= AMT <= 1g @ 0.3g*	$252.41	$226.85	$206.94	$187.91	$178.67	$161.23	$152.71
	1g < AMT <= 15g @ 5g*	$111.59	$101.46	$93.18	$85.98	$83.16	$72.23	$69.64
	WAUSID	$141.63	$160.19	$148.98	$123.83	$111.12	$106.23	$101.37
Cocaine (16.7% powder)	WAUSID	$135.80	$153.32	$142.34	$119.16	$107.42	$102.08	$97.12
Heroin	0.1g <= AMT <= 1 g @ 0.4g*	$457.24	$430.88	$404.44	$405.46	$417.76	$381.45	$386.86
	1g < AMT <= 10 g @ 2.5g*	$300.68	$271.35	$271.02	$265.91	$298.14	$254.49	$265.57
	WAUSID	$375.66	$393.25	$390.26	$376.33	$394.38	$401.84	$399.20
Meth-amphetamine	0.1g <= AMT <= 10 g @ 2.5g*	$212.25	$211.84	$178.62	$171.86	$164.72	$120.29	$165.99
	10g < AMT <= 100 g @ 27.5g*	$158.68	$128.05	$116.14	$95.04	$85.25	$64.33	$95.42
	WAUSID	$178.50	$161.55	$141.14	$113.98	$109.91	$104.13	$114.03

Source: Fries et al. (2008). To obtain prices for cocaine, crack and powder prices were averaged so that crack received a weight of 0.833 and powder received a weight of 0.167. Weighting was determined by the proportion of crack/powder samples in the file.

The standard published price series estimates almost always bracket the estimates developed for this analyses. Where there are exceptions, the exceptions are not large, and they might arise because the estimates average year T with year T-1 in order to reduce the volatility in the trends. Some differences may also arise because the standard published price series estimates were converted to 2007 dollar equivalents, while this study's estimates have not been adjusted using the consumer price index.

Both estimates reflect a large decrease in cocaine prices through most of the seven-year period. This study's estimates show more stability in heroin prices, although this is partly because the standard published price series estimates are adjusted for increases in the price index. Both series agree that methamphetamine prices have fallen for much of this period.

3.3.2 Estimating Metric Tons of Illegal Drug Use

Estimates of metric tons of consumption come from multiplying the estimated amount spent (Table 3.17) by the estimated amount purchased per dollar spent (Table 3.18, WAUSID estimates). The resulting estimates are reported in Table 3.19. An uncertainty range is reported in a table note.

Table 3.19: Consumption: 2000 through 2006 (Metric Tons Pure)

	2000	2001	2002	2003	2004	2005	2006
Cocaine	254.6	228.0	252.5	336.6	346.2	371.7	389.6
Heroin	31.8	31.4	32.6	32.1	29.2	26.9	27.6
Methamphetamine	65.5	72.1	88.8	117.7	142.8	167.4	157.3

Note Extending the procedures discussed regarding Table A.6, a rough uncertainty range for estimated metric tons of use is ±$59.3MT for cocaine, ±8.3MT for heroin and ±28.4MT for methamphetamine. Uncertainty may be larger for the later years.

Averaging across the seven-year period, Americans used about 313 metric tons of cocaine per year, about 30 metric tons of heroin per year, and about 116 metric tons of methamphetamine per year. An uncertainty range can be approximated. In general, the formula for estimating metric tons is:

$$T=1{,}000xE/P$$

Where:

- T is tonnage of drug used (from Table 3.19).
- E is expenditure on the drug (from Table 3.17)
- P is the price per pure gram (from Table 3.18)
- x denotes multiplication

The 1,000 appearing in the formula simply converts the estimates to metric tons. The variance can be approximated as:

$$VAR(T) = 1{,}000^2x(1/P)^2xVAR(E) + 1{,}000^2xE^2VAR(1/P)$$

First, ignore any uncertainty about prices by setting VAR(1/P)=0. This will certainly understate uncertainty, but uncertainty about prices is difficult to figure because it is likely due more to how the DEA assembles its sample than to statistical uncertainty. Second, after ignoring the uncertainty due to estimating drug prices, the remaining uncertainty is attributable to estimates of expenditures.

Although convenient, it is difficult to ignore uncertainty when estimating prices. At the same time, it is difficult to estimate the uncertainty in price estimates because (1) it is unclear how well STRIDE represents retail purchases and (2) the estimates have several components, each of which is measured with uncertainty.

Taken literally, these estimates show an appreciable increase in cocaine consumption. From an estimation formula perspective, this is attributable to a rise in cocaine purity from 2002 to 2006, which decreased the adjusted price per pure gram

These estimates show a slight decrease in heroin use. From an estimation perspective, this can be attributed to lower expenditures, because prices have remained fairly constant. Although ADAM-based estimates of heroin use are unavailable after 2003, the constancy of heroin prices suggests that average expenditure estimates based on 2000–2003 ADAM data approximate average expenditure estimates after 2003.

For methamphetamine, the estimate shows an increase in use and perhaps an end to that trend in 2006. This pattern is attributable to an increase in the number of chronic methamphetamine users. Given the unavailability of ADAM-based expenditure estimates for 2004–2006, when prices were apparently falling, the size of the post-2003 estimates is uncertain, but the large changes are consistent with treatment admissions reported earlier.

3.3.3 Comments on Tonnage of Use

Although Table 3.19 provides best estimates of tonnage of illegal drug use, the estimates suffer from a lack of ADAM data after 2003. How do the demand-based estimates reported in Table 3.19 compare with supply-based estimates of the amount of illegal drugs available to the United States?

A companion report (*Drug Availability Estimates in the United States*) provides comparable estimates of the tonnage of drug use in the United States (ONDCP, 2011). DAEUS estimates and WAUSID estimates are similar with respect to the level of use. (DAEUS estimates for heroin are lower but within the range of uncertainty.) However, trends do not necessarily agree.

DAEUS estimates that cocaine availability has been fairly constant from 2000 through 2006. The WAUSID estimates imply an increase in cocaine use, mainly because of a fall in cocaine prices. Trend estimates reported by the ADAM II Annual Report (ONDCP, 2010) show that across the ten counties that participated in ADAM, cocaine use tended to increase between 2000 and 2003 and then decrease from 2003 levels between 2007 and 2009. The years 2004 through 2006 do not appear in the ADAM II Annual Report but given statistics from 2000 through 2003 and from 2007 through 2009, it seems doubtful that cocaine use could have increased from 2004 through 2006.

DAEUS estimates that heroin availability had decreased from 2000 to 2006. Trends in heroin use reported in Table 3.19 are consistent. Both DAEUS and WAUSID agree about increases in methamphetamine availability.

3.4 Conclusions

A reader might feel the most comfortable with prevalence and expenditure estimates from 2000–2003 because these rest on a relatively rich foundation provided by ADAM data from a large number of counties in the United States. Granted, the estimates require projecting to those counties that lacked ADAM locations, but the availability of treatment episode data, and a presumed rough proportionality of chronic drug use and treatment admissions, provides a credible method for generalizing ADAM results to the entire U.S.

That foundation is weakened by the disappearance of the ADAM survey after 2003 and prior to 2007. Nevertheless, the prevalence estimates are probably not too badly affected provided treatment admission rates remained constant between 2004 and 2006. There is less certainty about expenditures because during a period of apparently decreasing prices for cocaine and heroin, there are no ADAM data to reflect whether chronic drug users changed their expenditure patterns. Best estimates are that chronic drug users spend all their residual income on illegal drug use, but this remains speculation.

The greatest problem is with a lack of statistical collection of drug prices. The best source is DEA's STRIDE data, which is based on forensic analyses of law enforcement specimen collection, but must be used for analyses with caution. The National Research Council (Manski et al., 2001) and others (Horowitz 2001) have warned that STRIDE provides a questionable basis for estimating drug prices. Others (Arkes et al., 2008) have countered that STRIDE provides adequate price series provided an analyst applies methodology similar to that used currently (Fries et al., 2008).

Chapter 4:
Alcohol and Tobacco Estimates

Drug users understate their illegal drug use when questioned on household surveys. For drugs like cocaine, heroin and methamphetamine, truthful reporting is low. For marijuana use, truthful reporting is higher, but many people still deny their use. Underreporting in household surveys is one reason for basing chronic user estimates on ADAM data, because the veracity of reporting is higher among arrestees, especially for chronic users (ONDCP, 2008). Underreporting complicates prevalence estimation because underreporting requires adjustments to self-reported behavior, but the sparseness of self-report studies provides an uncertain basis for making the necessary adjustments.[52]

This chapter reports self-reported estimates of alcohol and tobacco use and compares them with measures based on tax revenues. Although the use of alcohol and tobacco is legal (except for youth), for some the use of cigarettes and the heavy use of alcohol are stigmatized, so the limitations of self-reported use of tobacco and alcohol have some commonality with self-reported use of illegal drugs. Estimating underreporting of legal substances sets a lower bound for the underreporting of illegal drugs, meaning that users of illegal substances probably have even lower truthfulness rates.

This study reviews several sources of data on alcohol and tobacco consumption and selected three for this analysis:

- The National Survey on Drug Use and Health (NSDUH) conducted by the Substance Abuse and Mental Health Services Administration (SAMHSA),
- The National Epidemiologic Survey on Alcohol Use and Related Conditions (NE SARC) administered by the National Institute on Alcohol Abuse and Alcoholism (NIAAA), and
- State and Federal tax revenue information.

The NSDUH and NESARC both provide self-reported estimates of alcohol consumption and smoking frequency. Both surveys pertain to the civilian population living in non-institutionalized housing, including both individual homes and group homes such as dorms. The NSDUH includes 68,000 individuals 12 years old and older, while the NESARC includes 43,000 individuals ages 18 years and older. State sales revenue provides an objective measure of cigarette use; Federal excise revenue provides an objective measure of alcohol use.

Analysis shows that tax data yield higher estimates of consumption than do self-report data. Cigarette use estimates were 10–40 percent lower in survey data than in revenue data, while alcohol use estimates were only a third to half of that estimated through revenue data. The following provides a

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[52] The ADAM survey includes an objective test (urinalysis) to confirm drug use within two or three days prior to the arrestee's interview. The objective test provides useful confirmation for self-reports pertaining to a 3-day and 7 day reporting period, but given the short window of detection for many drugs, it provides less useful confirmation for a 30-day reporting period, which is the period of use of interest to this report. Marijuana and some other drugs of interest (e.g., benzodiazepines) can be detected for up to 30 days.

description of methods and estimates, and where possible, alternate estimates of consumption for further comparison.

4.1 Tobacco Consumption

Self-reported cigarette consumption is estimated using both the National Survey on Drug Use and Health (NSDUH) and the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), for the periods 2002—2006 and 2001/2002[53] respectively.

NSDUH

As a part of the NSDUH, respondents reported:

(A) The number of days, within the past 30 days, that they smoked all or part of a cigarette.
(B) The average number of cigarette they consumed on days when they smoked within the past 30 days.

Thus an individual estimate is calculated by multiplying (A) x (B) x 12.167.[54]

For (A), the survey reported a continuous number. For (B), the survey reported a range (e.g., "less than a cigarette, "1 to 2 days," "3 to 5 days," etc.). When the survey reported a range, estimation used the midpoint of the range as the best approximation of the actual number of cigarettes smoked. Since no bound existed in the response category "more than 35," estimation used a value of 40 cigarettes.[55]

Individual estimates were weighted and summed across all observations to represent a national (and representative) estimate. See Table 4.1 below.

Table 4.1: Cigarette Consumption: NSDUH

Year	*Cigarettes (billions)*	*Packs (billions)*
2002	251.9	12.6
2003	244.9	12.2
2004	250.5	12.5
2005	242.3	12.1
2006	242.1	12.1

53 "2001/2002" indicates a single 12-month period during those two years. The NESARC study is conducted in waves. Data from the second wave, 2004/2005, were not yet available when this report was written.

54 Because there are 365 days in a year, there are slightly more 12 30-day periods in the year. Thirty-day data are multiplied by 12.167 to obtain annual data. Other parts of this report use a multiplier of 12 because illegal drug use was reported on a monthly basis rather than a 30-day basis.

55 The value of 40 was chosen as the truncated midpoint of 36–45, which seems to be a logical range given the ranges immediately preceding this one (6–15, 16–25, 26–35). It is not likely that this specification greatly influences the eventual estimates, particularly because the percentage of respondents reporting this top category is relatively small.

NESARC

The NESARC study, despite primarily being a study of alcohol use, includes several questions regarding tobacco consumption. Continuing to let A and B reference the NSDUH questions, for the NESARC, respondents reported:

> (C) How often they smoked (e.g., "everyday," "1 to 2 times a week," etc.), as a smoker in the past 12 months,
> (D) How many cigarettes they typically smoked during this period (C), and
> (E) How many hours since their last cigarette.

The NESARC questions ask about smoking habits, but not if respondent does not currently smoke. Nevertheless, question (E) allows estimation of consumption for those who smoked earlier in the year, but had quit by the time of the survey. The methodology first estimates the number of cigarettes smoked as if the respondent had smoked for the entire year. This number is then multiplied by the proportion of the year during which the respondent actually smoked, such that:

> *TC* = Total cigarettes as a year-long smoker = (C) x (D),
> *P* = Proportion of the year as a smoker = 1 – E/(8,760 hrs/yr), and
> Total consumption for an individual = *TC x P*.

Thus, if a respondent had not smoked for 6 weeks (1,008 hours), the proportion of the year as a smoker would be defined as

> P = 1yr – 1008 hrs/(8760 hrs/yr) = 88.5%

If the respondent had quit smoking over a year ago, then *P* is set equal to 0 by default. Respondents sometimes reported their consumption as a range. Where possible, midpoint values are used as an approximation of the true value. Where this is not possible, the methodology places a reasonable bound on the open-ended range and imputes a midpoint.

As with the NSDUH, individual estimates are weighted and summed across all observations to reflect a national estimate. This resulted in an estimate of 286 billion cigarettes consumed in the 2001/2002 year.

Table 4.2: Cigarette Consumption: NESARC

Year	*Cigarettes (billions)*	*Packs (billions)*
2001/2002	275.2	13.8

While the NSDUH and NESARC studies show similar results, the NESARC estimate for 2001/2002 is 9 percent higher than the 2002 NSDUH estimate. This is somewhat surprising because NESARC excludes youth (17 years and younger) while NSDUH includes all individuals over 12. Youth under 18 may in fact account for a small percentage of cigarette consumption, so the estimates should be close, but still, the NESARC should result in a smaller estimate of consumption. Part of the difference may simply be attributable to how survey questions are phrased and ordered; of course part of the difference may result from sample variation.

Sales Data

States tax packs of cigarettes sold within the state. If the tax rate is $T and if the state collects $R, then $R/$T is an estimate of the number of packs sold in that state. States also tax alcohol, as does the Federal Government. Federal government revenue is easier to work with, so dividing revenues by the tax rate provides an estimate of alcohol consumption. The complication is that Federal excise taxes vary with the type of alcohol product, and the following discussion details how estimation deals with that issue.

This study gathered data on state excise tax for cigarettes and other tobacco products from multiple sources. The Tax Foundation's table *State Sales, Gasoline, Cigarettes, and Alcohol Tax Rates by State, 1999–2006* includes each state's excise tax rates on cigarettes (per pack) for each calendar year after 1999. State government websites provided tax revenues generated by the sale of tobacco products, most often split into cigarette sales and other tobacco. Tobacco tax revenue is either reported with separate categories for cigarettes and other tobacco products, or as a general category for non-specified tobacco products. This information was gathered from different sources depending on the state: the CAFR (Comprehensive Annual Financial Reports), the Department of the Treasurer, the Department of Revenue, the Office of Accounting, or the Office of the Comptroller. Only state excise taxes are included in the dataset. Federal excise tax is charged to the dealer/supplier and is already factored into the consumer price of the good. Therefore, it is not included in yearly tax revenue reports for tobacco sales.

For the few states that do not distinguish between cigarette and other tobacco revenue, the estimation methodology uses a proportion of their total tobacco revenue attributable to cigarettes. This proportion was estimated as the average percentage based on all states that do report tobacco revenues separately based on product.

Cigarette consumption based upon tobacco expenditures was calculated by dividing the state revenue numbers by the tax per pack. These calculations yield the total number of packs sold in any given year for those states that report cigarette tax revenue. However, state revenue data are missing for some or all of the years 2000–2006. Florida, Minnesota, New Mexico and West Virginia failed to report tobacco tax revenue separately for any year between 2000 and 2006. Data were unavailable for isolated years for the other 46 states. The most common absence of data occurs in 2000 and 2006, as the complete 2006 data are not yet available.

The methodology imputed revenue when it was missing based on a linear regression. The independent variable was the number of adult smokers in a state. Adult cigarette usage data were estimated by multiplying the total adult population (yearly Census data recording ages 18 and older) by the estimated percentage of adults who smoke as taken from the CDC's Behavioral Risk Factor Surveillance System (BRFSS). The dependent variable was the number of packs sold, using all states in a given year for which data were available. Results from the regression were used to impute packs used based on the estimated number of adult smokers when revenue data were missing. Using the imputations to supplement the state consumption data, the analysis yielded an estimate of packs of cigarettes consumed in each year as shown below.

Table 4.3: Cigarette Consumption: State Tax Revenue

Year	*Packs (billions)*
2001	17.3
2002	14.3
2003	16.6
2004	15.8
2005	14.4
2006	13.2

These estimates can be compared to the Federal Trade Commission estimates on total domestic cigarette units sold and given away (Federal Trade Commission, 2007, Table 1a). The FTC estimates differ from this study's estimates in that the FTC estimates include cigarettes given away—between 2 and 11 billion cigarettes annually. In addition, the FTC estimates include cigarettes sold to armed forces personnel within and outside of the United States, thus they represent a larger population than that included in the NSDUH survey. Cigarettes sold at the BX (base exchange) on military bases are exempt from standard cigarette taxes and thus are excluded from this analysis of state tax revenues. For these reasons, the FTC estimates of domestic cigarette consumption are higher than the estimates reported above based on state tax revenues. The FTC estimates are reported below.

Table 4.4: Domestic Cigarettes Sold or Given Away: FTC

Year	*Cigarettes (billions)*	*Packs (billions)*
2001	402.2	20.1
2002	387.4	19.4
2003	367.6	18.4
2004	363.4	18.2
2005	354.6	17.7

Table 4.5 compares estimates of cigarette consumption (by pack) from each of the four sources described above. As expected, the self-reported amounts from both the NSDUH and NESARC are lower than the amounts estimated through state tax revenues or by the FTC.[56] While the stigma against smoking is not as strong as the stigma against use of illegal drugs, there are still some who would wish to underreport their usage. On average, NSDUH survey respondents reported 10–25 percent fewer packs smoked than estimated by state tax revenue and 30–35 percent fewer than estimated by the FTC. Interestingly, underreporting of cigarette use is similar to underreporting of marijuana use.

[56] For comparison, FTC data have been converted to packs assuming 20 cigarettes per pack.

Table 4.5: Comparison of Consumption Estimates of Packs of Cigarettes Consumed

	Source			
Year	***NSDUH***	***NESARC***	***State tax***	***FTC***
2001		13.8	17.3	20.1
2002	12.6	N/A	14.3	19.4
2003	12.2	N/A	16.6	18.4
2004	12.5	N/A	15.8	18.2
2005	12.1	N/A	14.4	17.7
2006	12.1	N/A	13.2	N/A

4.2 Alcohol Consumption

Self-reported ethanol consumption is estimated using both the National Survey on Drug Use and Health (NSDUH) and the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), for the periods 2001–2006 and 2001/02 respectively.

NSDUH

NSDUH data report alcohol consumption in number of drinks rather than volume. However, using the CDC's estimates of a "standard drink,"[57] responses can be converted from the number of drinks consumed to gallons of ethanol as described below.

As a part of the NSDUH, respondents reported:

(A) The number of days a respondent had one or more drinks, and
(B) The usual number of drinks they consumed on days when they drank within the past 30 days.

First, an individual's self-report of the number of drinks in a year is calculated by multiplying (A) x (B) x 12.167. The number of drinks is then converted into total ethanol consumed by multiplying this number by factor of 0.004587 average gallons of ethanol per drink. The final estimate was thus calculated:

Ethanol consumed = (A) x (B) x 0.055810

Again individual estimates are weighted and summed across all observations to reflect a national (and representative) estimate.

[57] Centers for Disease Control, Alcohol and Public Health FAQs, http://www.cdc.gov/alcohol/faqs.htm, accessed December 2007. Standard drinks vary in size depending on type (beer, wine, liquor), but are estimated to contain a uniform amount of ethanol.

Table 4.6: Alcohol Consumption: NSDUH

Year	Gallons of ethanol (millions)
2001	158.79
2002	181.21
2003	182.63
2004	192.82
2005	179.41
2006	190.69

NESARC

The NESARC study, conducted by the National Institute on Alcohol Abuse and Alcoholism, includes a more detailed estimate of consumption. This study only had access to data from the first wave of NESARC, the year 2001/2002. As part of the NESARC, respondents reported individual consumption by type of alcoholic beverage (wine, wine cooler, beer and liquor). For each of these types of drinks, they reported:

(C) How often they drank (e.g., “everyday,” “1 to 2 times a week,” etc.), in the past 12 months,
(D) The typical size of the beverage they drank, and
(E) The average number of beverages they consumed on days when they drank in the past 12 months.

Thus in order to calculate an estimate of individual alcohol consumption, the procedure multiplies (C) x (D) x (E) for each type of beverage, and sums across beverage types. Again where possible, midpoint values are used as an approximation of the true value. Otherwise, a reasonable bound is imposed and the midpoint of the new range is imputed based on the bound. A national estimate resulted from weighting and summing over observations.

Using the NIAAA’s own estimates of national consumption, gallons of each type of alcohol can be converted into gallons of ethanol to facilitate comparison with NSDUH and Federal tax-based consumption estimates. The resulting 173 million gallons of ethanol corresponds very closely to NSDUH’s 170 million gallon average between years 2001 and 2002.

Table 4.7: Alcohol Consumption: NESARC (2001/2002)

Type	*Gallons (millions)*	*Conversion: gallons ethanol/ gallon alcohol*	*Gallons ethanol (millions)*
Wine cooler	182	*0.045*	8
Beer	2,241	*0.045*	101
Wine	229	*0.129*	29
Liquor	84	*0.411*	34
Total	***2,735***		***173***

Sales Data

Although both Federal and state alcohol tax revenues were reviewed, variability in state revenue reporting led to a focus on Federal tax revenue data for these estimates.[58] Federal tax rates were gathered from the Center for Science in the Public Interest and tax revenues were taken from the Tax Policy Center, revenue by type.

Table 4.8: Alcohol Consumption: Sales-Based Estimates (Millions)

	Year	***2001***	***2002***	***2003***	***2004***	***2005***
Beer	Tax revenue	$3,555	$3,651	$3,605	$3,660	$3,643
	Gallons*	6,130	6,295	6,215	6,311	6,281
	Ethanol (gallons)	276	283	280	284	283
Wine	Tax revenue	$667	$707	$751	$768	$807
	Gallons	624	661	702	718	754
	Ethanol (gallons)	80	85	91	93	97
Spirits	Tax revenue	$3,897	$4,040	$4,115	$4,296	$4,451
	Gallons	289	299	305	318	330
	Ethanol (gallons)	119	123	125	131	136
Total Ethanol (gallons)		***475***	***492***	***495***	***507***	***515***

* Based on tax rates of $13.50/100 proof gallon for spirits, $1.07 per gallon wine and $0.58 per gallon beer.

These data can be compared to similar data gathered by the National Institute on Alcohol Abuse and Alcoholism. NIAAA reports per capita consumption of alcohol by type for individuals over age 14.[59]

Table 4.9: NIAAA Estimates of Alcohol Consumption: Gallons of Ethanol Consumed per Capita

	Beer	***Wine***	***Spirits***	***Total***
2001	1.23	0.31	0.64	2.18
2002	1.23	0.33	0.65	2.20
2003	1.22	0.34	0.67	2.22
2004	1.21	0.35	0.68	2.23
2005	1.19	0.36	0.70	2.24

Using population statistics from the Census to estimate population over age 15 and NIAAA statistics on per capita consumption, these per capita estimates are converted to national annual ethanol consumption estimates.

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58 Expenditure-based data gathered on alcohol consumption exclude alcohol sold for export and include imported alcohol. Thus, they should capture domestic consumption fully.

59 National Institute of Alcoholism and Alcohol Abuse, Apparent per capita ethanol consumption for the United States, 1850–2005. (Gallons of ethanol, based on population age 15 and older prior to 1970 and on population age 14 and other thereafter). http://www.niaaa.nih.gov/Resources/DatabaseResources/QuickFacts/AlcoholSales/consum01.htm

Table 4.10: Gallons of Ethanol Consumed Nationally Based on NIAAA Estimates (Millions)

Year	Population	Beer	Wine	Spirits	Total
2001	224,732,707	276	70	144	490
2002	227,470,404	280	75	148	500
2003	230,027,258	281	78	154	511
2004	232,801,657	282	81	158	519
2005	235,755,550	281	85	165	528

Table 4.11 below shows the national estimates from all four sources for comparison. The estimates based on NIAAA's per capita consumption data correspond closely to the data based on Federal tax revenues.[60] However, comparing the sales-based consumption estimates and the self-report estimates, there is a great discrepancy between the two. The estimated ethanol content based on beer sales alone exceeds the estimated consumption based on self-report using either NSDUH or NESARC. How can this be explained?

Table 4.11: Ethanol Consumption in Millions of Gallons: All Sources

Year	Population	Beer	Wine	Spirits	Total
2001	224,732,707	276	70	144	490
2002	227,470,404	280	75	148	500
2003	230,027,258	281	78	154	511
2004	232,801,657	282	81	158	519
2005	235,755,550	281	85	165	528

Few studies have had the opportunity to compare self-reported alcohol consumption to alcohol sales data from the same population. One such study found self-reported volume accounted for only 40 percent of the volume sold. Although the exact percentage of underreporting likely varies with the location, the magnitude of the difference is telling. This differential could arise for several reasons.

- Intentional or unintentional underreporting of number of drinks in the self-report,
- Higher volume per drink consumed than "standard," or
- Higher ethanol content per drink consumed than "standard."

Underreporting of the number of drinks may occur in different groups. Although alcohol intake is not as stigmatized as consumption of illegal drugs, individuals who drink more may underreport their number of drinks. Studies suggest that systematic reporting errors tend to be proportional to level of intake. One further consideration is that a household survey such as the NSDUH may miss those who are at the highest level of drinking. Alcoholics who are under treatment or in transient living arrangements because of their alcoholism or other drug use are less likely to be included in the standard household survey. Given the prevalence of drinking in the adult user population, however, the survey's limited coverage is unlikely to account for much underreporting.

[60] In particular, volumes of beer and wine match fairly closely, but the NIAAA calculation yields higher estimates of ethanol consumed as spirits. This may be due to a difference in the estimated alcohol content in spirits, which varies significantly more than the within-category variation of alcohol content in wine and beer.

Several studies support the point that the volume of drinks actually consumed is much higher than the "standard" drink volume used on surveys. The CDC estimates the standard drink to be 12 oz of beer, 5 oz of wine, or 1.5 oz of hard liquor. A study at Duke University found that college students asked to pour their standard drink size for beer and liquor uniformly poured drinks in excess of the CDC standard. In particular, mixed drinks were 80 percent over standard and beer was 25 percent over standard. A Dutch study of individuals drawn from the general population showed overestimation by 26 percent for spirits, 14 percent for fortified wines, and 4 percent for wine. A more recent study of individuals drawn from Los Angeles and San Francisco urban health clinics showed that frequent drinkers and drinkers of higher alcohol content beverages reported drinking higher-than-average drink sizes. Overall, drinkers asked to estimate the volume of a drink underestimated the fluid ounces by 30 percent. Furthermore, the median sizes consumed of malt liquor, fortified wine, and spirits were three times, four times, and six times the standard size, respectively. The Duke University and California studies focused on populations whose members drink more frequently than other adults, but overall the evidence is clear that drinkers are either unable to accurately estimate drink sizes or routinely drink a greater than standard size drink. Thus, even if all survey respondents to NSDUH and NESARC accurately reported their number of drinks, the volume of drink may be significantly over the standard assumed by the CDC.

In order to compare across alcohol types, all of these volumes have been converted into volumes of pure ethanol. When the ethanol content deviates from the standard, this can also lead to a difference in the total consumed. One study asked a sample of respondents from the National Alcohol Survey (2000) to make their usual drink of choice and measure each alcoholic ingredient with a provided beaker. The weighted mean average ethanol content was higher overall than the average 0.6 oz per drink standard. In particular, the average drink was 0.66 oz ethanol for wine and 0.89 oz for spirits. This higher-than-average ethanol content will also lead to an overall underestimate of national consumption when using the "standard" drink.

Lastly, alcohol consumption varies widely both in the frequency of use and in the type of alcohol consumed. Consumption patterns vary throughout the year, from weekdays to weekends, and between drinking in the home and at other locations. The necessarily limited number of questions on a survey of drinking habits in the last month may be insufficiently detailed to truly measure the range of alcohol consumption patterns in a population. This could, of course, under- or overestimate the amount of alcohol consumed, but certainly contributes to the variability of estimates.

4.3 Conclusions

The analysis of alcohol and tobacco consumption has been included here to give some estimate of the underreporting that occurs when asking respondents to self-report the use of substances for which there is some social stigma although no legal prohibition. Given that there is significant underreporting even for legal drugs such as alcohol, how can one interpret the survey results for illegal drug use?

First of all, it should be noted that alcohol may be a poor substance by which to compare underreporting. As discussed above, much of the underreporting is not due to a desire to conceal, but to an inability to judge the amount of alcohol in an "average" drink. Someone who drinks a large tumbler of alcohol will report this as one drink even if it contains the alcohol of two standard drinks. Thus, this sort of underreporting is different from the underreporting of someone attempting to conceal a drug problem. Using cigarette data as a comparison, one sees underreporting of 10–40 percent compared to sales data for the same period. This provides a comparison point for the underreporting expected for illegal drugs, and as noted above, underreporting of tobacco use is apparently about the same as underreporting of marijuana use.

Some of the apparent underreporting is likely to come from losses in store inventory and other wastage. That amount is unknown, but it undoubtedly exists and causes the underreporting to be overstated.

In order to avoid the problems of underreporting in self-reports, this study used several sources of data to corroborate estimates, and an adjustment factor for underreporting. Estimates for chronic drug users were based on the ADAM survey and TEDS data. Thus they have little incentive to further conceal drug use, and in fact, their truthful reporting rates (ONDCP, 2010) are similar to the truthful reporting rates for alcohol. The TEDS dataset includes aggregate data on treatment admissions for drug use, thus it does not rely upon individuals to report their own use. For marijuana use in which there are fewer treatment episodes, an adjustment factor was used to account for underreporting in the NSDUH survey. As discussed further in chapters 2 and 3, there have been studies of drug self-reporting compared against toxicological testing for drug use. This report estimates that self-reports of cocaine, heroin and methamphetamine use derived from NSDUH should be inflated by a factor of 4; self-reports of marijuana use should be inflated by a factor of 1.25 to 1.35. This is a greater adjustment than would be necessary for adjusting cigarette self-reported use to match cigarette sales data, but this is in keeping with the greater stigma against illegal drug use. By these methods, this study has attempted to reach a reasonable estimate of drug use.

Chapter 5: Conclusions

Estimating prevalence and trends in the number of drug users, expenditures, and tonnage of use is a difficult and uncertain enterprise. Available data tell an inconsistent story, and telling that story requires more assumptions and statistical inferences than is desirable.

The National Survey on Drug Use and Health added a module to the interview on the marijuana market in 2001, and that module has been instrumental in improving estimates of prevalence, expenditures, and tonnage of use for marijuana. Studies sponsored by the Office of Applied Studies have provided credible estimates of underreporting, without which the NSDUH self-reported behaviors would lead to underestimates of marijuana use (Harrison et al., 2007). Still, one has to worry that the point-prevalence estimates of underreporting may change over time (Manski et al., 2001), especially as some states consider changes in law or policy that would lead respondents to have less cause to fear enforcement and stigmatization for truthfully reporting drug-using behavior.

The Arrestee Drug Abuse Monitoring survey is a crucial element in estimating prevalence and expenditures for cocaine, heroin, and methamphetamine. ADAM is the only survey that reaches a large number of heavy drug users. It is the only survey that asks a broad segment of users about market behaviors. The National Institute of Justice's decision to terminate ADAM after the 2003 survey year became an impediment to prevalence estimation, greatly increasing the uncertainty about estimates for 2004 through 2006.

An analyst cannot derive direct estimates of tonnage used based on survey results. This is even true of alcohol where dosage is potentially estimable. For illegal drugs, reporting is even more uncertain, because illegal drugs come in a staggering variety of bundles, and buyers cannot routinely understand the quality (purity) of what they are buying. Without reliable price estimates, the estimation of tonnage used comes to an unsatisfying conclusion.

It is important that specific components of ADAM II must be retained for it to support drug use estimates:

- ADAM II requests a urine specimen and most respondents comply. The urine specimens are instrumental for adjusting self-reported drug use for underreporting. If ADAM were to collect interviews at a later point in the criminal justice process, urine testing would be unavailable as an adjustment for underreporting.
- Applying estimation procedures developed by Rhodes, Kling, and Johnston to arrestee self-reported drug use behavior provides the least biased method for estimating the prevalence of chronic drug use in the community. Estimates using this methodology would be much less certain if a future ADAM II were to interview offenders later in the criminal justice process, simply because the remaining drug users are an increasingly selective sample of chronic drug users.

- By asking about drug use and purchases during the last few days, the last week, and the last month, ADAM reduces the recall period to the recent past. The use of a calendar improves the accuracy of longer recall periods.
- Excluding the NSDUH module for marijuana purchasing, no other national survey asks drug users about market behaviors. Retaining ADAM's market questions is essential for estimating expenditure on illegal drugs. Of course, the market questions could be asked of convicted offenders, but here again the problem is recall by a selective sample. Furthermore, the reports would only be useful if they were asked of very recently incarcerated offenders. Otherwise, the self-reports of incarcerated offenders would be interesting for providing a historical view of drug use but those self-reports could not provide a profile of contemporary drug use.

It is also of concern that the recommendations of the National Research Council to improve price estimates (Manski et al., 2001) have never been implemented.

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Appendix A: Deriving Prevalence Estimates for 2000–2003

This appendix is a technical discussion of applying data from the Arrestee Drug Abuse Monitoring survey and other sources to estimate the prevalence of drug use, expenditures by drug users, and tonnage of use. These estimates pertain to 2000–2003, the only years for which ADAM data were available when these calculations were performed.

A.1 Drug User Prevalence

This subsection provides prevalence estimates of the number of Americans who used cocaine, heroin, methamphetamine and marijuana each year between 2000 and 2003. It is both conceptually and analytically convenient to divide this population into two groups: chronic users and occasional users. It is necessary to further divide it into adults and juveniles.

A.1.1 Methodology for Estimating Chronic Drug Use—Adults

The methodology for estimating the prevalence of chronic drug use among adults (age 18 and older) employs data from the Arrestee Drug Abuse Monitoring System (ADAM), the National Survey on Substance Abuse Treatment Services (N-SSATS), and the Treatment Episode Data Set (TEDS).

To summarize, the methodology requires four steps:

- First, estimate the prevalence of chronic drug users in each county that houses an ADAM program. Let C_A represent the estimated total number of chronic users across all the counties that participate in ADAM.
- Second, identify an indicator variable that is roughly proportional to the number of chronic users in a county, specifically, the number of clinical admissions for substance abuse treatment. Let V represent the total number of substance abuse treatment admissions across the United States, and let V_A represent the number of admissions across the ADAM sites.
- Third, for counties that participate in ADAM, estimate a constant of proportionality between treatment admissions and chronic users. Let $\delta = C_A/V_A$ represent that constant of proportionality, so that there are δ chronic users per treatment admission.
- Finally, the estimate of chronic drug use in the United States is a variation on the equation $C = \delta V$.

This appendix provides a summary. Details appear in other appendices and other sources (Rhodes et al., 2007).

Estimating the Prevalence of Adult Chronic Drug Use in an ADAM County

The ADAM data comprise a random sample of adult male arrestees who were booked into jails and lockups in 39 urban counties. The ADAM samples are typically collected quarterly during two-week periods. Data are available from the beginning of 2000 through the end of 2003, although not all the 39 sites report for each quarter. Interviewers approach sampled arrestees and ask them to answer a 20-minute questionnaire and to provide a urine specimen. The urine is tested to determine whether or not the arrestee used cocaine, heroin or methamphetamine (as well as other drugs not of interest here) during the last two or three days. Urine testing also tells whether or not the arrestee used marijuana during the last several weeks. The results from the urine tests are used to adjust for underreporting. An explanation follows.

The ADAM interviewers ask arrestees about the frequency of their drug use during the 30 days prior to the interview. Answers to the 30-day use question are used here to identify those arrestees who use at or above the chronic user threshold. The ADAM interviewers also ask arrestees about the frequency of being arrested and booked during each month of the year that preceded their current arrest (i.e., the one that resulted in their being interviewed). Using statistical modeling (Rhodes et al., 2007), the arrest rate is estimated as a function of variables (including age, prior arrest history, abused substances, and so on) that were also reported on the ADAM instrument.

Call this estimated arrest rate:

$R(X)$ the estimated arrest rate for chronic drug users who share characteristics X.

This is typically a number like R(X) = 0.5, implying that a chronic users with characteristics X gets arrested about once every two years. A number R(X) = 0.333 implies that a chronic user with characteristics X gets arrested once every three years. These arrest rates were estimated separately for each of the 39 ADAM sites, by year.

The estimate implies that an arrestee, who is a chronic drug user for whom R(X) = 0.5, must represent two chronic drug users with characteristics X (including himself) in the general population. Likewise an arrestee for whom R(X) = 0.333 must represent three chronic drug users (including himself) in the general population. Consequently, in order to estimate the total number of chronic drug users in a county, each chronic drug users with characteristics X in the arrestee population is assigned a weight of W(X), where:

$$W(X) = \frac{1}{R(X)}$$

Were it not for several complications, the sum of W(X) over all arrestees would provide an estimate of the number of chronic drug users in the county that houses the ADAM program.

The first complication is that ADAM comprises a sample rather than a population of arrestees. This seems to be a minor complication because ADAM is a probability sample, so the W(X) are simply inflated by the sampling weights. After adjustment:

$$W(X)' = W(X) \bullet ADAM\ \ SAMPLING\ WEIGHT$$

The second complication is that some chronic drug users will deny their use when questioned in a jail. If a chronic user denies his use, then he would not be identified as a chronic user in the arrestee pool, so he would receive a weight of zero. As a result, the sum of $W(X)'$ would understate the total number of drug users in the county. To deal with this problem, the estimation methodology developed a measure of truthful reporting by chronic drug users: the estimated probability of admitting to use of cocaine, heroin or methamphetamine during the last 30 days conditional on testing positive for cocaine, heroin or methamphetamine. The logic is that someone who tested positive for drug use during the last 2 or 3 days is almost definitely a drug user, and an affirmative report of using drugs during the last 30 days indicates that the respondent is truthful about his use. A similar but separate calculation was performed for marijuana, for which the urine test can potentially identify drug use over several weeks.

The weight is again adjusted, this time to account for denial of drug use, thus:

$$W(X)'' = \frac{W(X)'}{PROBABILITY\ TRUTHFUL\ REPORTING}$$

The third complication is that ADAM is a probability sample of *male* arrestees. There is a female counterpart to ADAM, and although it is not a probability sample, it is treated as if it were representative of all female arrestees to derive an adjustment that accounts for female chronic users. Define the following terms:

- The number of female arrestees (a_F) and male arrestees (a_M) in the county (from Uniform Crime Reports, provided by the Federal Bureau of Investigation);
- The proportion of female arrestees who are chronic users (c_F) and the proportion of male arrestees who are chronic users (c_M) (from the male and female ADAM surveys); and
- The average arrest rate for male chronic drug users (r_M) and female chronic drug users (r_f)[61] (from male and female ADAM surveys).

The weight was adjusted so that:

$$W(X)''' = W(X)''\left[1 + \frac{a_F}{a_M}\frac{c_F}{c_M}\frac{r_M}{r_F}\right] \quad where$$

$$\left[\frac{male\ \ plus\ \ female\ chronic}{male\ chronic}\right] = \left[1 + \frac{female\ chronic}{male\ chronic}\right] = \left[1 + \frac{a_F}{a_M}\frac{c_F}{c_M}\frac{r_M}{r_F}\right]$$

Dividing female arrests by male arrests estimates the number of female arrestees per male arrestee at an ADAM site. This might be a sufficient adjustment if chronic users were as prevalent among males as they are among females, but that is not necessarily true, so the study multiplies by a second adjustment. Given that $a_F c_F$ estimates the number of female chronic user arrestees and that $a_m c_m$ estimates the

61 If females have a lower average arrest rate than males, then female arrestees should account for more chronic drug users in the community that do their male counterparts.

number of male chronic user arrestees, the ratio of the two corrects for gender-based variation in chronic drug use. This would be sufficient if males and females were arrested at the same rates, but that may not be the case. Recalling that W(X) is roughly $1/r_M$ on average across male arrestees, the adjustment is multiplied by r_M and divided by r_F.

The sum of $W(X)'''$ over all male chronic drug users who appear in the ADAM sample within an ADAM site is an estimate of the number of chronic drug users in the county represented by that ADAM sample. That is:

[A.1] $$C = \sum W(X)'''$$

Rhodes et al. (2007) show that the estimation is more complicated than described in this simplified rendition, but this is fundamentally the way that this study estimates the number of chronic drug users in a county that houses an ADAM program.

Estimates were completed for each of four years in every ADAM site that had sufficient data. Some of the ADAM sites reported for fewer than four years. When a year I estimate is unavailable but a year I+1 estimate is available, year I+1 is substituted for year I. When year J is available but year J+1 is unavailable, year J is substituted for J+1. The first and last year estimates for Philadelphia, which were very small compared with 2001 and 2002, were discarded. The presumption was that Philadelphia had serious startup and shutdown problems, so the average from 2001 and 2002 was substituted for the presumably biased year one estimate. There may have been unidentified startup problems in some other sites, but those were not apparent from inspecting the data. Observations from Cook County (Chicago) were also discarded. There was an implausibly large trend toward increased drug use in Cook County, and this trend dominated the estimates because Cook County was much larger than the other ADAM sites. Because the Abt researchers know the difficulty of selecting a random sample of arrestees in Cook County (having been the original ADAM contractor), they suspect that the Cook County sampling plan had never stabilized and that Cook County estimates are unreliable.[62]

Estimating the Prevalence of Adult Chronic Drug Use when ADAM Data are Unavailable

Having estimated the number of chronic drug users for the 39 ADAM sites, the next step is to extend the estimates from 39 sites to the rest of the nation. This approach assumes proportionality between the number of chronic drug users in a county (C) and treatment admissions for drug abuse (V), such that one can predict C from knowledge of V. Some details are reserved for appendices B and C. Appendix B (Identifying an Indicator Variable) explains the choice of treatment admissions as a ratio variable. Appendix C explains the formula for the ratio estimator.

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62 The decision to exclude Cook County at this stage of estimation had important consequences. Had Cook County been included, the number of adult chronic users of cocaine would have been about 11 percent higher in 2000 and 24 percent higher in 2004. Estimates for adult chronic heroin users would have been 42 percent higher in 2000 and 72 percent higher in 2004. Estimates for methamphetamine and marijuana were not much affected. Although the researchers were reluctant to give special treatment to Cook County, these trends were implausible, and they could not ignore their own experience with the inadequacy of the Cook County sampling plans.

Let:

$\hat{C}_A$ represent the estimated total number of chronic drug users across all ADAM sites. This comes from formula [A.1].

V_A represent the total for treatment admissions across the ADAM sites.

$\hat{C}$ represent the estimated number of chronic drug users across the United States.

V_N represent the total for treatment admissions across the United States excluding counties that have ADAM programs.

Then the estimate of C is:

$$\hat{C} = \hat{C}_A \left[\frac{V_N + V_A}{V_A} \right] = \hat{C}_A \lambda \quad \text{[A.2]}$$

This formula demonstrates that the number of chronic drug users in the nation can be estimated by multiplying the estimate of chronic drug users across the ADAM sites by λ : the ratio of total treatment admissions across the nation divided by total treatment admissions across the ADAM sites. This calculation is done on a drug-by-drug basis.

For example, if there were 400 treatment admissions across the nation for cocaine, and if the ADAM sites collectively accounted for 100 treatment admissions, then $\lambda = 4$. Based on the analysis reported in Appendix B, the estimated values of λ are:

- Cocaine: 3.75
- Heroin: 4.19
- Methamphetamine: 3.19
- Marijuana: 5.72

Apparently the ADAM sites account for about one in four chronic cocaine and heroin users, about one in three chronic methamphetamine users, and somewhat fewer than one in six chronic marijuana users.

To specify a formula for the sampling variance, it is convenient to rewrite [A.2] into a mathematically equivalent form:

$$\hat{C} = \hat{C}_A + \hat{C}_A \left[\frac{V_N}{V_A} \right] = \hat{C}_A + \left[\frac{\hat{C}_A}{V_A} \right] V_N = \hat{C}_A + \delta V_N \quad \text{[A.3]}$$

The principal uncertainty when estimating $\hat{C}$ arises from two sources. The first source is imprecision in the estimates of chronic drug users for the ADAM sites. The second source is imprecision in the estimate of the relationship between chronic drug use and treatment admissions. The sampling variance can be estimated two ways, both of which will be useful here. The first method uses equation [A.3] to specify the sampling variance as:

[A.4] $$VAR(\hat{C}) = VAR(\hat{C}_A) + VAR(\delta)V_N^2$$

The second method rearranges equation [A.3] to estimate the sampling variance as:

[A.5] $$VAR(\hat{C}) = VAR(\delta)\left[V_A + V_N\right]^2$$

The advantage of [A.4] is that it should be smaller than [A.5].[63] The disadvantage is that this study's estimate of $VAR(\hat{C}_A)$ understates the sampling variance for the number of chronic drug users in ADAM sites. The researchers think this understatement should be small, but cannot be sure. Thus, the second variance term might be considered as providing a more conservative measure of uncertainty.[64]

A.1.2 Methodology for Estimating Chronic Drug Use—Juveniles

The ADAM survey is limited to adults. This study turned to the Monitoring the Future (MTF) survey to estimate chronic drug use for juveniles. MTF understates drug use for older children because the survey does not account for children who leave school. It may understate drug use for those who remain in school if chronic users are more likely to be absent on the day that the survey is administered. Although these problems are absent in the NSDUH, children appear to be more willing to report drug use on the MTF survey than on the NSDUH.[65]

The survey reports drug use in categories: 1–2 occasions per month, 3–5 occasions, and so on. Because the threshold of 4 or more times per month could not otherwise be distinguished, it was assumed that 2/3 of reports in the 3–5 occasion category were for chronic use. The MTF survey reports drug use by 8th, 10th and 12th grade students. The study computed a simple average of the proportion of children in

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63 The intuition is that the study has estimates for 39 ADAM sites. The variance for the sum of those estimates is VAR(C), which appears in [A.4]. The second expression [A.5] is based on a regression where the estimates from those 39 sites appear as dependent variables and the second variance expression estimates the variance for those 39 sites as if they were predicted from the regression. The "predictions" are less precise than the "realizations" so the second variance expression is larger than the first.

64 The second measure of uncertainty will capture all the sampling variance provided at least two conditions are met. The first condition is that the estimates from the ADAM sites are *unbiased*, meaning that on average they equal the true number of chronic users. One cannot be sure this is true and it seems likely that adjustments for various factors (such as truthful reporting and correcting for women arrestees) imparts some bias to these estimates. The second condition is that ADAM is a random sample of counties. This is known to be not true, but a lesser condition will work: ADAM sites must provide an unbiased relationship between chronic drug users and treatment admissions. Although there is no way to establish that fact, the researchers see no reason to believe that ADAM provides a seriously biased estimate of that relationship.

65 Children between 13 and 14 report three to five times as much marijuana use on the Monitoring the Future survey as they do on the NSDUH; children between the ages of 15 and 17 report about twice as much marijuana use on the MTF survey as they do on the NSDUH.

each grade who reported using a specified drug on 4 or more occasions per month. That simple average was multiplied by 20 million, roughly the number of children between the ages of 15 and 19 according to the U.S. Census Bureau. An approximate sampling variance was estimated for these prevalence estimates.[66]

Juveniles have a modest impact on prevalence estimates for chronic cocaine and heroin users; they increase the adult-only estimates by roughly 5 percent. They have a larger impact on methamphetamine estimates, increasing the adult-only estimates by 15 to 20 percent. They have an even larger impact on marijuana estimates, increasing the adult-only estimates by 20 to 25 percent.

A.1.3 Estimating the Prevalence of Chronic Drug Use for the Nation

The final step for estimating chronic drug users is to apply formula [A.2] and then add estimates for juveniles.[67] Table A.1 reports the resulting estimates of the number of chronic drug users for the nation for 2000 through 2003. For each of the drugs, the table reports a point estimate and an uncertainty range (below the point estimate) of two standard errors. As noted, the uncertainty range does not take all uncertainty into account, so the provisional range understates the true uncertainty by a presumably small amount.

Table A.1: Chronic Users of Cocaine, Heroin, Methamphetamine and Marijuana (2000–2003)

		2000		***2001***		***2002***		***2003***	
Cocaine		2,580		2,654		2,626		2,743	
	range	2,144	3,016	2,217	3,091	2,189	3,063	2,307	3,179
Heroin		865		834		854		779	
	range	617	1,112	587	1,082	606	1,101	532	1,026
Methamphetamine		804		857		881		1,011	
	range	694	913	748	966	772	990	902	1,121
Marijuana		9,812		9,886		10,054		10,412	
	range	8,472	11,152	8,546	11,226	8,714	11,395	9,071	11,753

Note: Uncertainty intervals equal plus or minus two standard errors.

The estimates indicate that the number of chronic cocaine users, the number of chronic heroin users, and the number of chronic marijuana users have remained constant between 2000 and 2003. There does appear to have been an increase in the prevalence of chronic methamphetamine users.

The uncertainty intervals do not capture all the uncertainty in these estimates. If uncertainty were to be estimated based on formula [A.5] instead of [A.4], the standard error upon which the uncertainty

66 Let P be the proportion of juveniles who were estimated to be chronic drug users, let N be the sample size, and let DEFF be the estimated design effect. The design effect was set at 3, which is conservative according to MTF documentation. Given that there are 20 million juveniles, the sampling variance is estimated at (20^2)x((Px(1-P))/(N/3)). The sampling variance was estimated for 2003 only, and presuming that it would not be much different for the other years. The estimate is approximate, especially because it does not reflect any of the uncertainty about dividing the 3–5-day users into 3-day users and 4–5-day users.

67 The data source is Table 4.4a from the MTF reports for 2000 through 2003. These are available from the MTF web site: http://www.monitoringthefuture.org/.

estimate rests would increase by 35 percent for cocaine, 30 percent for heroin, 45 percent for methamphetamine and 20 percent for marijuana.[68] These more conservative standard errors are not greatly different from the ones that were used to construct the table, providing some comfort that the uncertainty intervals are not misleading.

A.1.3 Methodology for Estimating Occasional Drug Use

Estimates of the number of occasional users come from the National Survey on Drug Use and Health (formerly the National Household Survey on Drug Use). An occasional drug user was defined as someone who said that he or she used cocaine, heroin, methamphetamine or marijuana 1 to 3 days during the month before being questioned. (For methamphetamine, the question asked about the frequency of use per week during the previous year.)

The Office of Applied Studies at the Substance Abuse Mental Health Services Administration warns that changes to the NSDUH in 2002 resulted in a break in the time-series. SAMHSA/OAS provides no adjustment, so prevalence estimates from 2001 and 2002 NSDUH data are not comparable. Results from the 2003 survey were not available when these calculations were done.[69] The study averaged the number of chronic users for 2000 through 2002 and applied that average to the years 2000 through 2003. Standard errors are meaningless, so are not reported.

The researchers were concerned that occasional users underreport to the NSDUH, but the level of that underreporting is uncertain. The best estimate for underreporting comes from Fendrich et. al. (1999). Based on hair bioassay, the authors report that "…toxicological results were nearly five times the survey-based estimates for past month use ..." for cocaine. Although they reported that respondents were more willing to report heroin use, their heroin sample was small. The Fendrich estimates presumably include chronic and occasional users.

The Fendrich estimates come from a single study in a specific sample, so one cannot be sure of generalizing beyond that study. Nevertheless, additional evidence indicates that underreporting is appreciable. Assume that the ADAM-based estimates are accurate. Then the ratio from dividing adult chronic user estimates according to the NSDUH by adult chronic user estimates based on ADAM data is a measure of reporting truthfulness to the NHSDA. The NSDUH reports an average of about 620,000 adult chronic cocaine users between 1999 and 2002.[70] The ADAM-based estimate for adults is about 2.3 million. This suggests a truthful reporting rate of about 27 percent, an estimate that agrees roughly with Fendrich. Averaged over that same period, the NSDUH report about 76,000 chronic users of heroin, compared with about 770,000 according to ADAM-based estimates. This suggests a truthfulness rate of

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[68] The increases are for adult-only estimates. The estimates for juveniles do not change. Therefore the standard errors that underlie the uncertainty estimates would not change by as much as is indicated in the text.

[69] Self-reported occasional users of cocaine grew from 500,000 in 2000 to 744,000 in 2001 and to 1,024,000 in 2002. There is no evidence that cocaine use actually grew during this three-year period. Self-reported marijuana use grew from 3.0 million in 2000 to 3.4 million in 2001 and to 3.8 million in 2002. There is no evidence that marijuana use followed such trends.

[70] The source is the study's tabulations of NSDUH/NHSDA for 1999 through 2002. These were provided on the SAMHSA web site. The estimates were completed using SAMHSA's on-line analysis software.

about 10 percent, but the NSDUH sampling variance is high for heroin so the 10 percent estimate is subject to considerable measurement error.

Table A.2: Occasional Users of Drugs: 2000–2002 (Thousands of Users per Month)

	Year			
	2000	**2001**	**2002**	**Average**
Cocaine				
1 day	351	370	622	448
2 days	131	250	298	226
3 days	69	184	174	142
Total	552	805	1,094	817
Weighted	2,206	3,218	4,377	3,267
Heroin				
1 day	19	14	21	18
2 days	7	15	26	16
3 days	15	3	4	7
Total	41	32	51	41
Weighted	165	127	205	166
Methamphetamine				
1 day		58	52	55
2 days		53	30	41
3 days		25	54	39
Total		137	135	136
Weighted		547	538	543
Marijuana				
1 day	1,626	1,899	2,151	1,892
2 days	1,217	1,307	1,331	1,285
3 days	775	811	1,014	867
Total	3,618	4,017	4,496	4,044
Weighted	4,523	5,021	5,620	5,055

Notes: The average is the three-year average for cocaine, heroin and marijuana. It is the two-year average for methamphetamine because the NSDUH did not ask about days used prior to 2001. The weight is 4 for cocaine, heroin and methamphetamine; it is 1.25 for marijuana.

Fendrich and his colleagues did not test their sample for marijuana use. Although the Office of Applied Studies conducted urine testing for marijuana in conjunction with the NSDUH (Harrison, Enev and Harrington 2007), results were not available when these calculations were performed. Consequently there is no external verification of the truthfulness of self-reports for marijuana. The NSDUH reports 5.8 million chronic adult marijuana users in 2000, 6.5 million in 2001 and 8.4 million in 2002.[71] According to the ADAM-based estimates, the number is close to 8.0 million adult chronic users between 2000 and 2003. This suggests a truthfulness rate of about 80 percent for adult chronic users. It was later learned from the Harrison et al. study that the rate is probably closer to 75 percent, so the 80 percent estimate is reasonable.

[71] According to the NSDUH, a total of 6.7 million Americans used marijuana on 4 or more days per month in 2000, 7.6 million did so in 2001, and 9.6 million did so in 2002.

For current purposes, the study has inflated self-reports of occasional drug use from the NSDUH by a factor of 4 when those reports involve cocaine, heroin or methamphetamine. Self-reports of occasional marijuana use have been inflated by a factor of 1.25. There is no compelling justification for these inflation factors, which actually apply to a mixture of occasional and chronic users, but they seem justified given the best available evidence. Nevertheless, the accuracy of estimates of occasional drug use is not crucial to estimates of expenditures. Someone who uses cocaine on 1 day per month spends 1/30th as much as someone who uses cocaine on 30 days per month, so it is most important to be confident about chronic user estimates. Mistakes when estimating prevalence for occasional users are less important. Specifically, when the NSDUH-based occasional users are multiplied by 4, they account for about 9 percent of cocaine expenditures, about 2 percent of heroin expenditures, and about 6 percent of methamphetamine expenditures. Using a multiplier of 1.25 for marijuana users results in occasional marijuana users accounting for 4 percent of marijuana expenditures. Clearly, the selection of some other multiplier would not greatly change the estimates of expenditures.

Putting aside the issue of reporting veracity, The NSDUH cannot be used for trend estimates because of survey design changes. As an estimate of occasional drug use, the study simply averages the number of 1- to 3-day users for 2001 through 2003 according to the NSDUH, and then adjusts for underreporting.

A.1.4 Comments about Chronic and Occasional User Estimates

These estimates are most accurate if chronic drug users run an appreciable risk of arrest. If this were untrue, then the method of inflating the number of chronic drug users in an arrestee population by the rate at which chronic users get arrested would provide statistics with intolerably high sampling variation, because that would entail dividing by a very small number (i.e., the estimated arrest rate) with a high sampling variance for chronic users with low arrest rates. The NSDUH provides confirmation that chronic drug users do have an appreciable risk of being arrested. From the NSDUH for 2001 and 2002, the study extracted the records of occasional and chronic users and tabulated their annual arrest rates.[72] This was based on the response to the question of how many times they had been arrested and booked in the last year. Table A.3 reports estimates.

[72] The reported arrest rates (variable NOBOOKY2) were averaged across the 2001 and 2002 surveys. This question was not asked on the 2000 survey. NOBOOKY2 reported the number of arrests during the last year conditional on having ever been arrested. The study used responses to the question about whether the respondent had ever been arrested and booked (BOOKED) to convert the conditional rates to unconditional rates.

Table A.3: Arrest Rates by Drug Type and Use Level: 2001–2002 (Averages from 2001 and 2002)

	Use Level	
Drug Type	***Occasional***	***Chronic***
Cocaine	0.30	0.44
Heroin	0.56	0.49
Methamphetamine	0.52	0.32
Marijuana	0.15	0.29
All respondents	0.04	

Notes: All respondents include all respondents to the NSDUH regardless of self-report drug use. Most were not users.

The category "all respondents" includes everyone included in the NSDUH sampling frame, not just drug users. Clearly the arrest rate for drug users is higher than the arrest rate for those who do not use drugs. These statistics have a considerable margin of error,[73] but they are sufficiently accurate to imply that chronic drug users run an appreciable risk of arrest.

The researchers' opinion is that the weakest link in the chronic user estimates stems from the adjustment for underreporting. Future improvements in ADAM could largely overcome these problems.

The NSDUH is a larger problem. As a scientific survey the NSDUH meets the highest standards. It stands unchallenged as a report of drug use by Americans *who live in stable households and are willing to report to government interviewers*. But when one wants to use the NSDUH to estimate the prevalence of drug use (as compared with the prevalence of reported drug use), the survey is less useful. Good measures of truthful reporting are simply lacking, but the few studies available suggest that underreporting is significant and cannot be ignored in a study such as WASOD.

Lacking measures of underreporting, the study has assumed that Fendrich et al. have provided the best estimate of underreporting. Nevertheless, it is acknowledged that evidence supporting this assumption is meager. Fortunately, expenditure estimates are relatively insensitive to assumptions about underreporting because occasional users account for a small proportion of drug use. This appendix turns to expenditure estimates next.

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73 Respondents to the NSDUH appear to underreport arrests, but estimating the size of that underreporting is difficult. According to the Uniform Crime Reports, there were about 14 million arrests per year during this period, but respondents to the NSDUH only reported about 7 million. There are at least two explanations other than lying about past arrests. The first explanation is definitional. The UCR includes all arrests whether or not they resulted in a booking, while the NSDUH asks respondents about bookings. In this regard, there should be more arrests in the URC than in the NSDUH data. However, the UCR does not report bookings that did not result from arrests (such as revocations), so in that regard there should be more arrests in the NSDUH than in the UCR. The researchers are uncertain about how these two biases offset each other. A second problem is that an arrest sometimes removes a person from the household, so he or she is no longer eligible for being interviewed by the NSDUH. By removing some respondents who had been arrested and incarcerated, incarceration of some potential respondents would cause the NSDUH to understate arrest rates.

A.2 Expenditures on Illicit Drugs

Data about expenditures for cocaine, heroin and methamphetamine come exclusively from ADAM. Data about marijuana expenditures come from both the ADAM survey and the NSDUH. This section explains how those two data sources were used to derive estimates of expenditures on cocaine, heroin, methamphetamine and marijuana from 2000 through 2003.

A.2.1 Definition of Expenditures

Expenditures on illicit drugs means *dollar-equivalent expenditure* on those drugs. Drugs are typically acquired by money exchange, and when that is the case, the dollar expenditure is obvious. At other times drugs are acquired through bartering, and when that is the case, the dollar-equivalent expenditures for those transactions are less obvious. The approach is to impute a dollar-equivalent value for bartered transactions based on the dollar price for an equivalent quantity of drugs.

Because of price inflation, the value of a dollar decreases over time. A common practice when reporting household expenditures is to increase the dollar value of earlier purchases when comparing expenditures over time. The Consumer Price Index is typically used for this purpose because the CPI is adjusted to reflect the price increase in the mix of goods purchased by the average urban dweller. This practice may be unsuitable for chronic drug users, however, because a large proportion of their market basket (as the mix of goods is known) comprises illegal drug purchases—which are not an ingredient of the CPI.

This study reports expenditures in terms of *nominal* dollars. This means that estimations provided in this chapter have not been adjusted for inflation. If the estimates had been adjusted using the CPI, the 2000 estimates would have been about 7 percent higher, the 2001 estimates would have been about 4 percent higher, and the 2002 estimates would have been about 3 percent higher. If the reader feels that estimates would be more meaningful if adjusted for inflation, he or she is invited to adjust the estimates using these percentage adjustments.

A.2.2 Methodology for Estimating Expenditures

ADAM data are important for developing these estimates because ADAM asks a battery of questions about recent purchasing and bartering for cocaine, heroin, methamphetamine and marijuana. The study developed a computing algorithm to convert answers to those questions into estimates of monthly expenditures by individual chronic users. Then those monthly estimates were converted into a national estimate of average expenditures per month for chronic users. Finally, an estimate of total expenditures by chronic users was derived by multiplying the estimated average expenditures by the estimated number of chronic users.

The NSDUH asks no questions about expenditures on cocaine, heroin or methamphetamine. Presuming that average expenditures by household members are equivalent to average expenditures by arrestees conditional on the frequency of drug use, ADAM data were used to estimate the average expenditure per day of drug use for all four drugs. That daily estimate was applied to all occasional users who reported frequency of use to the NSDUH. Average expenditures were then estimated for occasional users.

Estimating Monthly and Daily Expenditures Using ADAM Data

ADAM interviewers ask arrestees if they have purchased or otherwise acquired cocaine, heroin, methamphetamine or marijuana during the last month. If the arrestee admits to a recent acquisition, he is asked a series of follow-up questions.

If he says that he *purchased* the drug, the interviewer asks him about the price he paid for the last purchase. The interviewer also asks him to estimate the amount of drugs that he received as a result of that purchase. Then the interviewer asks him how many times he purchased that day and on how many days he purchased during the last month. He is also asked whether he used the entire purchase himself or whether he gave some away or sold some.

If he says that he *bartered* to cover some or all the drug price, the interviewer asks him to estimate how much he received as a result of the transaction. The study's computing algorithm imputes a dollar equivalent value for that reported amount. The imputation is based on the empirical relationship between the price paid and amount purchased based on reports by those who actually made cash purchases. For example, if a respondent said that he bartered for 1 gram of cocaine, a dollar value of $100 for that 1 gram might have been imputed. Additionally, the interviewer asks the respondent how many times he bartered during the same day and during the last month, and whether he used the amount himself.

Respondents were divided into two groups. The *first group* (Own Use) comprised people who said they had purchased or bartered for cocaine (or heroin or methamphetamine or marijuana) and had used the entire purchase for their own use. The *second group* (Gift/Sold) comprised people who said they had purchased or bartered for cocaine (or heroin or methamphetamine or marijuana) but had either shared the drug or had sold some.[74] The data were uninformative about the amount given to others and the amount sold, and given that an estimate of expenditures net of what was resold to others was required, data from the second group could not be used directly to estimate how much its members spent on drugs.[75]

Using only those respondents from the first group (Own Use), the study estimated the dollar value of purchased drugs for the month as the product of price paid for the last purchase times the number of purchases made that same day times the number of days when purchases were made during the last month. The estimated dollar value of bartered drugs was the same except that the imputed dollar-equivalent value was substituted as the putative purchase price. The dollar-equivalent values for the purchased and bartered drugs were combined for any user who reported both behaviors to yield a *provisional* dollar expenditure estimate for that user. For example, if the respondent said that he paid $20 for the last purchase, that he bought 2 times during that day, and that he bought on 10 days during the month, then his monthly purchase was $400 = $20 x 2 x 10.

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[74] In some instances, chronic users did not answer the market portion of the ADAM instrument. When that was the case, expenditures were imputed based on the results from the regression analysis. Essentially, those respondents with missing data were treated as members of group 2.

[75] The problem is with sales. Suppose that arrestee A bought $100 worth of cocaine but sold $50 of that purchase to someone else. Then someone else would report a $50 purchase for what is in reality just $100 worth of drugs. The study sought to avoid this double counting.

The provisional estimate was sometimes unbelievably large. An upper limit was placed on expenditures for own use based on the physiological limitations for drug use.[76] If the consumption implied by that expenditure exceeded the physiological limit, that respondent was moved from the first group (Own Use) to the second group (Gift/Sold). The justification for moving a case was that either the respondent misunderstood the question (or was otherwise unable to give a credible answer) or else he actually sold some of the drug but was unwilling to admit the crime.

Using data for the first group (Own Use), the study used statistical analysis (regression analysis) to establish the relationship between expenditures on own use and frequency of use during the same month.[77] That estimated relationship was then used to impute the dollar expenditure for everyone in the second group (Gift/Sold) based on the frequency of drug use.[78]

The analysis was repeated site by site. Methamphetamine use was rare in many ADAM sites east of the Mississippi, and heroin use was rare in certain ADAM sites. When there were too few cases for meaningful analysis, ADAM sites were grouped into regional groupings and conducted the analysis by regions. Although grouping probably introduced some inaccuracies, grouping was done where drug use was relatively rare. Consequently the potential inaccuracies should have little effect on the estimated average expenditure because sites that were grouped contribute little to an estimate that is weighted by the number of drug users in that site.

Table A.4 reports average monthly expenditures by chronic users for cocaine, heroin, methamphetamine and marijuana.[79] The "average" is the weighted average across the ADAM sites. The "weights" are the estimated number of drug users in those sites. For example, if there are C chronic drug users across the ADAM sites, and if a site has c chronic drugs users, then that site gets a weight of

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76 The maximum number of doses per day (based on physiological limits to drug use) was multiplied by the prevailing price of drugs in the county. This gave a maximum expenditure per day of use. If reported expenditure exceeded the maximum daily expenditure times reported days of use, the response was judged to be unreasonable.

77 Ordinary least squares regression was used. The dependent variable was the reported expenditure for the month. The independent variable was the number of days of use during the month. The slope was interpreted as the expenditure per day of use.

78 The study actually predicted expenditures for both groups. It may seem preferable to use the group 1 estimates directly instead of using predictions based on the regression results. However, the group 1 estimates themselves have an unknown amount of sampling variance, so one does not want to use those estimates as if they were data points known with certainty. As explained, the study used predictions from the regression, combined with econometric logic, to estimate the uncertainty in the group 1 estimates.

79 Separate estimates were performed for crack and powdered cocaine. The crack and powder cocaine estimates were weighted by the number of chronic users of crack/powder cocaine to derive an estimate for cocaine.

c/C. When a site lacked an estimate for time T, an estimate was substituted from an available year.[80] The table reports an uncertainty interval based on plus or minus two standard errors.[81]

Table A.4: Monthly Expenditures by Chronic Drug Users: 2000–2003

		2000		2001		2002		2003	
Cocaine		$979		$960		$1,001		$1,005	
	range	$847	$1,110	$829	$1,091	$866	$1,137	$874	$1,136
Heroin		$1,019		$1,077		$1,072		$1,054	
	range	$808	$1,229	$814	$1,340	$915	$1,228	$907	$1,201
Methamphetamine		$1,101		$1,062		$1,101		$1,022	
	range	$915	$1,288	$876	$1,249	$924	$1,278	$841	$1,204
Marijuana		$268		$277		$279		$272	
	range	$243	$292	$252	$301	$253	$305	$248	$297

Note: Uncertainty intervals equal plus or minus two standard errors.

In 2003, a chronic user of cocaine spent $1,005 per month, on average, on his cocaine use. Chronic users of other drugs spend $1,054 per month for heroin, $1,022 per month for methamphetamine and $272 per month for marijuana. The range of uncertainty is between $874 and $1,136 for cocaine based on plus or minus two standard errors. Table A.4 reports the uncertainty interval for other drugs. There are at least three reasons why this uncertainty interval understates the confidence interval. One is that the uncertainty interval pertains strictly to the ADAM sites; it was assumed that those sites provide representative estimates for other places that are not ADAM sites. A second reason is that the estimates are for men; it was assumed that women spend about the same on average. A third reason is that some chronic users are juveniles, and their expenditure patterns may differ from the patterns of adults. Roughly four of every five chronic users are adult males, however, so the estimates should be reasonably valid as estimates for the entire country.

The study used the results from the regression analysis (described above) to estimate daily expenditure on drug use.[82] Across the ADAM sites, the average expenditure per day of use for powder cocaine was about $46, and the average expenditure per day of use for crack cocaine was about $56. It appears that crack users spend somewhat more on their daily use, but the differences are not great. Averaging the daily rate for powder and crack yields the estimated $51.39 (plus or minus $2) per day spent by chronic users of cocaine.

80 If the estimate was missing from 2000, the year 2001 estimate were substituted. If the estimate was missing from 2003, the year 2002 estimate was substituted. If year T and T+2 estimates were available but a year T+1 estimate was not, the averages from T and T+2 were used.

81 As explained, the sampling error arises from three sources: (1) the regression parameter estimates have a degree of uncertainty. (2) ADAM is a sample of arrestees. (3) ADAM sites are a sample of counties. To estimate standard errors, ADAM sites were treated as if they were a random sample of counties, and because that is not true, the uncertainty interval is not a confidence interval.

82 The regression parameter associated with days of use during the month was taken as an estimate of daily expenditure amounts. The sampling variance for that estimated parameter was taken as a measure of uncertainty.

Heroin users spend about $46.54 (plus or minus $2) per day. Methamphetamine users spend about $62.43 (plus or minus $3.20) per day. According to the ADAM data, marijuana users spend about $11.75 (plus or minus about 30 cents) per day. This latter estimate is especially interesting because it can be compared to the daily expenditure amount reported by the NSDUH. The NSDUH estimates will be discussed later, but at this point, note that the NSDUH estimates are only about half as large as the ADAM-based estimates.

Estimating National Expenditures — Chronic Users

The algorithm described above led to dollar-equivalent values for the average expenditures on cocaine, heroin, methamphetamine and marijuana by chronic drug users. The estimated total annualized expenditure is the product of the estimated number of chronic drug users times the average monthly expenditure on the specified drug times 12.

To estimate the sampling variance for total annualized expenditures by chronic drug users, the study used a first-order approximation for the variance of the total number of chronic users times the average expenditure per chronic user. That estimate is:

[A.6] $$VAR(Expenditure\,by\,chronic) = VAR(\hat{C})\hat{\bar{S}}^2 + VAR(\hat{\bar{S}})\hat{C}^2$$

where:

$\hat{\bar{S}}$ is estimated mean annualized expenditure by chronic users

$\hat{C}$ is estimated number of chronic users

Estimating National Expenditure—Occasional Users (Cocaine, Heroin and Methamphetamine)

To estimate expenditures for occasional users, the study multiplied the estimated number of occasional users by their average monthly expenditure on cocaine (heroin, methamphetamine, or marijuana) times 12.[83] That is, it was assumed that the average expenditure by an arrestee who used cocaine on one day per month was equivalent to the average expenditure by a household member who admitted to use on one day during the month. Given the unknown level of uncertainty surrounding the occasional user estimates, the uncertainty for expenditure estimates is based exclusively on the sampling variance for the daily expenditure estimates. This will understate the uncertainty for the occasional user expenditures. Because the NSDUH asks questions about marijuana expenditures, the NSDUH data were used to derive separate, alternative estimates of expenditures by occasional users of marijuana.

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[83] See the previous note. An ordinary least squares regression was estimated where the dependent variable was total expenditure on cocaine (heroin, methamphetamine or marijuana) for the month and the independent variable was the number of days during the month when cocaine was used. The slope parameter was interpreted as the marginal expenditure on cocaine per day of use. The regression was repeated for each ADAM site, and the final estimate of expenditure per day of use was a weighted average across the ADAM sites. The estimated number of cocaine users was the weight for each site.

A.2.3 Estimating National Expenditures—All Users

Table A.5 reports estimates for expenditures on cocaine, heroin, methamphetamine and marijuana for 2000 through 2003. The table reports a point estimate as a single number and a range of uncertainty equal to two times the square root of the sampling variance. This understates the full range of uncertainty in these estimates because the researchers were unable to place a probability-based measure of uncertainty on all the component parts of the estimators. For example, estimates of occasional drug use were treated as being measured without error, and because there is error in these estimates, standard errors will be too small.

Table A.5: Expenditure on Illegal Drugs: 2000–2003 ($ Billions)

		2000		2001		2002		2003	
Cocaine		$33.6		$33.9		$34.8		$36.4	
	range	$27.0	$40.1	$27.1	$40.6	$28.1	$41.6	$29.6	$43.1
Heroin		$10.7		$10.9		$11.1		$10.0	
	range	$7.0	$14.5	$6.8	$15.1	$7.6	$14.7	$6.6	$13.4
Methamphetamine		$11.4		$11.7		$12.4		$13.2	
	range	$9.1	$13.7	$9.4	$14.0	$10.0	$14.8	$10.6	$15.8
Marijuana		$32.8		$34.1		$34.9		$35.2	
	range	$27.6	$37.9	$28.5	$39.6	$29.4	$40.4	$29.9	$40.6
Total		$88.5		$90.6		$93.3		$94.8	
	range	$80.3	$96.7	$82.0	$99.1	$84.9	$101.6	$86.3	$103.2

Note: Uncertainty intervals equal plus or minus two standard errors.

A.3 Amount Consumed by Weight: 2000–2003

Converting expenditures into pure amounts of cocaine, heroin and methamphetamine is straightforward if one knows the average price paid for those drugs. (Marijuana is measured in bulk, but the estimation is the same as that for the other drugs.) For example, if purchasers pay $100 per pure gram of cocaine, and if they spend $10B in total on cocaine, then they purchase 100 metric tons of cocaine. Such prices can be estimated using a combination of data from the System to Retrieve Information from Drug Evidence (STRIDE) and the Arrestee Drug Abuse Monitoring (ADAM) program, with other reports used as corroboration.

A.3.1 Prices for Illegal Drugs

Two sources of data are especially important for deriving estimates of the retail price for illegal drugs. The first source is the System to Retrieve Information from Drug Evidence (STRIDE). The second is the ADAM program.

STRIDE reports the purchase prices and amount purchased in pure grams (bulk for marijuana) for purchases made by Federal agents (and a few other police) throughout the United States. The National Research Council has criticized researchers for using STRIDE to estimate illegal drug prices, although the consensus among researchers who use these data is that they provide the best available way to derive retail sales prices. STRIDE is not a random sample of purchases, however, so researchers use *model-*

based procedures to develop price estimates. A model-based procedure attempts to mimic what the price estimate would be if the sample had been selected randomly from all purchases.

Appendix H describes the estimation process for deriving drug prices. This process did not work for marijuana because retail-level purchases are sparse in STRIDE. Nevertheless, the STRIDE-based estimates were consistent with prices reported by knowledgeable sources on the Internet. NORML reported an average price of $10.16 per gram for ounce purchases between 1996 and 1997.[84] An Internet survey set recent (2004) prices at between $7.30 and $9.54 per gram depending on how one does the tabulations.[85] Based on the study team's own analysis of marijuana prices, which used the same methodology as was used for cocaine, heroin and methamphetamine prices, marijuana prices were estimated to be between $7.60 and $9.67 per gram for 2003. The point estimate across the four years was $6.40 (2000), $7.06, $9.30 and $8.54. The levels of these retail-level price estimates are consistent with the prices reported by others, although there is concern that the apparent trends may not be reliable.[86]

A.3.2 Estimates from the Institute for Defense Analysis

The Institute for Defense Analysis (Fries et al., 2008) reports trends in retail drug prices. One cannot use the IDA estimates directly for three reasons. The first reason is that IDA reports separate estimates for powder cocaine and for crack cocaine, but the expenditure estimates do not differentiate by form of cocaine. Therefore one must average across powder and crack.

The second problem is that IDA reports average prices (based on the expected purity hypothesis) conditional on the amount purchased. The amounts are 0.1 to 2 grams, 2 to 10 grams, 10 to 50 grams and more than 50 grams for powder cocaine. The amounts are 0.1 to 1 gram, 1 to 15 grams, and more than 15 grams for crack. To derive the correct retail price estimate for this report, one must weight these conditional estimates where the weights are proportional to the amount of cocaine that is purchased in these categories.

Note that this is not the average price paid at retail, which is what is reported by IDA. Rather it is the average price per ton of pure cocaine purchased. This is the correct price because the estimate of tonnage is the ratio of expenditures to price paid per ton purchased.

IDA does not report the distribution of purchase amounts. One might approximate the purchase amounts by assuming that enforcement agents who submit samples for DEA testing provide a good way

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84 http://www.norml.org/index.cfm?Group_ID=4444

85 Responses were provided in categories. The low estimate comes from using the lower range of the categories; the high estimate comes from using the upper end of the categories. See: http://www.marijuanaprices.homestead.com/polls.html

86 The prices were calculated as the reciprocal of average grams per dollar. Because of a mathematical theorem known as Jensen's inequality, this produces an estimate of dollars per gram that is biased downward. The bias is only a few percentage points, however. The reported prices are illustrative; all calculations were done with the estimates of grams per dollar paid.

to estimate the distribution of purchase amounts, but that seems highly unlikely, and it cannot be determined from the STRIDE data, because STRIDE does not distinguish between purchases for use and purchases for resale. That is why the calculations in A.3.1 used the distribution inferred from ADAM purchases.

Nevertheless, if one assumes that DEA purchase amounts are representative of purchase amounts across the nation, and if only purchases of less than 15 grams are considered, the IDA prices are between $88 and $157 per pure grams. The trend is toward lower prices. The estimates used for this report (as described above) are by year $125 (2000), $129 (2001), $122 (2002) and $113 (2003). The estimates used for this report are bracketed by the adjusted IDA estimates but are less volatile.

A.3.3 Estimating Metric Tons of Illegal Drug Use

To estimate the total amount of cocaine, heroin, methamphetamine and marijuana used between 2000 and 2003, the estimated total expenditure on cocaine (heroin, methamphetamine and marijuana) was multiplied by the average number of grams purchased per dollar spent. The standard error for that estimate was approximated using a formula explained in Appendix E. Table 4.6 reports estimates for 2000 through 2003.

Table A.6: Metric Tons of Consumption: 2000–2003

		2000		***2001***		***2002***		***2003***	
Cocaine		268.0		263.1		285.4		322.3	
	range	212.0	324.0	206.7	319.5	225.7	345.2	257.4	387.2
Heroin		22.8		24.2		25.3		20.9	
	range	14.7	30.9	14.8	33.6	16.9	33.6	13.5	28.3
Methamphetamine		74.6		90.7		105.0		90.5	
	range	49.8	99.3	61.3	120.2	74.4	135.7	61.7	119.3
Marijuana		5,113		4,824		3,751		4,130	
	range	3,862	6,364	3,723	5,925	2,813	4,688	3,083	5,177

Note: Uncertainty intervals equal plus or minus two standard errors.

The researchers warn that the uncertainty estimates do not capture all the uncertainty in these measures, and with regard to prices, one must be mindful of the cautionary note added by the National Research Council. STRIDE is not a random sample of purchases, and furthermore, there would seem to be little motivation for DEA and other Federal agents to make retail-level purchases of marijuana. This raises the prospect that purchases that nevertheless occur and get entered into STRIDE fail to represent purchases that are made by marijuana purchasers other than police.

Appendix B: Estimating Drug Treatment Admissions 2000–2003

To apply ratio estimation, the researchers sought a county-level variable that was proportional to the number of chronic drug users in the county. More specifically, for each county, they sought a variable that was proportional to chronic cocaine use, a second variable that was proportional to chronic heroin use, a third that was proportional to chronic methamphetamine use, and a fourth proportional to chronic marijuana use. All three variables were derived from the same data sources: the National Survey of Substance Abuse Treatment Facilities (N-SSATS) and the Treatment Episode Data Set (TEDS).

The N-SSATS was used to estimate the number of treatment admissions per year in each county in the United States for 2000 and 2002. Using data elements provided by N-SSATS, the number of those admissions that were for adults was estimated, and for adult admissions, the numbers that were for outpatient treatment exclusive of detoxification and methadone maintenance was estimated. Using estimates from the TEDS analysis, treatment admissions were prorated into the categories: cocaine, heroin, methamphetamine and marijuana.

Finally, regression analysis was used to estimate the proportion of chronic users to treatment admissions (from N-SSATS) for cocaine, heroin, methamphetamine, and marijuana. The estimates of chronic users per treatment admission were used to extend prevalence estimates from counties that house ADAM programs to all counties across the United States.

B.1 Data Sources

TEDS and N-SSATS are collected by the Office of Applied Studies of the Substance Abuse Mental Health Services Administration. Treatment admissions are not strictly proportional to chronic drug users, because both the willingness to enter treatment and the availability of treatment for those who seek it vary across the United States. In some places, treatment may be readily available; in other places it may be limited. Nevertheless, there is no reason to think that ADAM sites have higher or lower average admission rates than non-ADAM sites, so using treatment admissions as indicators of chronic drug use provides the basis for a ratio estimator.

This study requires estimates of treatment admissions (for cocaine, heroin, methamphetamine and marijuana)[87] for all counties in the United States. Analysis of data from the Treatment Episode Data Set, combined with data from the National Survey of Substance Abuse Treatment Services, provides the requisite data. From N-SSATS:

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87 TEDS reports admissions for amphetamine use. It was presumed that admissions for methamphetamine use are proportional to admissions for amphetamine use. SAMHSA has reported estimates suggesting that 94 percent of treatment admissions for amphetamines are attributable to methamphetamine. See Office of Applied Studies, Treatment Episode Data Set (TEDS) 1994–1999. http://wwwdasis.samhsa.gov/teds99/1999_teds_rpt.pdf

- The study identified treatment admission by facility and subtracted admission for juveniles. Juveniles were excluded because ADAM is limited to adults.
- Treatment admissions that were for alcohol abuse exclusively were eliminated, so that the remaining admissions were for drug abuse or for alcohol and drug abuse combined.
- The number of treatment admissions that were for detoxification was estimated, and that estimate was subtracted from the total number of treatment admissions.
- The result is an estimate of the number of adult treatment admissions for substance abuse exclusive of alcohol for every county in the United States. At this point the estimates do not distinguish treatment admission by type of substance.
- To estimate the distribution of treatment admissions by type of drug used, the study turned to TEDS.

From TEDS.

- Data from TEDS were used to estimate the proportion of treatment admissions that were for cocaine, heroin, methamphetamine and marijuana in major Metropolitan Statistical Areas. Small MSAs are aggregated in TEDS, so an average ratio was developed for those small MSAs. Some treatment programs are outside of MSAs, and those are excluded from the calculations because of uncertainty about the drug types for those treatment episodes. This decision will understate chronic drug user estimates by what is presumably a small amount since about 14.7 percent of treatment admissions fell outside of MSAs.

- While TEDS data apply to MSAs, N-SSATS data apply to counties. The study assumed that the proportions by drug type estimated for MSAs applied to each county within those MSAs, and multiplying those proportions by N-SSATS treatment admissions provided estimates of the total number of adults who were admitted to substance abuse treatment for cocaine, heroin, methamphetamine and marijuana treatment in every county in the United States.

N-SSATS data are spotty and section B.2 explains how the study "cleaned" N-SSATS data and applied imputation routines to deal with missing data. Even with cleaning, these estimates of treatment admissions are measured with considerable error, and that fact will enter into the statistical analysis.

Treatment admissions for 2000 and 2002 were combined, and divided by 2, to estimate treatment admissions in each county. There was no 2001 N-SSATS survey. Sometimes a county failed to report their admissions to N-SSATS for one year, in which case the admissions for the year that was reported was used. Otherwise the estimate of δ was based on the two-year averages.[88]

[88] An argument could be made for doing separate estimates for 2000 and 2002. The researchers decided against that approach for two reasons. The first reason is that data are unavailable for treatment admissions during 2001 and 2003, so the study would have had to use an average for 2000 and 2002 for 2001 and some other estimate for 2003. The second reason is that treatment admissions can increase or decrease from year to year for reasons that have little to do with the number of chronic users. The researchers felt that the two-year average would be a more stable estimate of the relationship between admissions and chronic drug users.

B.2 Data Assembly and Cleaning

The Arrestee Drug Abuse Monitoring (ADAM) survey asks questions about chronic drug use among the arrestees and whether the arrestees have been recently admitted to inpatient or outpatient drug treatment programs. To predict the rate of admissions for chronic users, the study first selected the respondents of interest (cocaine users, heroin users, etc.) Second, weighted averages of treatment admission rates among drug users in each ADAM county were computed. The following sections describe the selection and estimation procedure.

B.2.1. Selecting Chronic Users among Arrestees

The ADAM dataset surveys male arrestees over the age of 18 in 43 counties. The sampled arrestees are interviewed within 48 hours of an arrest. They are asked whether they had consumed one or more of several substances in the last 12 months. This question was asked in one question for marijuana (S6), heroin (S15) and methamphetamine (S18).[89] This question was asked separately for crack cocaine (S9) and powder cocaine (S12); a cocaine user was identified as anyone who had used crack or powder.

Chronic users, for this appendix only, are defined as individuals who used a drug two or more times per week during any of the last 11 months (the length of the calendar). This implies that the respondent had answered "Yes" to either question S6, S9, S12, S15 or S18. The respondents were then asked whether they had ever been admitted to inpatient (T1) or outpatient (T2) drug abuse treatment and if yes, the number of times they were admitted to inpatient (T16) or outpatient (T30) treatment in the previous year. Altogether there were 57,016 observations, although the samples sizes were considerably smaller for specific types of drugs.

Inpatient Dataset

Tabulating inpatient admissions began with 57,016 observations. There were 155 observations with missing values for the number of times a respondent was admitted to inpatient substance abuse treatment (T16).[90] Of these observations, 118 were coded as "No" for question T1 that asked whether the individual was ever admitted to inpatient treatment for drug use. Therefore, data cleaning recoded the T16 values as 0 indicating that the respondents had been admitted zero times in the last 12 months. Data cleaning deleted 662 missing observations that were coded as "Yes" in T1 but were missing or coded as "9999" in T16. The following were also deleted: all observations where T16 was coded as "5555" for "Yes, but not specified" and all observations with "8888" implying the respondent refused to answer or "9999" implying the response was missing. This reduced the total dataset to 56,181 observations. If T16 was coded as "7777" then it was recoded to 0 because "7777" meant *not applicable,* implying the respondent answered no to question T1.

The next stage involved selecting the observations for each of the four drugs of interest: cocaine, heroin, marijuana and methamphetamine. This was done separately for each drug and resulted in four smaller datasets.

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89 The parentheses show the names of the survey variables.

90 Missing in this case means the observation was literally missing and not coded as "9999," which is a code used for missing observations.

Cocaine

The survey respondents were separately interviewed about their use of crack or rock cocaine in the last 12 months (S9) and their use of powder cocaine in the last 12 months (S12). The treatment estimates do not distinguish between crack and powder cocaine. Data assembly selected all respondents who reported using either crack or powder cocaine in the last 12 months, and removed a few observations with missing chronic user weights.[91] The resulting analysis file had 20,272 observations.

Heroin

The survey respondents were asked if they had used heroin in the last 12 months in question S15. Data assembly selected respondents who admitted using heroin at any point in the last 12 months and removed those respondents who did not have chronic user weights. This resulted in a dataset of 5,503 observations.

Marijuana

Similar to heroin, the survey respondents were asked if they had used marijuana in the last 12 months in question S12. Data assembly selected respondents who admitted using marijuana at any point in the last 12 months and removed those respondents who did not have chronic user weights. This resulted in a dataset of 41,317 observations.

Methamphetamine

Similar to heroin and marijuana, the survey respondents were asked if they had used methamphetamine in the last 12 months in question S18. Data assembly selected respondents who admitted using methamphetamine at any point in the last 12 months and removed those respondents who did not have chronic user weights. This resulted in a dataset of 12,230 observations.

Outpatient Dataset

The outpatient dataset began with the same 57,016 observations as the inpatient dataset. Data assembly selected observations based on the same criterion as was used to assemble the inpatient dataset but used variable T2 instead of T1 and T30 instead of T16. Question T2 asks a respondent if he had ever been admitted to an outpatient treatment facility for drug use and T30 asks the respondent the number of times he had been admitted to outpatient treatment in the last 12 months. Data assembly selected the sample on identical criteria to the inpatient observations and this resulted in 88,551 observations. If T30 was coded as “7777” then it was recoded as 0 because “7777” meant not applicable when the respondent answered no to question T2.

Data assembly proceeded to select the smaller datasets for each of the main drugs using criteria identical to those used in the inpatient sample. This resulted in a dataset of 20,269 observations for cocaine, 5,501 observations for heroin, 41,314 observations for marijuana, and 12,230 observations for methamphetamine.

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91 Construction of the chronic user weights used covariates such as age, prior record, and other variables that were occasionally missing. This a few cases were missing chronic user weights.

B.2.2. Estimating the Rate of Treatment Admissions Among Chronic Users in Each County

Variables T16 and T30 in the ADAM survey record the number of times each arrestee was admitted to treatment for drug abuse in the last 12 months. To generalize rates to all chronic users in the county, instead of only the arrestees, the Abt researchers weighted the responses using the chronic user weights to estimate the mean number of treatment admissions in each ADAM site for each year. The weighted means were estimated in SAS PROC SURVEYMEANS.

These calculations were done separately for each of the drugs, in each ADAM site, in each year and were calculated separately for individuals admitted to inpatient and outpatient treatment. The results for inpatient admissions are displayed in Tables B.1 to B.4 and results for outpatient admissions are displayed in Tables B.5 through B.8. A missing standard error with a defined mean in these tables implies that there was only one observation in the ADAM site in the specific year. A mean of zero implies that no respondent in the site was admitted to treatment in that particular year. Finally, a site with no mean and no standard error implies that there were no chronic user respondents in that site or that the survey was not conducted in that ADAM site in that particular year. The tables exclude the ADAM sites for Chicago and Philadelphia as the estimates were not credible.

The above-discussed ADAM results are for males alone. The probability based sampling was only used on the male arrestee population. A simultaneous non-probability survey was also conducted on the female arrestee population. The same above analysis was repeated on the female sample excluding the use of the chronic user weights as these weights could not be estimated in a non-probability sample.

Table B.1: Mean Inpatient Treatment Admissions for Cocaine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.215	0.185	0.373	0.208
	(0.051)	(0.042)	(0.078)	(0.045)
Washington DC	.	.	0.021	0.186
	.	.	(0.016)	(0.057)
Portland	0.148	0.176	0.245	0.176
	(0.032)	(0.037)	(0.052)	(0.037)
San Diego	0.189	0.150	0.098	0.155
	(0.052)	(0.037)	(0.025)	(0.042)
Indianapolis	0.083	0.066	0.051	0.055
	(0.025)	(0.034)	(0.023)	(0.021)
Houston	0.190	.	.	0.138
	(0.061)	.	.	(0.077)
Fort Lauderdale	0.017	.	.	.
	(0.012)	.	.	.
Detroit	0.553	0.071	.	.
	(0.163)	(0.029)	.	.
New Orleans	0.057	0.053	0.071	0.110
	(0.019)	(0.023)	(0.024)	(0.036)
Phoenix	0.145	0.135	0.138	0.095
	(0.025)	(0.023)	(0.023)	(0.022)
Chicago	0.046	0.086	0.068	0.090

Table B.1: Mean Inpatient Treatment Admissions for Cocaine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
	(0.025)	(0.032)	(0.014)	(0.028)
Dallas	0.114	0.166	0.161	0.205
	(0.034)	(0.081)	(0.038)	(0.032)
Birmingham	0.107	0.114	0.136	0.235
	(0.060)	(0.041)	(0.039)	(0.099)
Omaha	0.093	0.070	0.107	0.109
	(0.044)	(0.033)	(0.033)	(0.035)
Philadelphia	0.204	0.222	0.192	0.212
	(0.056)	(0.068)	(0.043)	(0.049)
Miami	0.128	.	.	0.071
	(0.038)	.	.	(0.035)
Cleveland	0.177	0.133	0.175	0.100
	(0.038)	(0.036)	(0.044)	(0.024
San Antonio	0.088	0.044	0.030	0.018
	(0.043)	(0.014)	(0.012)	(0.010)
Kansas City - Jackson County	.	0.171	.	.
	.	(0.081)	.	.
San Jose	0.155	0.122	0.104	0.069
	(0.077)	(0.038)	(0.032)	(0.024)
Denver	0.111	0.072	0.083	0.138
	(0.027)	(0.018)	(0.021)	(0.037)
Atlanta	0.077	.	0.152	0.113
	(0.028)	.	(0.032)	(0.026)
Albuquerque	0.110	0.171	0.168	0.110
	(0.036)	(0.037)	(0.034)	(0.034)
Minneapolis	0.480	0.185	0.203	0.104
	(0.253)	(0.068)	(0.049)	(0.045)
Sacramento	0.102	0.140	0.066	0.098
	(0.037)	(0.035)	(0.021)	(0.028)
Tucson	0.118	0.080	0.127	0.071
	(0.024)	(0.018)	(0.031)	(0.023)
Anchorage	0.150	0.149	0.092	0.194
	(0.039)	(0.051)	(0.029)	(0.065)
Des Moines	0.105	0.081	0.079	0.130
	(0.047)	(0.038)	(0.041)	(0.058)
Laredo	0.162	0.101	0.096	.
	(0.054)	(0.086)	(0.065)	.
Las Vegas	0.098	0.114	0.049	0.086
	(0.024)	(0.024)	(0.017)	(0.021)
Oklahoma City	0.206	0.113	0.099	0.121
	(0.049)	(0.027)	(0.024)	(0.041)
Salt Lake City	0.109	0.131	0.255	0.194
	(0.029)	(0.041)	(0.055)	(0.045)
Seattle	0.169	0.233	0.117	0.137
	(0.040)	(0.051)	(0.026)	(0.035)
Spokane	0.196	0.241	0.180	0.073
	(0.046)	(0.063)	(0.067)	(0.029)
Honolulu	0.231	0.222	0.080	0.137

Table B.1: Mean Inpatient Treatment Admissions for Cocaine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
	(0.061)	(0.099)	(0.031)	(0.057)
Albany - Capital Area	0.168	0.195	0.160	0.220
	(0.055)	(0.073)	(0.051)	(0.072)
Charlotte-Metro	0.168	0.178	0.212	0.261
	(0.103)	(0.054)	(0.053)	(0.054)
Tulsa	.	.	0.091	0.113
	.	.	(0.029)	(0.031)
Woodbury County	.	.	0.063	0.000
	.	.	(0.050)	.

Table B.2: Mean Inpatient Treatment Admissions for Heroin (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.208	0.310	0.339	0.316
	(0.056)	(0.057)	(0.109)	(0.069)
Washington DC	.	.	0.090	0.275
	.	.	(0.060)	(0.115)
Portland	0.318	0.288	0.370	0.318
	(0.065)	(0.084)	(0.098)	(0.072)
San Diego	0.117	0.372	0.195	0.231
	(0.048)	(0.089)	(0.066)	(0.075)
Indianapolis	0.000	0.054	0.079	0.145
	(0.000)	(0.042)	(0.063)	(0.107)
Houston	0.516	.	.	0.000
	(0.231)	.	.	.
Fort Lauderdale	0.028	.	.	.
	(0.037)	.	.	.
Detroit	0.431	0.081	.	.
	(0.240)	(0.055)	.	.
New Orleans	0.057	0.095	0.116	0.131
	(0.020)	(0.048)	(0.043)	(0.067)
Phoenix	0.174	0.212	0.225	0.084
	(0.040)	(0.085)	(0.073)	(0.032)
Chicago	0.060	0.147	0.097	0.208
	(0.027)	(0.053)	(0.024)	(0.060)
Dallas	0.035	0.328	0.411	0.480
	(0.036)	(0.223)	(0.151)	(0.129)
Birmingham	0.000	0.139	0.117	0.390
	(0.000)	(0.185)	(0.129)	(0.271)
Omaha	0.342	0.000	0.261	0.000
	(0.228)	(0.000)	(0.245)	(0.000)
Philadelphia	0.217	0.555	0.404	0.342
	(0.085)	(0.147)	(0.108)	(0.128)
Miami	0.470	.	.	0.462
	(0.199)	.	.	(0.249)
Cleveland	0.403	0.125	0.275	0.087
	(0.106)	(0.094)	(0.089)	(0.043)
San Antonio	0.359	0.057	0.072	0.142
	(0.135)	(0.029)	(0.033)	(0.078)
Kansas City - Jackson County	.	0.351	.	.
	.	(0.323)	.	.
San Jose	0.047	0.047	0.089	0.298
	(0.044)	(0.048)	(0.039)	(0.118)
Denver	0.215	0.124	0.229	0.043
	(0.082)	(0.090)	(0.105)	(0.027)
Atlanta	0.140	.	0.617	0.076
	(0.081)	.	(0.235)	(0.075)
Albuquerque	0.178	0.276	0.120	0.162
	(0.089)	(0.062)	(0.043)	(0.059)

Table B.2: Mean Inpatient Treatment Admissions for Heroin (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Minneapolis	1.520	0.290	0.448	0.467
	(0.729)	(0.139)	(0.149)	(0.174)
Sacramento	0.147	0.152	0.025	0.109
	(0.075)	(0.054)	(0.015)	(0.070)
Tucson	0.411	0.117	0.320	0.075
	(0.096)	(0.049)	(0.091)	(0.050)
Anchorage	0.316	0.292	0.000	0.000
	(0.268)	(0.237)	(0.000)	(0.000)
Des Moines	0.084	0.365	0.000	0.000
	(0.104)	(0.310)	(0.000)	(0.000)
Laredo	0.416	0.182	0.346	.
	(0.182)	(0.199)	(0.219)	.
Las Vegas	0.112	0.127	0.071	0.127
	(0.056)	(0.052)	(0.044)	(0.051)
Oklahoma City	0.524	0.164	0.357	0.554
	(0.275)	(0.098)	(0.181)	(0.233)
Salt Lake City	0.308	0.210	0.370	0.383
	(0.096)	(0.082)	(0.095)	(0.108)
Seattle	0.192	0.299	0.136	0.229
	(0.047)	(0.063)	(0.049)	(0.084)
Spokane	0.265	0.445	0.222	0.258
	(0.097)	(0.139)	(0.098)	(0.116)
Honolulu	0.317	0.425	0.148	0.410
	(0.153)	(0.249)	(0.089)	(0.196)
Albany - Capital Area	0.754	0.288	0.248	0.920
	(0.328)	(0.177)	(0.132)	(0.273)
Charlotte-Metro	0.000	0.270	0.550	0.490
	.	(0.172)	(0.337)	(0.452)
Tulsa	.	.	0.206	0.151
	.	.	(0.220)	(0.110)

Table B.3: Mean Inpatient Treatment Admissions for Marijuana (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.065	0.095	0.106	0.067
	(0.020)	(0.018)	(0.025)	(0.019)
Washington DC	.	.	0.004	0.041
	.	.	(0.004)	(0.018)
Portland	0.079	0.077	0.106	0.081
	(0.017)	(0.015)	(0.020)	(0.016)
San Diego	0.086	0.084	0.085	0.086
	(0.021)	(0.014)	(0.017)	(0.015)
Indianapolis	0.030	0.034	0.030	0.029
	(0.010)	(0.015)	(0.012)	(0.010)
Houston	0.047	.	.	0.049
	(0.016)	.	.	(0.029)
Fort Lauderdale	0.017	.	.	.
	(0.009)	.	.	.
Detroit	0.119	0.032	.	.
	(0.041)	(0.014)	.	.
New Orleans	0.023	0.033	0.029	0.049
	(0.007)	(0.013)	(0.011)	(0.017)
Phoenix	0.076	0.067	0.059	0.053
	(0.014)	(0.012)	(0.010)	(0.009)
Chicago	0.025	0.028	0.034	0.060
	(0.012)	(0.014)	(0.009)	(0.021)
Dallas	0.054	0.081	0.070	0.084
	(0.020)	(0.038)	(0.020)	(0.014)
Birmingham	0.031	0.037	0.029	0.050
	(0.018)	(0.016)	(0.010)	(0.021)
Omaha	0.020	0.025	0.050	0.047
	(0.010)	(0.010)	(0.013)	(0.013)
Philadelphia	0.063	0.093	0.107	0.081
	(0.019)	(0.023)	(0.025)	(0.018)
Miami	0.092	.	.	0.033
	(0.026)	.	.	(0.021)
Cleveland	0.052	0.050	0.046	0.080
	(0.013)	(0.016)	(0.010)	(0.022)
San Antonio	0.033	0.032	0.019	0.023
	(0.017)	(0.011)	(0.007)	(0.012)
Kansas City - Jackson County	.	0.105	.	.
	.	(0.039)	.	.
San Jose	0.064	0.064	0.049	0.067
	(0.027)	(0.016)	(0.012)	(0.016)
Denver	0.099	0.100	0.109	0.123
	(0.021)	(0.024)	(0.019)	(0.026)
Atlanta	0.021	.	0.068	0.034
	(0.010)	.	(0.018)	(0.011)
Albuquerque	0.049	0.107	0.089	0.047
	(0.019)	(0.020)	(0.030)	(0.013)

Table B.3: Mean Inpatient Treatment Admissions for Marijuana (Standard Errors in Parentheses)

Site	***2000***	***2001***	***2002***	***2003***
Minneapolis	0.166	0.116	0.108	0.085
	(0.095)	(0.035)	(0.029)	(0.022)
Sacramento	0.091	0.038	0.020	0.030
	(0.038)	(0.010)	(0.006)	(0.008)
Tucson	0.052	0.052	0.070	0.052
	(0.013)	(0.012)	(0.014)	(0.017)
Anchorage	0.091	0.072	0.062	0.083
	(0.021)	(0.020)	(0.015)	(0.021)
Des Moines	0.041	0.055	0.052	0.060
	(0.014)	(0.015)	(0.016)	(0.022)
Laredo	0.080	0.103	0.060	.
	(0.043)	(0.070)	(0.041)	.
Las Vegas	0.039	0.038	0.017	0.035
	(0.009)	(0.008)	(0.005)	(0.008)
Oklahoma City	0.077	0.048	0.058	0.063
	(0.016)	(0.010)	(0.013)	(0.017)
Salt Lake City	0.088	0.095	0.104	0.084
	(0.020)	(0.028)	(0.020)	(0.020)
Seattle	0.073	0.100	0.078	0.073
	(0.018)	(0.026)	(0.015)	(0.019)
Spokane	0.079	0.092	0.063	0.047
	(0.018)	(0.025)	(0.022)	(0.015)
Honolulu	0.095	0.042	0.100	0.039
	(0.026)	(0.014)	(0.034)	(0.014)
Albany - Capital Area	0.170	0.077	0.133	0.072
	(0.049)	(0.032)	(0.036)	(0.026)
Charlotte-Metro	0.124	0.060	0.105	0.083
	(0.076)	(0.018)	(0.026)	(0.020)
Tulsa	.	.	0.036	0.052
	.	.	(0.010)	(0.012)
Woodbury County	.	.	0.030	0.033
	.	.	(0.016)	(0.026)

Table B.4: Mean Inpatient Treatment Admissions for Methamphetamine (Standard Errors in Parentheses)

Site	***2000***	***2001***	***2002***	***2003***
New York	0.000	0.000	0.231	0.134
	.	(0.000)	(0.136)	(0.159)
Portland	0.177	0.185	0.160	0.156
	(0.044)	(0.043)	(0.037)	(0.036)
San Diego	0.103	0.089	0.110	0.123
	(0.026)	(0.020)	(0.023)	(0.023)
Indianapolis	0.013	0.023	0.000	0.144
	(0.014)	(0.023)	(0.000)	(0.105)
Houston	0.249	.	.	0.276
	(0.152)	.	.	(0.254)
Detroit	1.000	0.000	.	.
	.	(0.000)	.	.
New Orleans	0.170	0.000	0.000	0.000
	(0.229)	(0.000)	(0.000)	(0.000)
Phoenix	0.085	0.070	0.102	0.080
	(0.017)	(0.014)	(0.018)	(0.015)
Chicago	0.000	0.000	0.000	0.000
	.	.	(0.000)	(0.000)
Dallas	0.098	0.517	0.046	0.159
	(0.064)	(0.335)	(0.028)	(0.058)
Birmingham	0.000	0.938	0.081	0.328
	(0.000)	(0.321)	(0.072)	(0.234)
Omaha	0.036	0.043	0.103	0.073
	(0.019)	(0.028)	(0.033)	(0.027)
Philadelphia	0.705	0.893	0.164	0.411
	(0.212)	(0.855)	(0.157)	(0.232)
Cleveland	0.093	0.000	0.035	0.000
	(0.095)	.	(0.038)	(0.000)
San Antonio	0.022	0.105	0.249	0.020
	(0.016)	(0.068)	(0.192)	(0.019)
Kansas City - Jackson County	.	0.315	.	.
	.	(0.215)	.	.
San Jose	0.074	0.110	0.094	0.088
	(0.027)	(0.028)	(0.020)	(0.022)
Denver	0.034	0.124	0.114	0.028
	(0.025)	(0.061)	(0.041)	(0.017)
Atlanta	0.101	.	0.237	0.079
	(0.083)	.	(0.107)	(0.048)
Albuquerque	0.185	0.207	0.108	0.031
	(0.102)	(0.058)	(0.047)	(0.015)
Minneapolis	0.038	0.251	0.035	0.008
	(0.027)	(0.114)	(0.020)	(0.006)
Sacramento	0.146	0.041	0.044	0.040
	(0.079)	(0.012)	(0.013)	(0.013)
Tucson	0.043	0.035	0.054	0.069
	(0.027)	(0.018)	(0.017)	(0.041)

Table B.4: Mean Inpatient Treatment Admissions for Methamphetamine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Anchorage	0.080	0.024	0.162	0.342
	(0.057)	(0.026)	(0.103)	(0.178)
Des Moines	0.070	0.059	0.090	0.110
	(0.029)	(0.022)	(0.030)	(0.039)
Las Vegas	0.034	0.051	0.023	0.055
	(0.012)	(0.013)	(0.008)	(0.014)
Oklahoma City	0.191	0.082	0.084	0.085
	(0.056)	(0.024)	(0.023)	(0.029)
Salt Lake City	0.104	0.099	0.135	0.157
	(0.033)	(0.038)	(0.030)	(0.033)
Seattle	0.109	0.057	0.126	0.073
	(0.031)	(0.022)	(0.036)	(0.037)
Spokane	0.134	0.093	0.105	0.027
	(0.035)	(0.029)	(0.053)	(0.013)
Honolulu	0.138	0.035	0.101	0.082
	(0.032)	(0.014)	(0.035)	(0.028)
Albany - Capital Area	0.961	0.000	0.050	0.000
	(0.063)	(0.000)	(0.076)	(0.000)
Charlotte-Metro	0.000	0.234	0.882	0.326
	(0.000)	(0.246)	(0.550)	(0.268)
Tulsa	.	.	0.054	0.053
	.	.	(0.023)	(0.016)
Woodbury County	.	.	0.079	0.010
	.	.	(0.045)	(0.012)

Table B.5: Mean Outpatient Treatment Admissions for Cocaine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.408	0.162	0.206	0.223
	(0.160)	(0.031)	(0.041)	(0.055)
Washington DC	.	.	0.093	0.035
	.	.	(0.059)	(0.025)
Portland	0.126	0.112	0.206	0.242
	(0.028)	(0.023)	(0.039)	(0.054)
San Diego	0.046	0.117	0.033	0.089
	(0.021)	(0.032)	(0.014)	(0.027)
Indianapolis	0.147	0.146	0.041	0.093
	(0.039)	(0.033)	(0.014)	(0.030)
Houston	0.050	.	.	1.102
	(0.019)	.	.	(0.715)
Fort Lauderdale	0.017	.	.	.
	(0.010)	.	.	.
Detroit	0.349	0.167	.	.
	(0.109)	(0.107)	.	.
New Orleans	0.045	0.062	0.012	0.024
	(0.018)	(0.026)	(0.006)	(0.011)
Phoenix	0.059	0.073	0.074	0.075
	(0.014)	(0.015)	(0.016)	(0.023)
Chicago	0.040	0.175	0.059	0.089
	(0.022)	(0.083)	(0.015)	(0.030)
Dallas	0.072	0.035	0.071	0.074
	(0.023)	(0.023)	(0.019)	(0.018)
Birmingham	0.023	0.026	0.049	0.072
	(0.018)	(0.014)	(0.020)	(0.030)
Omaha	0.061	0.008	0.051	0.022
	(0.037)	(0.006)	(0.021)	(0.012)
Philadelphia	0.121	0.162	0.081	0.122
	(0.055)	(0.050)	(0.028)	(0.042)
Miami	0.125	.	.	0.069
	(0.071)	.	.	(0.032)
Cleveland	0.068	0.054	0.068	0.060
	(0.022)	(0.014)	(0.022)	(0.019)
San Antonio	0.102	0.028	0.133	0.061
	(0.077)	(0.014)	(0.090)	(0.038)
Kansas City - Jackson County	.	0.050	.	.
	.	(0.037)	.	.
San Jose	0.057	0.134	0.105	0.078
	(0.032)	(0.043)	(0.025)	(0.023)
Denver	0.084	0.044	0.058	0.074
	(0.025)	(0.015)	(0.017)	(0.029)
Atlanta	0.070	.	0.004	0.023
	(0.026)	.	(0.003)	(0.009)
Albuquerque	0.115	0.118	0.090	0.126
	(0.036)	(0.027)	(0.025)	(0.042)

Table B.5: Mean Outpatient Treatment Admissions for Cocaine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Minneapolis	0.244	0.047	0.068	0.036
	(0.174)	(0.012)	(0.018)	(0.016)
Sacramento	0.030	0.047	0.056	0.080
	(0.015)	(0.020)	(0.017)	(0.027)
Tucson	0.062	0.082	0.056	0.039
	(0.016)	(0.020)	(0.013)	(0.014)
Anchorage	0.111	0.077	0.086	0.102
	(0.037)	(0.029)	(0.027)	(0.040)
Des Moines	0.113	0.110	0.088	0.095
	(0.044)	(0.049)	(0.037)	(0.034)
Laredo	0.149	0.039	0.150	.
	(0.055)	(0.039)	(0.129)	.
Las Vegas	0.034	0.034	0.021	0.054
	(0.012)	(0.011)	(0.008)	(0.016)
Oklahoma City	0.031	0.063	0.067	0.023
	(0.011)	(0.024)	(0.022)	(0.013)
Salt Lake City	0.168	0.092	0.146	0.075
	(0.044)	(0.031)	(0.035)	(0.025)
Seattle	0.166	0.131	0.153	0.159
	(0.029)	(0.031)	(0.033)	(0.033)
Spokane	0.070	0.112	0.132	0.119
	(0.024)	(0.031)	(0.036)	(0.040)
Honolulu	0.136	0.170	0.158	0.000
	(0.043)	(0.100)	(0.066)	(0.000)
Albany - Capital Area	0.148	0.081	0.116	0.224
	(0.061)	(0.030)	(0.053)	(0.076)
Charlotte-Metro	0.129	0.146	0.125	0.069
	(0.085)	(0.043)	(0.040)	(0.027)
Tulsa	.	.	0.010	0.042
	.	.	(0.008)	(0.018)
Woodbury County	.	.	0.360	0.000
	.	.	(0.201)	.

Table B.6: Mean Outpatient Treatment Admissions for Heroin (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.273	0.466	0.362	0.364
	(0.060)	(0.091)	(0.089)	(0.094)
Washington DC	.	.	0.206	0.087
	.	.	(0.163)	(0.052)
Portland	0.217	0.153	0.183	0.248
	(0.052)	(0.044)	(0.055)	(0.061)
San Diego	0.214	0.167	0.172	0.147
	(0.101)	(0.057)	(0.065)	(0.073)
Indianapolis	0.158	0.113	0.065	0.253
	(0.088)	(0.115)	(0.066)	(0.169)
Houston	0.176	.	.	0.000
	(0.128)	.	.	.
Fort Lauderdale	0.000	.	.	.
	(0.000)	.	.	.
Detroit	0.270	0.321	.	.
	(0.166)	(0.249)	.	.
New Orleans	0.060	0.095	0.037	0.044
	(0.026)	(0.045)	(0.018)	(0.023)
Phoenix	0.078	0.130	0.113	0.091
	(0.032)	(0.035)	(0.040)	(0.041)
Chicago	0.076	0.043	0.097	0.201
	(0.034)	(0.024)	(0.029)	(0.066)
Dallas	0.227	0.102	0.159	0.227
	(0.139)	(0.079)	(0.082)	(0.095)
Birmingham	0.000	0.139	0.453	0.000
	(0.000)	(0.185)	(0.313)	(0.000)
Omaha	0.234	0.000	0.000	0.000
	(0.168)	(0.000)	(0.000)	(0.000)
Philadelphia	0.346	0.182	0.146	0.171
	(0.232)	(0.084)	(0.062)	(0.068)
Miami	0.144	.	.	0.000
	(0.083)	.	.	(0.000)
Cleveland	0.103	0.000	0.197	0.055
	(0.049)	(0.000)	(0.077)	(0.033)
San Antonio	0.170	0.039	0.071	0.000
	(0.134)	(0.024)	(0.068)	(0.000)
Kansas City - Jackson County	.	0.000	.	.
	.	(0.000)	.	.
San Jose	0.006	0.199	0.082	0.109
	(0.007)	(0.121)	(0.040)	(0.061)
Denver	0.110	0.066	0.182	0.087
	(0.084)	(0.034)	(0.069)	(0.047)
Atlanta	0.183	.	0.047	0.074
	(0.130)	.	(0.050)	(0.062)
Albuquerque	0.226	0.120	0.114	0.153
	(0.129)	(0.043)	(0.050)	(0.061)

Table B.6: Mean Outpatient Treatment Admissions for Heroin (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Minneapolis	0.950	0.241	0.230	0.102
	(0.514)	(0.116)	(0.138)	(0.060)
Sacramento	0.000	0.019	0.088	0.083
	(0.000)	(0.014)	(0.041)	(0.051)
Tucson	0.070	0.036	0.081	0.018
	(0.049)	(0.036)	(0.039)	(0.019)
Anchorage	0.280	0.000	0.000	0.146
	(0.182)	(0.000)	(0.000)	(0.157)
Des Moines	0.084	0.000	1.029	0.104
	(0.104)	(0.000)	(0.173)	(0.072)
Laredo	0.261	0.000	0.544	.
	(0.124)	(0.000)	(0.442)	.
Las Vegas	0.195	0.030	0.040	0.087
	(0.080)	(0.018)	(0.028)	(0.040)
Oklahoma City	0.000	0.208	0.312	0.146
	(0.000)	(0.217)	(0.173)	(0.141)
Salt Lake City	0.310	0.150	0.208	0.135
	(0.108)	(0.062)	(0.066)	(0.059)
Seattle	0.269	0.183	0.131	0.270
	(0.065)	(0.056)	(0.040)	(0.093)
Spokane	0.069	0.309	0.238	0.107
	(0.040)	(0.107)	(0.093)	(0.065)
Honolulu	0.325	0.295	0.038	0.075
	(0.112)	(0.210)	(0.039)	(0.075)
Albany - Capital Area	0.000	0.025	0.024	0.530
	(0.000)	(0.027)	(0.016)	(0.191)
Charlotte-Metro	0.000	0.399	0.492	0.035
	.	(0.212)	(0.219)	(0.039)
Tulsa	.	.	0.000	0.070
	.	.	(0.000)	(0.062)

Table B.7: Mean Outpatient Treatment Admissions for Marijuana (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.179	0.084	0.102	0.078
	(0.075)	(0.019)	(0.023)	(0.021)
Washington DC	.	.	0.053	0.014
	.	.	(0.023)	(0.008)
Portland	0.110	0.147	0.136	0.134
	(0.032)	(0.032)	(0.023)	(0.023)
San Diego	0.063	0.067	0.070	0.051
	(0.027)	(0.013)	(0.014)	(0.012)
Indianapolis	0.078	0.075	0.021	0.059
	(0.017)	(0.015)	(0.008)	(0.014)
Houston	0.033	.	.	0.138
	(0.011)	.	.	(0.121)
Fort Lauderdale	0.003	.	.	.
	(0.002)	.	.	.
Detroit	0.075	0.052	.	.
	(0.023)	(0.026)	.	.
New Orleans	0.032	0.046	0.008	0.014
	(0.015)	(0.017)	(0.004)	(0.006)
Phoenix	0.044	0.042	0.048	0.029
	(0.010)	(0.007)	(0.008)	(0.006)
Chicago	0.025	0.083	0.033	0.052
	(0.012)	(0.065)	(0.012)	(0.021)
Dallas	0.030	0.016	0.045	0.030
	(0.010)	(0.010)	(0.012)	(0.008)
Birmingham	0.041	0.002	0.022	0.060
	(0.023)	(0.002)	(0.011)	(0.023)
Omaha	0.031	0.020	0.043	0.013
	(0.016)	(0.009)	(0.014)	(0.006)
Philadelphia	0.099	0.079	0.039	0.055
	(0.052)	(0.027)	(0.012)	(0.017)
Miami	0.081	.	.	0.062
	(0.048)	.	.	(0.026)
Cleveland	0.026	0.042	0.030	0.063
	(0.006)	(0.015)	(0.007)	(0.016)
San Antonio	0.056	0.040	0.023	0.052
	(0.034)	(0.014)	(0.011)	(0.028)
Kansas City - Jackson County	.	0.047	.	.
	.	(0.023)	.	.
San Jose	0.032	0.060	0.066	0.077
	(0.013)	(0.015)	(0.011)	(0.017)
Denver	0.040	0.028	0.039	0.033
	(0.011)	(0.009)	(0.010)	(0.012)
Atlanta	0.022	.	0.005	0.015
	(0.009)	.	(0.003)	(0.005)
Albuquerque	0.051	0.055	0.029	0.078
	(0.022)	(0.015)	(0.012)	(0.020)

Table B.7: Mean Outpatient Treatment Admissions for Marijuana (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Minneapolis	0.098	0.052	0.048	0.025
	(0.062)	(0.021)	(0.012)	(0.007)
Sacramento	0.034	0.014	0.030	0.059
	(0.012)	(0.005)	(0.008)	(0.015)
Tucson	0.044	0.051	0.037	0.051
	(0.012)	(0.013)	(0.009)	(0.016)
Anchorage	0.096	0.050	0.107	0.041
	(0.023)	(0.014)	(0.038)	(0.014)
Des Moines	0.071	0.117	0.070	0.082
	(0.019)	(0.022)	(0.016)	(0.027)
Laredo	0.087	0.048	0.095	.
	(0.049)	(0.034)	(0.081)	.
Las Vegas	0.044	0.026	0.026	0.019
	(0.010)	(0.006)	(0.007)	(0.005)
Oklahoma City	0.016	0.022	0.041	0.025
	(0.005)	(0.007)	(0.011)	(0.009)
Salt Lake City	0.102	0.104	0.121	0.064
	(0.024)	(0.027)	(0.024)	(0.016)
Seattle	0.117	0.057	0.132	0.082
	(0.018)	(0.013)	(0.028)	(0.020)
Spokane	0.078	0.108	0.085	0.074
	(0.022)	(0.027)	(0.019)	(0.021)
Honolulu	0.053	0.046	0.045	0.024
	(0.015)	(0.015)	(0.017)	(0.015)
Albany - Capital Area	0.116	0.049	0.095	0.147
	(0.032)	(0.016)	(0.030)	(0.056)
Charlotte-Metro	0.044	0.092	0.067	0.046
	(0.026)	(0.026)	(0.021)	(0.014)
Tulsa	.	.	0.023	0.031
	.	.	(0.008)	(0.009)
Woodbury County	.	.	0.149	0.034
	.	.	(0.075)	(0.027)

Table B.8: Mean Outpatient Treatment Admissions for Methamphetamine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
New York	0.000	0.000	0.176	0.371
	.	(0.000)	(0.122)	(0.276)
Portland	0.122	0.147	0.166	0.259
	(0.029)	(0.028)	(0.031)	(0.056)
San Diego	0.038	0.098	0.124	0.086
	(0.018)	(0.020)	(0.026)	(0.021)
Indianapolis	0.416	0.183	0.039	0.169
	(0.259)	(0.095)	(0.029)	(0.119)
Houston	0.000	.	.	1.457
	(0.000)	.	.	(1.138)
Detroit	1.000	0.000	.	.
	.	(0.000)	.	.
New Orleans	0.511	0.108	0.087	0.000
	(0.687)	(0.125)	(0.110)	(0.000)
Phoenix	0.067	0.072	0.055	0.055
	(0.017)	(0.014)	(0.011)	(0.011)
Chicago	0.000	0.000	0.000	0.000
	.	.	(0.000)	(0.000)
Dallas	0.062	0.150	0.089	0.124
	(0.034)	(0.140)	(0.058)	(0.050)
Birmingham	0.000	0.312	0.000	0.109
	(0.000)	(0.257)	(0.000)	(0.106)
Omaha	0.021	0.020	0.063	0.052
	(0.015)	(0.018)	(0.021)	(0.024)
Philadelphia	0.288	0.229	0.164	0.100
	(0.210)	(0.274)	(0.157)	(0.101)
Cleveland	0.093	1.000	0.291	0.000
	(0.095)	.	(0.202)	(0.000)
San Antonio	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Kansas City - Jackson County	.	0.089	.	.
	.	(0.070)	.	.
San Jose	0.090	0.091	0.166	0.097
	(0.028)	(0.019)	(0.023)	(0.020)
Denver	0.148	0.106	0.129	0.008
	(0.078)	(0.057)	(0.049)	(0.006)
Atlanta	0.230	.	0.014	0.000
	(0.208)	.	(0.014)	(0.000)
Albuquerque	0.266	0.134	0.080	0.113
	(0.154)	(0.042)	(0.045)	(0.045)
Minneapolis	0.114	0.232	0.066	0.020
	(0.069)	(0.186)	(0.033)	(0.014)
Sacramento	0.052	0.019	0.035	0.092
	(0.020)	(0.007)	(0.011)	(0.023)
Tucson	0.048	0.043	0.044	0.046
	(0.023)	(0.024)	(0.017)	(0.024)

Table B.8: Mean Outpatient Treatment Admissions for Methamphetamine (Standard Errors in Parentheses)

Site	*2000*	*2001*	*2002*	*2003*
Anchorage	0.035	0.317	0.282	0.067
	(0.026)	(0.236)	(0.144)	(0.053)
Des Moines	0.050	0.097	0.131	0.151
	(0.022)	(0.028)	(0.035)	(0.054)
Las Vegas	0.045	0.037	0.030	0.037
	(0.015)	(0.010)	(0.009)	(0.013)
Oklahoma City	0.026	0.034	0.037	0.053
	(0.012)	(0.017)	(0.016)	(0.023)
Salt Lake City	0.112	0.132	0.088	0.105
	(0.041)	(0.039)	(0.021)	(0.022)
Seattle	0.081	0.027	0.108	0.064
	(0.026)	(0.013)	(0.040)	(0.033)
Spokane	0.036	0.082	0.095	0.040
	(0.017)	(0.024)	(0.028)	(0.019)
Honolulu	0.068	0.054	0.067	0.059
	(0.020)	(0.018)	(0.023)	(0.028)
Albany - Capital Area	0.000	0.000	0.050	0.000
	(0.000)	(0.000)	(0.076)	(0.000)
Charlotte-Metro	0.000	0.187	0.000	0.091
	(0.000)	(0.208)	(0.000)	(0.101)
Tulsa	.	.	0.018	0.026
	.	.	(0.012)	(0.012)
Woodbury County	.	.	0.330	0.032
	.	.	(0.151)	(0.032)

B.3 A National Estimate of Treatment Admission Rates

The previous ADAM calculations provide an admissions rate in each of the ADAM sites representing the R_T in the equation [3.3]. Unfortunately, calculations cannot simply divide the frequencies from TEDS by the ADAM rates as there are as many as 298 CBSAs in TEDS but there are a maximum of 38 valid ADAM sites with treatment admissions rates. Additionally, the ADAM survey was conducted between 2000 and 2003 but TEDS data come from 2000 to 2006.

To perform the calculations, it was therefore necessary to calculate a representative statistic of the rates of admission from ADAM and forecast the rates for 2004, 2005 and 2006. This was accomplished by computing a weighted mean of treatment admissions rates over time and across sites. First, values for years in sites that had missing estimated mean rates of treatment admission were imputed by using the estimated values with the mean of the existing rates. This imputation was done for all drugs except methamphetamine. For methamphetamine, imputed zero was simply imputed for the missing values as the methamphetamine problem is geographically limited and as a consequence it is reasonable to assume that most of these sites did not have any treatment admissions for methamphetamine.

After imputation the weighted mean was calculated by using a separate estimate for the number of chronic users with an ADAM county for each individual drug in each individual year. The calculations were as follows:

Let j = 1 to J represent the j[th] ADAM site in the analysis and where J is the total number of ADAM sites in the analysis.

Let t = 1 to 4 be the years in the analysis. Where 1 represents 2000, 2 represents 2001, 3 represents 2002 and 4 represents 2003.

R_{jt} is the previously estimated or imputed treatment admission rate for ADAM site j in year t. The procedure for estimating Rjt is described in Rhodes et al. (2007).

C_{jt} is the alternatively estimated number of chronic users in ADAM site j in year t.

First, calculate C_{jt} as the proportion of the number of chronic users in site j at time t relative to the total number of chronic users across years. Formally,

$$P_{jt} = \frac{C_{jt}}{\sum_{j=1}^{J}\sum_{t=1}^{4} C_{jt}}$$ such that $$\sum_{j=1}^{J}\sum_{t=1}^{4} P_{jt} = 1$$

Second, calculate W_{jt} or the weighted treatment rate for each ADAM site in each year as $W_{jt} = C_{jt} \times P_{jt}$

Finally, calculate the national treatment rate as $$R_{TN} = \sum_{J=1}^{J}\sum_{t=1}^{4} W_{jt}$$

Appendix C: National Estimates of Chronic Drug Use

A ratio estimator was used to derive national estimates of the number of chronic drug users, exclusive of ADAM sites. To explain, let:

$\hat{C}_i$ represent the estimated number of chronic drug users in each of the ADAM sites, where i=1…39.

$\hat{V}_i$ represent the indicator variable for chronic drug users in each of the ADAM sites, where i=1…39.

The first step was to estimate the regression:

$$\frac{\hat{C}_i}{\sqrt{\hat{V}_i}} = \delta\sqrt{\hat{V}_i} + e_i$$

where δ is a scalar parameter and e_i is a random error with mean zero. Note that the weighted OLS estimate is:

$$\hat{\delta} = \frac{\sum_i C_i}{\sum_i V_i}$$

The regression provides an estimate of $\sigma^2_{\hat{\delta}}$, the sampling variance for δ.

Then an estimate of chronic drug users outside the ADAM sites is:

$$\hat{C} = \hat{\delta}\sum_i \hat{V}_i$$

where the sum is over all counties in the United States, excluding counties that participate in ADAM.

and the sampling variance is:

$$\sigma^2_{\hat{C}} = \sigma^2_{\hat{\delta}}\left[\sum_i V_i\right]^2$$

where the sum is over all counties in the United States, excluding counties that participate in ADAM.

Survey researchers commonly use the ratio estimator, but econometricians might be inclined to use a different estimator. That choice is discussed here, arguing for use of the ratio estimator.

In general, one could estimate a weighted least squares regression as:

[C.1] $$\frac{C_i}{w_i} = \delta \frac{V_i}{w_i} + \varepsilon_i$$

Different choices of the weights result in different estimates. A key point here is to recognize that both C_i and V_i are measured with considerable error. One might ignore the error in C_i because that error will be captured in ε_i, and so long as the error has zero mean, this will not bias the parameter estimate of δ. However, error in the measurement of V_i will bias the estimate of δ for some weighting scheme.

To demonstrate the above assertion, the study follows the argument in Greene (2003, page 85) showing the bias resulting from measurement error in an ordinary least squares regression. This argument ignores the error in C_i, because that error does not affect the bias. It is presumed that the error occurs in the measurement of V_i, so that one observes:

[C.2] $V_i' = V_i + e_i$ where $E(e_i) = 0$.

Then the estimator for δ is:

[C.3] $$\hat{\delta} = \frac{\sum C_i V_i' / w_i^2 -}{\sum V_i'^2 / w_i^2}$$

Substituting [C.1] and [C.2] into [C.3], produces:

[C.4] $$E(\hat{\delta}) = \frac{\sum (\delta V_i + \varepsilon_i)(V_i + e_i) / w_i^2}{\sum (V_i + e_i)^2 / w_i^2}$$

Multiplying [C.4] through and taking the probability limit yields the expected value. If all observations are weighted equally, then:

[C.5] $$E(\hat{\delta}) = \frac{\delta \sigma_V^2}{\sigma_V^2 + \sigma_e^2} = \frac{\delta}{1 + \frac{\sigma_e^2}{\sigma_V^2}}$$ when $w_i = 1$

When there is no measurement error, $\sigma_e^2 = 0$, and the estimate of δ is unbiased. When there is measurement error, the estimate of δ is biased downward.

Bias is avoided by giving observations with high V more weight than those with lower V. Specifically, let $w_i = \sqrt{V'_i}$. Substituting this weight into [C.1] and taking the probability limit yields:

[C.6]
$$E(\hat{\delta}) = E\left[\frac{\sum (\delta V_i + \varepsilon_i)}{\sum (V_i + e_i)}\right] = \delta$$

Hence the attraction of the ratio estimator is that it provides an unbiased estimate of δ .

Although $w_i = \sqrt{V_i}$ will produce an unbiased estimate of $\hat{\delta}$, the same cannot be said about the estimated sampling error for $\hat{\delta}$. In general the error term $\varepsilon_i / \sqrt{V'_i}$ will be heteroscedastic, and heteroscedasticity will cause the estimated sampling error for δ to be biased. To deal with this problem, a heteroscedastic-consistent estimation procedure was used, but in fact the standard errors were not affected.

Appendix D: Extending Prevalence Estimates to 2004–2006

A limitation of the ADAM-based methodology is that the collection of ADAM data stopped in 2003 and the collection of ADAM II data only restarted in ten counties during 2007. Developing estimates for 2004 through 2006 requires projecting the 2000–2003 adult chronic user estimates forward. This section describes that methodology, which uses both the ADAM data and the Treatment Episode Data Set (TEDS) data.

Presuming that only serious or chronic users enter substance abuse treatment, the number of adult chronic drug users can be counted as they enter treatment. If C adult chronic drug users generate an average of R_T treatment admissions per year, then during a year there will be:

$$T = CxR_T$$

treatment admissions. Estimates of T and R_T, then, lead to estimates of the number of adult chronic drug users according to the formula:

$$\hat{C} = \frac{\hat{T}}{\hat{R}_T} \qquad [D.1]$$

Formula [D.1] provides the estimation approach used for this report because credible estimates of T and R_T are available. The source is identified below.

D.1. Adult Treatment Admissions According to TEDS: Estimating T

TEDS provides counts of the number of adult users (18 and older) who enter substance abuse treatment for 2000 through 2006. These counts probably underestimate treatment admissions because TEDS' coverage is not comprehensive of all treatment programs, although it does include those that received public funding for providing treatment services. Consequently, TEDS-based estimates are likely to underestimate the number of chronic drug users. Somewhat offsetting this downward bias, many treatment admissions are sequential (e.g., detoxification to outpatient), but counted as two entries (two people) in TEDS. Although the TEDS data collection protocol attempts to minimize such double counting, some undoubtedly still exists. It is unlikely that these two biases perfectly offset each other.

TEDS allows separate tabulations of outpatient and inpatient treatment episodes. The sum of outpatient and inpatient admissions could provide $\hat{T}$ for formula [D.1]. Instead, this study derives separate admissions rates R_T for inpatient and outpatient treatment from ADAM, and it consequently develops separate estimates of C based on inpatient and outpatient admissions. In this way, two estimates of chronic drug use were developed, from which this report selects one as the more credible.

TEDS also provides separate tabulations of treatment admissions for males and females. Given that treatment admission rates vary with gender, that distinction is important. Therefore, a further refinement of formula [D.1] comes from distinguishing between treatment admissions for men and women, an important step because most ADAM sites also collected questions about entering substance abuse treatment from a non-probability sample of woman arrestees. For study purposes, the survey of woman arrestees is treated as if it were a simple random sample.[92]

Finally, TEDS allows separate tabulations by drug of abuse. TEDS identifies the primary, secondary and tertiary drug of abuse reported by the client at the time of admission. The study distinguishes admissions for cocaine, heroin and methamphetamine. An admission is for cocaine if cocaine is identified as the primary or secondary drug. [93] Similar rules apply for heroin and methamphetamine.

Table D.1 shows a tabulation of the number of adult treatment admissions by year for three drugs, two genders, and two types of treatment so there are 3x2x2 = 12 cells per year not counting the totals.[94] This table provides estimates of T that enter the numerator of a refined version of equation [D.1] where the refinements account for treatment type and gender.

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92 The ADAM sampling procedures for males assure that the sample is reasonably balanced, so that weighted and unweighted estimates are similar. This is not necessarily true for the female sample. One justification for believing that an unweighted sample of females, nevertheless, provides estimates with small bias is that the female samples are essentially take-every samples. Unfortunately, they are only take-every samples during the periods when interviewers are stationed at the jails, so they may be unrepresentative for other women booked into jail.

93 The justification is that using the primary and secondary drug of abuse leads to TEDS-based estimates that were closest to the ADAM-based estimates for 2000–2003. When the tabulations include tertiary drug of abuse, the TEDS-based estimates were higher than the ADAM-based estimates. The differences are not large, however, as most treatment admissions for the drugs of interest are primary or secondary.

94 These are treatment admissions not drug users because a single user may have entered treatment more than once during the year. A single user may be represented in more than one row, for example if he or she had cocaine as the primary drug of admission and heroin as the secondary drug. The estimation methodology requires that T be treatment admissions not a count of admitted drug users; it requires that chronic drug users be counted for each drug they use. Thus the methodology used to tabulate these data is consistent with the methodology used to estimate chronic users.

Table D.1: Number of Adult Inpatient and Outpatient Treatment Admissions by Drug, Gender and Year (Drug either Primary or Secondary at Admission)

Outpatient	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Cocaine							
Male	144,053	141,220	151,989	155,448	157,215	155,498	155,376
Female	99,343	96,342	100,113	102,128	105,528	104,558	103,223
Totals	243,396	237,562	252,102	257,576	262,743	260,056	258,599
Heroin							
Male	104,377	105,621	107,144	100,510	96,965	92,258	89,904
Female	57,546	57,262	58,263	56,267	54,091	51,682	49,570
Totals	161,923	162,883	165,407	156,777	151,056	143,940	139,474
Methamphetamine							
Male	28,848	36,816	50,363	54,502	58,976	65,505	70,631
Female	26,055	30,677	37,472	41,599	47,087	53,988	56,534
Totals	54,903	67,493	87,835	96,101	106,063	119,493	127,165
Inpatient	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Cocaine							
Male	161,645	160,670	169,247	168,686	164,288	164,757	161,437
Female	77,571	74,350	77,879	77,650	74,505	74,899	73,972
Totals	239,216	235,020	247,126	246,336	238,793	239,656	235,409
Heroin							
Male	106,812	112,147	117,119	113,494	106,878	103,805	100,811
Female	41,690	42,483	44,512	43,555	41,218	39,247	39,091
Totals	148,502	154,630	161,631	157,049	148,096	143,052	139,902
Methamphetamine							
Male	21,499	23,826	28,632	30,669	33,435	38,980	35,144
Female	15,161	16,838	20,282	21,399	22,773	28,356	26,948
Totals	36,660	40,664	48,914	52,068	56,208	67,336	62,092

D.2. Admission Frequency According to ADAM: Estimating R_T

Data from the ADAM calendar lead to estimates of the rate at which users in the adult arrestee population generate treatment admissions, the denominator of equation [D.1].[95] The definition of chronic users for these calculations differs from the earlier definition, because treatment admissions apply to the last year and thus a definition of chronic use as frequent use during the last month will not work. Instead, for this narrow purpose, chronic users are defined as individuals who used a drug two or more times per week in any of the last 11 months in the ADAM calendar. Using weights developed in a separate study, these estimates generalize the rate of treatment admissions for adult male arrestees to the general population of drug users (Rhodes et al, 2007). For females, the estimates are assumed to approximate the admission rates for chronic drug users in the general population, because the separate study did not develop weights for females. ADAM counties provided four estimates: inpatient treatment admission rates for males and for females and outpatient treatment admission rates for

[95] The base includes all arrestees who said they had used cocaine, heroin or methamphetamine sometime during the year before being arrested; that is, for cocaine treatment admission rates, data pertained to offenders who said they had used cocaine during the last years. Similar selection rules applied to heroin and methamphetamine users.

males and for females for each of three drug types: cocaine, heroin and methamphetamine. The study estimated a national average for each of these four county-specific estimates using as weights the distribution of chronic adult male drug users across the ADAM sites.[96] Table D.2 reports estimates. For example, on average a chronic male cocaine user generates 0.158 inpatient and 0.120 outpatient treatment admissions per year.

Table D.2: Preliminary Estimated National Rate of Treatment Admissions per Year for Adult Chronic Drug Users Based on ADAM Calendar Data

	Inpatient	*Outpatient*
Cocaine		
Male	0.158	0.120
Female	0.150	0.116
Heroin		
Male	0.185	0.137
Female	0.246	0.263
Methamphetamine		
Male	0.089	0.079
Female	0.122	0.112

Before pursuing this further, it is important to note the limitations of these estimates. Contrary to evidence in Table D.2 that outpatient admissions exceed inpatient admissions (particularly for methamphetamine), the calculated treatment admission rate is higher for inpatient than it is for outpatient. One speculation is that arrestees may have experienced inpatient substance abuse treatment as part of a term of incarceration. Those treatment episodes would be defined as inpatient by ADAM but are not likely to be reported to TEDS.[97] Another speculation is that TEDS misses many treatment admissions for detoxification, while these are reported by ADAM respondents. These two explanations suggest that estimates based on outpatient treatment admissions are more reliable than estimates based on inpatient treatment admissions.

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96 If site A had twice as many chronic drug users as site B, then site A received a weight that was twice as large as that of site B. For reasons discussed in Appendix A, Chicago and Philadelphia were excluded, reducing the number of ADAM counties to 38. See Appendix A for details.

97 In general, TEDS facilities receive state alcohol or drug agency funding for providing alcohol or drug treatment services. Substance Abuse Mental Health Services Administration, Office of Applied Studies, Treatment Episode Data Set (TEDS) 1995–2005, June 2007. TEDS documentation does not clearly state whether or not treatment delivered through jails and prisons would typically be reported to the TEDS system, except to say that Federal prisons do not report to TEDS. According to the Bureau of Justice Statistics, about 23,000 jail inmates received substance abuse treatment during 2002. This number understates the receipt of treatment because (1) it is based on a point-prevalence estimates of jail populations so it would understate the number of offenders in jails during the year and (2) offenders may have entered substance abuse treatment subsequent to the interview (James & Karberg, 2005, Table 11). Almost all prisons offer substance abuse treatment programs (Karberg & Stephan, 2003, Table 17). With respect to the 1997 prison population, 10 percent of prisoners had participated in treatment as of their admission. This may understate the receipt of treatment because treatment may not occur until the offender's sentence approaches its end. Nevertheless, about 15 percent of 807,000 state prisoners and 12 percent of 73,000 Federal prisoners had participated in substance abuse treatment since being admitted to prison (Mumola, 1999, Tables 14 and 15).

It is also possible that the average admission rates across the 40 ADAM sites are higher or lower than the average admission rates across the entire U.S., so using the average across the 40 ADAM sites could differ from the actual national treatment admission rates. However, the 40 ADAM counties do account for 36 percent of national treatment admissions, which represent a large sample. Furthermore, a TEDS variable which captures prior treatment admission for everyone entering a substance abuse program can be used to help quantify the potential difference between the ADAM sites and the average site nationally, namely, whether the average number of prior treatment admissions differs between the ADAM sites and other sites.

The following exercise reveals the potential variations. Over the seven-year period the average number of prior admissions for cocaine among non-ADAM and among ADAM sites was virtually identical, with a ratio of 0.968. For heroin, non-ADAM sites showed prior admissions 21 percent higher than for ADAM sites. For methamphetamine during the same period, the non-ADAM prior admissions were 20 percent lower than those recorded at ADAM sites. Because the ADAM treatment rate is used in the denominator of the formula this means that, unadjusted, this method would overestimate the number of heroin users and underestimate methamphetamine users. For methamphetamine, this is also likely because of the chosen 2003 sites, over half were in the Western states and mid-West areas where methamphetamine use was inordinately high, as well as epicenters such as Hawaii and Southern California.

In order to counter this bias, the methodology adjusts the treatment admission rates based on ADAM data and TEDS data in Table D.3. This table shows the prior admission rates, comparing non-ADAM and ADAM sites.

Table D.3: Lifetime Prior Admission Rates as a Function of Primary Drug and Time According to TEDS

Year	*Site*	*Cocaine*	*Heroin*	*Methamphetamine*
2000	Non-ADAM sites	1.52	2.46	0.89
	ADAM sites	1.65	2.23	1.10
	National average	1.57	2.37	0.97
2001	Non-ADAM sites	1.55	2.57	0.88
	ADAM sites	1.65	2.10	1.08
	National average	1.59	2.39	0.94
2002	Non-ADAM sites	1.55	2.50	0.86
	ADAM sites	1.54	1.99	1.09
	National average	1.54	2.31	0.94
2003	Non-ADAM sites	1.59	2.45	0.90
	ADAM sites	1.60	2.05	1.14
	National average	1.59	2.29	0.98
2004	Non-ADAM sites	1.62	2.49	0.94
	ADAM sites	1.63	2.11	1.17
	National average	1.62	2.34	1.01
2005	Non-ADAM sites	1.50	2.43	0.89
	ADAM sites	1.51	1.90	1.12
	National average	1.50	2.27	0.96
2006	Non-ADAM sites	1.42	2.45	0.92
	ADAM sites	1.53	1.91	1.10
	National average	1.45	2.29	0.97

Table D.3: Lifetime Prior Admission Rates as a Function of Primary Drug and Time According to TEDS

Year	Site	Cocaine	Heroin	Methamphetamine
All Years	Non-ADAM sites	1.54	2.48	0.90
	ADAM sites	1.59	2.06	1.12
	National average	1.56	2.33	0.97

The final treatment rates are adjusted using the formula:

$$R_{national} = P \bullet R_{ADAM} + (1-P)\left(ADJ \bullet R_{ADAM}\right)$$

Where:

P = The proportion of treatment admissions from ADAM sites: P = 0.36.

R_{ADAM} = The treatment admission rate reported in Table D.2.

ADJ = This is an adjustment factor derived from Table D.3:

ADJ = 0.968 for cocaine

ADJ = 1.214 for heroin

ADJ = 0.805 for methamphetamine

$R_{national}$ = The best estimate of treatment admission rates

Final rates $R_{national}$ used in the rest of the calculations appear in Table D.4.

Table D.4: Final Estimated National Rate of Treatment Admissions per Year for Adult Chronic Drug Users Based on ADAM Calendar Data Adjusted Using TEDS Data

	Inpatient	Outpatient
Cocaine		
Male	0.154	0.118
Female	0.146	0.114
Heroin		
Male	0.211	0.156
Female	0.280	0.299
Methamphetamine		
Male	0.078	0.069
Female	0.107	0.098

ADAM data are unavailable for 2004 through 2006. In order to develop estimates for those years, this study must either assume a constant treatment admissions rate for those years or estimate a trend. For these estimates treatment admission rates are assumed to remain constant, with the following evidence supporting this assumption. Though ADAM data are unavailable for this time period, NSDUH can provide some evidence of trends. From the NSDUH, the study estimated the rate at which chronic drug users report entering substance abuse treatment during the year of the survey.[98] For this purpose, a chronic

[98] See Appendix E for methodology.

drug user is someone who used the specified drug on 4 or more days during the month before the interview. The results of these tabulations are shown in Table D.5. After averaging 2002 and 2003 for cocaine (to account for changes in survey methodology), there is no evidence that treatment admissions for cocaine changed materially between 2002 and 2006. The picture is less clear for heroin, but the confidence intervals (not shown in the figure) are sufficiently wide that year-to-year variations in the estimates are not significantly different from each other. Data are too sparse for methamphetamine treatment admissions to provide any useful inferences.

Table D.5: NSDUH Calculations of Chronic Drug Users and Treatment Entry

	2002	***2003***	***2004***	***2005***	***2006***
Cocaine					
Treated	157,346	57,309	128,801	120,496	137,512
Number chronic	790,440	758,451	895,454	807,761	925,631
Proportion treated	0.199	0.076	0.144	0.149	0.149
Heroin					
Treated	36,624	22,799	51,619	26,818	132,696
Number chronic	114,316	91,031	118,041	84,214	229,121
Proportion treated	0.320	0.250	0.437	0.318	0.579

Note: All estimates are computed using NSDUH sample weights.

TEDS reports the number of all prior treatment admissions for individuals entering treatment facilities.[99] The average number of prior treatment admissions by year was tabulated for cocaine, heroin and methamphetamine. The tabulation is based on the primary drug of abuse at the time of admission. If there were trends in admission rates, the average number of prior treatment admissions should change slowly over time. That does not appear to happen.[100]

Finally, at the time this report made its calculations, ADAM data were available for 2007 for ten ADAM sites. Have treatment admission rates changed across time over those ten sites? Over these ten ADAM sites, adult male drug users generated 0.0717 outpatient treatment admissions per year during 2007 and about 0.0852 outpatient treatment admissions per year during the period 2000 through 2003. The same group generated 0.197 inpatient treatment admissions per year during 2007 and about 0.142 inpatient treatment admissions per year between 2000 and 2003. Both of these differences in treatment admissions are within the 95 percent confidence interval and thus the differences are not statistically significant.

99 This study experimented with using the prior admission variable for the denominator of equation [D.1]. There are two principal problems. The first is TEDS provides no way of estimating the length of the drug use career, so there is no credible way to convert the number of treatment admissions into rates of treatment admissions. Second, even if that conversion were possible, estimation requires an estimate of the current (last year) rate of admissions not the lifetime rate. The study abandoned an attempt at estimating treatment admission rates using TEDS data.

100 The table shows that the number of admissions for methamphetamine treatment increases from 2000 though 2005. However, the rate at which methamphetamine abusers enter treatment does not change materially over that same period. This implies that the number of methamphetamine abusers has increased from 2000 through 2005.

D.3. Combining TEDS and ADAM Data to Estimates Chronic Drug Use

All the elements are now in place to calculate the number of adult chronic drug users as described in equation [D.1]. The number of chronic users is calculated by dividing the number of adult treatment admissions by the rate at which chronic users are admitted. This calculation was repeated for each of the three drugs, heroin, cocaine and methamphetamine. Estimates based on inpatient and outpatient treatment admissions are reported in Table D.6.

Table D.6: Estimates of the Number of Chronic Drug Users according to Inpatient and Outpatient Driven Estimates

Outpatient	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Cocaine							
Male	1,221,791	1,197,763	1,289,101	1,318,438	1,333,425	1,318,862	1,317,828
Female	873,930	847,530	880,703	898,430	928,340	919,807	908,062
Totals	2,095,721	2,045,293	2,169,804	2,216,868	2,261,765	2,238,669	2,225,890
Heroin							
Male	668,584	676,552	686,308	643,814	621,107	590,956	575,877
Female	192,418	191,468	194,815	188,141	180,865	172,810	165,748
Totals	861,002	868,020	881,123	831,955	801,972	763,766	741,626
Methamphetamine							
Male	415,618	530,415	725,588	785,220	849,677	943,742	1,017,593
Female	266,013	313,202	382,577	424,712	480,742	551,199	577,193
Totals	681,631	843,616	1,108,165	1,209,932	1,330,420	1,494,941	1,594,786

Inpatient	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Cocaine							
Male	1,047,387	1,041,069	1,096,645	1,093,010	1,064,512	1,067,551	1,046,039
Female	529,790	507,791	531,893	530,329	508,850	511,541	505,210
Totals	1,577,177	1,548,861	1,628,538	1,623,339	1,573,362	1,579,092	1,551,249
Heroin							
Male	506,951	532,272	555,870	538,665	507,265	492,679	478,469
Female	148,810	151,640	158,882	155,467	147,125	140,089	139,533
Totals	655,761	683,912	714,753	694,132	654,389	632,769	618,002
Methamphetamine							
Male	276,292	306,197	367,961	394,139	429,686	500,947	451,649
Female	141,961	157,664	189,912	200,371	213,237	265,514	252,330
Totals	418,253	463,861	557,873	594,511	642,923	766,461	703,979

Both inpatient- and outpatient-based estimates are shown here, and it is clear that they disagree. For cocaine, the outpatient-based estimates are 38 percent higher on average; for heroin, the outpatient-based estimates are 24 percent higher on average; and for methamphetamine the outpatient-based estimates are 97 percent higher on average. The number of inpatient treatment admissions may be grossly underestimated for reasons discussed earlier: many episodes of detoxification may be unreported to TEDS but reported to ADAM, and many episodes of inpatient treatment delivered through jails and prisons may be unreported to TEDS but reported to ADAM. Estimates based on outpatient treatment admissions have more justification, so they appear in the rest of this report.

Table D.7 compares directly the original adult chronic user estimates from Table A.1 and the chronic user estimates based on outpatient treatment admissions from Table D.6. It also reports an “adjusted trend” explained below.

Table D.7: Final Estimates of Adult Chronic Drug Users in Thousands Cocaine, Heroin and Methamphetamine

	2000	2001	2002	2003	2004	2005	2006
Cocaine							
ADAM-based	2,433	2,516	2,466	2,614			
TEDS-based	2,096	2,045	2,170	2,217	2,262	2,239	2,226
Adjusted	2,433	2,516	2,466	2,614	2,660	2,633	2,618
Heroin							
ADAM-based	816	794	807	748			
TEDS-based	861	868	881	832	802	764	742
Adjusted	816	794	807	748	737	702	682
Methamphetamine							
ADAM-based	690	717	754	907			
TEDS-based	682	844	1,108	1,210	1,330	1,495	1,595
Adjusted	690	717	754	907	1,062	1,193	1,273

The ADAM-based estimates are the same as those reported in Table A.1. These estimates have also been carried forward without adjustment into the row called Adjusted. The TEDS-based estimates are the same as those reported in Table D.6 based on admissions to outpatient treatment. The TEDS-based estimates are multiplied by an adjustment factor and then carried into the adjusted rows for 2004 through 2006. The adjustment factor is 1.18 for cocaine, 0.92 for heroin, and 0.80 for methamphetamine. The adjustment factors were selected to assure that on average the ADAM-based and the TEDS-based estimates would agree for 2000–2003. These adjusted values are used as a best-estimate reported in Chapter 3.

Appendix E: Treatment Entry According to the National Survey on Drug Use and Health

This appendix uses self-reports of substance abuse treatment reported in the NSDUH to estimate the annual proportion of chronic drug users receiving treatment from 2001 through 2006. Because data for methamphetamine users are limited, the estimates pertain to users of marijuana, heroin and cocaine.[101]

The goal is to calculate the proportion of chronic drug users who have received related treatment within the last year, for each drug ($d \in$ [(1=cocaine, 2= heroin, 3 = marijuana)]). The proportion (P_d) of chronic users of drug *d,* receiving treatment for drug *d* in the last year is given as,

$$P_d = \frac{T_d}{N_d}$$

where T_d = the number of current chronic users of drug *d* (1=cocaine, 2= heroin, 3 = marijuana) receiving treatment for drug *d* in the past year, and

N_d = the total number of current chronic users of drug *d*.

Calculating the proportion of chronic drug users who have received treatment in the last year requires survey questions for:

(1) Use of each drug for a given period of time (30 days in this case), and
(2) Whether a chronic user has received substance abuse treatment for that drug.

While the NSDUH provides comprehensive data on frequency of use, questions about substance abuse treatment are imperfect. Measure of (N_d) comes from one of three items asked in the NSDUH (one for each drug). These specific items [COCUS30A, HER30USE, MJDAY30A] all ask the question:

…During the past 30 days [including today], on how many days did you use {cocaine/heroin/marijuana}?

Respondents who indicated that they used from 4 to 30 times in the past month were labeled as chronic users of that drug. Since each respondent was asked all three questions, it was possible for a single respondent to be a chronic user of more than one drug. From these responses the Abt researchers summed the total number of chronic drug users for each drug.[102]

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[101] While ideally methamphetamine would be included in this exercise, the NSDUH does not collect the necessary data elements that allow doing so.

[102] Sample weights were used in calculating total CDUs so results are based on a national representative estimate.

For (T_d), an indirect calculation based on two separate questions in the NSDUH was used. The first question [TXYREVER] was not drug specific, and asked,

> During the past 12 months…have you received treatment or counseling for your use of alcohol or any drug, not counting cigarettes?

Respondents who were identified as chronic drug users and who reported that they had received drug and/or alcohol treatment in the last year, were then matched to a followup question based on the drug they reportedly abused.[103] The followup question was used to determine whether the treatment they reported receiving was likely to be for the drug they abuse. In all there were 3 total questions [TXLTYCOC, TXLTYHER, TXLTYMJ], all of which asked,

> The last time you entered treatment [including current treatment], did you receive treatment or counseling for your use of {cocaine/heroin/marijuana}?

Using these two pieces of data, it was determined (a) whether a chronic drug user had received treatment in the past 12 months, and (b) whether the most recent treatment received was for the abused drug of interest.[104] From these responses, the researchers summed the total number of chronic drug users receiving treatment, for each drug.

The results of these calculations are shown in Table E.1.

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103 Respondents who reported chronic use of more than one drug were matched to multiple questions consistent with their reported use.

104 One limitation of using the NSDUH data is that calculations only imperfectly determine whether the treatment reported in TXYREVER is related to the relevant (abused) drug. This is because respondents may have received other (more recent) treatments for drugs/alcohol not related to the drug of interest. The implication of this potential mismeasurement is that estimates may underestimate the actual number of chronic drug users entering treatment in the last year.

Table E.1: NSDUH Calculations of Chronic Drug Users and Treatment Entry

	2001	2002	2003	2004	2005	2006
Marijuana						
T_{MJ}	275,798	355,981	352,866	291,559	273,371	137,512
N_{MJ}	7,616,686	9,599,223	9,556,244	9,330,619	9,606,622	9,759,882
P_{MJ}	0.036	0.037	0.037	0.031	0.028	0.032
Cocaine						
T_C	151,024	157,346	57,309	128,801	120,496	137,512
N_C	697,342	790,440	758,451	895,454	807,761	925,631
P_C	0.217	0.199	0.076	0.144	0.149	0.149
Heroin						
T_H	26,175	36,624	22,799	51,619	26,818	132,696
N_H	82,063	114,316	91,031	118,041	84,214	229,121
P_H	0.319	0.320	0.250	0.437	0.318	0.579

Note: All estimates are computed using NSDUH sample weights

Estimates of *P* show the proportion of chronic drug users in receiving treatment for each drug by year. Figures E.1–E.3 show these trends with their associated 95 percent confidence intervals.[105] These graphs seem to indicate that for marijuana and heroin, there do not seem to be significant changes in the percentage of chronic drug users receiving treatment over time.[106] Also, with the exception of 2003, the percent of chronic cocaine users receiving treatment for cocaine had remained relatively stable.[107]

[105] In computing these standard errors, one must account for the complex sample design of the NSDUH. An appropriate way to accomplish this is to use the Taylor expansion method to estimate sampling errors. This is easily done in SAS using "proc surveymeans." Including both "stratum" and "cluster" statements in this procedure allows one to control for the design effects of complex sample design. Two variables are included as part of the NSDUH dataset that allow researchers to specify the appropriate stratum [VESTR] and clusters [VEREP] for accurate variance calculations. Also, the variance calculations did not account for clustering because there were too few observations per strata. Cases where there were fewer than 3 observations in a stratum were manually collapsed into common strata. Insufficiently large strata (i.e., total observations were fewer than 3) were collapsed together based on numerical closeness of the stratum values (e.g., 2001 was collapsed with 2004 before 2007) until the number of observations in a stratum reached 3 or more.

[106] Estimates for heroin users are based on fewer than 40 total observations and should be interpreted with caution.

[107] This dramatically different result for 2003 may be, at least in part, an artifact of the survey design changes the NSDUH underwent from 2001 to 2003.

Figure E.1: Percentage of Chronic Marijuana Users Receiving Treatment in the Last 12 Months

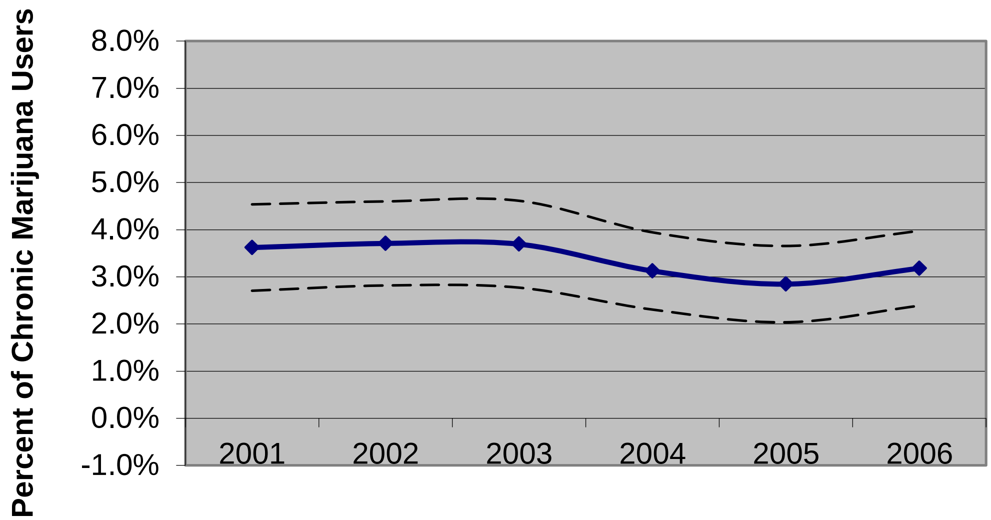


Figure E.2: Percentage of Chronic Cocaine Users Receiving Treatment in the Last 12 Months

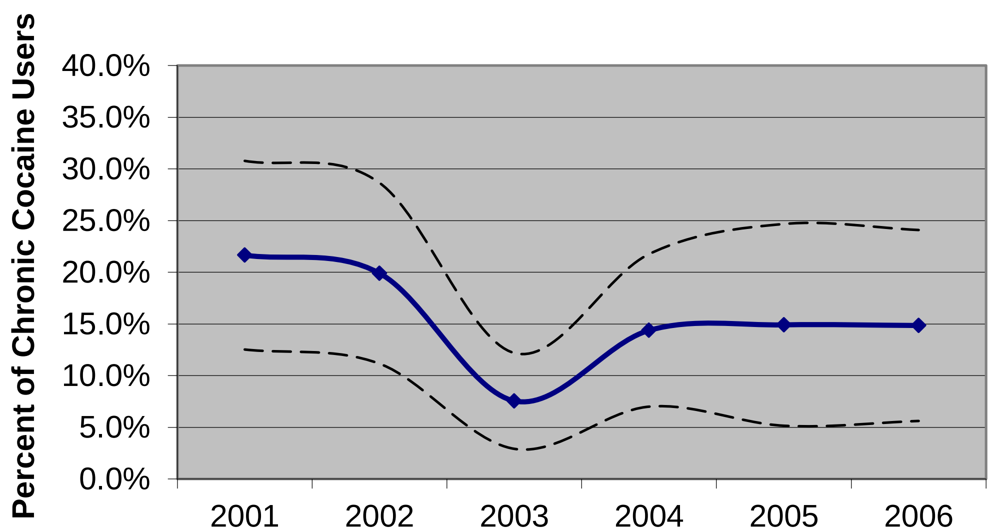
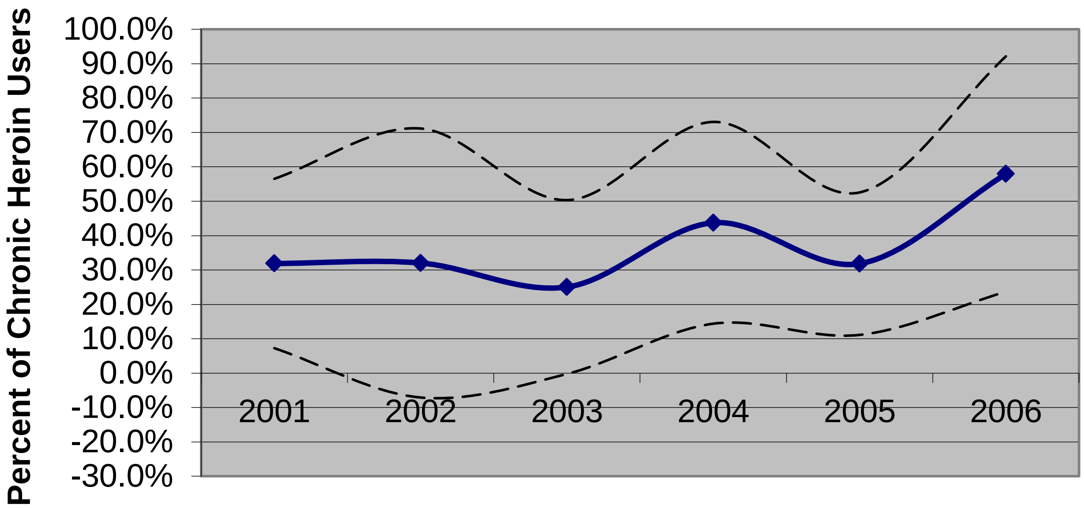


Figure E.3: Percentage of Chronic Heroin Users Receiving Treatment in the Last 12 Months



Appendix F: Illustrative Calculations for Chronic Drug Use by Youth

The 2006 MTF survey reports 30-day use by frequency of use for 8th, 10th and 12th graders. Table F.1 reports the estimates from MTF as well as calculations done for this study for cocaine use.

Table F.1: Data/Calculations from MTF Survey for Cocaine, 2006 Percentage Reporting Use during the Last 30 Days by Grade

30-day frequency	***8th grade***	***10th grade***	***12th grade***
No occasions	99.1%	98.5%	97.5%
1 to 2	0.4%	0.6%	1.2%
3 to 5	0.3%	0.4%	0.6%
6+	0.2%	0.5%	0.7%
Implied 4+ occasions	0.40%	0.77%	1.10%
Implied youth rate	0.76%		
Implied users	158,667		

According to self-reports by 8th graders, 99.1 percent of 8th graders had not used cocaine in the previous 30 days, 0.4 percent had used it on 1–2 occasions, and 0.3 percent had used it on 3–5 occasions. Assume that those who report use on 3 to 5 occasions are evenly divided among those who use on 3, 4 or 5 occasions; then, the estimated number per 100 children who used cocaine on 4 or more occasions is:

$$\frac{100-99.1-0.4-0.3/3}{100}=\frac{.40}{100}=0.0040$$

This is reported as the "Implied 4+ occasions" in the illustration. Averaging the rate across 8th, 10th and 12th graders gives the "Implied youth rate." This is:

$$\left(\frac{0.40+0.77+1.10}{3}\right)/100=\frac{0.76}{100}=0.0076$$

The final step multiplies 0.76 percent by 21 million juveniles. This gives:

$$\frac{0.76}{100}21=0.16$$ million chronic juvenile cocaine users.

Table F.2 shows estimates of the estimated number of youth (in thousands) who were chronic users by drug and by year.

Table F.2: Number of Juvenile Chronic Users (Thousands)

Years	*Cocaine*	*Heroin*	*Methamphetamine*
2001	145	42	133
2002	168	49	133
2003	198	35	110
2004	163	44	103
2005	142	49	79
2006	159	35	61

Appendix G: Expenditures on Illegal Drugs

With the exception of marijuana, drug expenditure estimates come exclusively from the section of the ADAM interview that asks about purchasing practices (market section). For marijuana that ADAM market section was augmented with additional data from the market section of the NSDUH. This appendix explains use of the ADAM data.

ADAM interviewers ask arrestees if they have purchased or otherwise acquired cocaine, heroin, methamphetamine or marijuana during the last month (MU1). If the arrestee admits to a recent acquisition, then he is asked a series of questions. Responses to those questions were used to estimate the dollar value of drugs purchased by each ADAM respondent during the last month. Section G.1 explains the computing algorithm. Details are available as SAS computing code. Then the above estimates of total expenditures were used to estimate the average expenditure by chronic drug users in each ADAM site. Section G.2 explains how the data were assembled from the ADAM sites to derive a national average. A different procedure, described in section G.3, was used to estimate the average expenditures by juveniles and occasional users.

G.1 Monthly Expenditures by Chronic Drug Users

If a respondent says that he purchased the drug exclusively with money, the interviewer asks him about the price he paid for the last purchase (MU12). The interviewer also asks him to estimate the amount of drugs that he received as a result of that purchase (MU13). Then the interviewer asks him how many times he purchased that day (MU15) and on how many days he purchased during the last month (MU17). He is also asked whether he used the entire purchase himself or whether he gave some away or sold some. If he did not use the entire amount for his own use, he is asked to estimate the proportion that was for his personal use (MU14).

If he says that he bartered to cover some or the entire drug price, the interviewer asks him to estimate how much he received as a result of the transaction (MU25). The study's computing algorithm imputes a dollar equivalent value for that reported amount. The imputation is based on the empirical relationship between the price paid and amount purchased given reports by those who actually made purchases.[108] Additionally the interviewer asks the respondent how many times he bartered during the same day and during the last month, and whether he used the amount himself.

[108] The imputation was conceptually simple. The price paid was identified as a function of amount purchased. Thus, a dollar equivalent value for the amount acquired by barter could be imputed based on the purchase price for equivalent amounts. For example, if buyers spent an average of $100 for 1 gram of cocaine, a $100 purchase to someone who bartered for 1 gram of cocaine was imputed. The complexity arises from ADAM's allowing the respondent to report amount purchased in different kinds of units—bags, vials, and so on. To deal with that complexity, a table of conversions was developed that associated units with price paid and applied that table of conversions to estimates the dollar equivalent value of bartered drugs. See the computing code for those conversions.

Respondents were then divided into two groups. The *first group* (Own Use) comprised people who said they had purchased or bartered for cocaine (or heroin or methamphetamine or marijuana) and had used the entire purchase for their own use. The *second group* (Gift/Sold) comprised people who said they had purchased or bartered for cocaine (or heroin or methamphetamine) but had either shared the drug or had sold some.[109] That is, they claimed they had used only some of the purchase themselves; the rest went to others. The data were uninformative about the amount given to others and the amount sold, and given the requirement for an estimate of expenditures net of what was purchased for resale, use data from the latter group could not be used directly to estimate how much a respondent spent on drugs.[110]

Using only those respondents from the first group (Own Use), the study estimated the dollar value of drugs purchased during the month as the product of price paid for the last purchase times the number of purchases made that same day times the number of days when purchases were made during the last month. The estimated dollar value of bartered drugs was the same except that the imputed dollar-equivalent value was substituted as the putative purchase price. The dollar-equivalent values for the purchased and bartered drugs were combined for any user who reported both behaviors to yield a *provisional* dollar expenditure estimate for that user.

The provisional estimate was sometimes unbelievably large. An upper limit was placed on expenditures for own use based on the physiological limitations for drug use.[111] If the consumption implied by that expenditure exceeded the physiological limit, that respondent was moved from the first group (Own Use) to the second group (Gift/Sold). The justification for moving a case was that either the respondent misunderstood the question (or was otherwise unable to give a credible answer) or else he actually sold some of the drug but was unwilling to admit the crime.

Using data from the first group (Own Use), statistical analysis (regression analysis) was used to establish the relationship between expenditures on own use and frequency of use during the same month.[112]

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109 In some instances, chronic users did not answer the market portion of the ADAM instrument. When that was the case, expenditures were imputed based on the results from the regression analysis. Essentially, those respondents with missing data were treated as members of group 2.

110 The problem is with sales. Suppose that arrestee A brought $100 worth of cocaine but sold $50 of that purchase to someone else. Then someone else would report a $50 purchase for what is in reality just $100 worth of drugs. The study sought to avoid this double counting.

111 The maximum number of doses per day (based on physiological limits to drug use) was multiplied by the prevailing price of drugs in the county. This gave a maximum expenditure per day of use. If reported expenditure exceeded the maximum daily expenditure times reported days of use, the response was judged to be unreasonable.

112 Ordinary least squares regression was used. The dependent variable was the reported expenditure for the month. The independent variables were the number of days of use during the month. The slope was interpreted as the expenditure per day of use.

That estimated relationship was then used to impute the dollar expenditure for everyone in *both* groups based on the frequency at which they used the drug.[113]

The analysis was repeated for each site. Methamphetamine use was rare in many ADAM sites east of the Mississippi, and heroin use was rare in certain ADAM sites. When there were too few cases for meaningful analysis, ADAM sites were grouped into regional groupings and conducted the analysis by regions. Although grouping probably introduced some inaccuracies, grouping was done where drug use was relatively rare, so the potential inaccuracies should have little effect on the estimated average expenditure.

Let:

[G.1] $$E_i = X_i \beta_i + e_i$$

represent a regression specification where E_i is a vector of expenditure estimates and X_i is a matrix of explanatory variables for the ith ADAM site. The matrix comprises a constant, the number of days of use during the month, and dummy variables for years. All observations were drawn from group 1. Let β be slope coefficients and let σ^2 represent the variance of e, a random error term distributed as iid.

Let $\overline{X}_i$ represent a columns vector: the weighted mean value of columns of X_i for groups 1 and 2 combined. The weights are the ADAM sampling weights. Then an estimate of the mean expenditure for chronic users in the ith ADAM site is:

[G.2] $$\hat{\overline{E}}_i = \overline{X}_i' \hat{\beta}_i$$

The sampling variance for this estimator can be broken into two parts. (The study ignore a small residual variance that will go to zero in large samples.[114]) The first part results from the sampling variance of $\hat{\beta}$. Let V represent the parameter covariance matrix. Then this first variance term can be estimated as:

$$\sigma_1^2 = \overline{X}_i' \hat{V} \overline{X}_i$$

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113 Multiplying the last purchase price by the number of times purchased that day times the number of days purchased during the month yields an estimate of expenditures during the month. That estimate has an unknown amount of measurement error. Because the estimate appears as the dependent variable in the regressions, the measurement error will appear as the residual error in the regression. The error for the prediction from the regression was used as a measure of the sampling error for this observation.

114 Suppose there were M chronic drug users in the i[th] ADAM site and let σ_e^2 be the variance for e. Then this residual variance is σ_e^2 / M^2. This will go to zero for large M.

The second variance term results from the ADAM sampling plan. Treating the E_i as if they were observations rather than estimates, estimation of that second variance term (σ_2^2) is straightforward given ADAM's sampling design (see Hunt & Rhodes, 2000). The sampling variance for estimated average expenditure in the i[th] ADAM site is $VAR(\bar{E}_i) = \sigma_1^2 + \sigma_2^2$. These variance terms are independent across ADAM sites.

These results can be used to estimate the sampling variance for the overall mean across the ADAM sites. Let W_i represent the weight for the i[th] ADAM site, where the weights are proportional to the estimated number of chronic users in the i[th] ADAM site. Then if $VAR(\bar{E}_i)$ is the estimated sampling variance for the estimated mean in the i[th] site, the sampling variance across all ADAM sites is:

$$VAR(\bar{E})_{ADAM} = \sum W_i^2 VAR(\bar{E}_i)$$

[G.3]

The problem with this solution is that the researchers wish to know the average expenditure for chronic users across the country. There seems to be no alternative to treating the ADAM sites as if they were a random sample of all counties in the United States, so that the estimated mean expenditure is treated as an unbiased estimate of mean expenditures for chronic drug users in the United States. However, the sampling variance should recognize that the ADAM sites are a sample of all sites, so the sampling variance [G.3] is biased downward.

The study corrects for this bias by using σ_3^2, which is the variance of $\hat{\bar{E}}_i$ across the M ADAM sites. Then note that ADAM represents R proportion of all chronic drug users because ADAM counties account for R proportion (roughly equal to 0.25 depending on the drug) of all treatment admissions for drug use. The sampling variance for average expenditures across the United States is written as:

$$VAR(\bar{E})_{national} = VAR(\bar{E})_{ADAM} + (1-R)^2 \frac{\sigma_3^2}{M}$$

[G.4]

The first part of this variance expression captures the variance from estimating the mean expenditure using data from the ADAM sites. The second part of the variance expression captures the additional variance that occurs because the average expenditure for the ADAM sites (for which there are have data) were attributed to the rest of the county (for which there are no data). This second component of the variance term only applies to counties that lack ADAM programs, and hence, the $(1\text{-}R)^2$ term. The larger the proportion of users in those ADAM sites, the larger the value of R, and the smaller the value of this second variance term. The smaller the variance across the ADAM sites, the smaller the value of σ_3^2, and hence the smaller the size of this second variance term.

The main text reports average expenditures by chronic users for cocaine, heroin, methamphetamine and marijuana. The "average" is the weighted average across the ADAM sites. The "weights" are the estimated number of drug users in those sites. For example, if there are C chronic drug users across the ADAM sites, and if a site has c chronic drugs users, then that site gets a weight of c/C. When a site lacked an estimate for time T, the estimate for time T+1 or time T-1, whichever was available, was substituted. If both were available, the average was used.

G.2 Daily Expenditures by Occasional Users

Daily expenditure estimates for occasional users were derived as the slope coefficient for days of use in the regression specified in equation [G.1]. The N estimates were averaged across the ADAM sites. Weights come from the inverse of the sampling variances.[115] The sampling variance for this estimate is straightforward but it does not account for the fact that the ADAM sites are a sample of all counties. As was done earlier, the ADAM sites were treated as if they were a random sample of all counties and added a variance term to account for sampling the counties. The estimates assume that women and juveniles have the same daily expenditure patterns as adult males; furthermore they assume that occasional users in the general population have the same daily expenditure patterns as daily users who get arrested.

G.3 National Expenditure Estimates—Chronic Users

The algorithm described above led to dollar-equivalent values for the average expenditures on cocaine, heroin, methamphetamine and marijuana by chronic drug users. The estimated total expenditure is the product of the estimated number of chronic drug users times the average expenditure on a specific drug.

To estimate the sampling variance for expenditures by chronic drug users, the study used a first-order approximation for the variance of the total number of chronic users times the average expenditure per chronic user. That estimate is:

[G.5] $$VAR(Expenditure\,by\,chronic) = VAR(\hat{C})\hat{\bar{S}}^2 + VAR(\hat{\bar{S}})\hat{C}^2$$

where:

$\hat{\bar{S}}$ is estimated mean expenditure by chronic users

$\hat{C}$ is estimated number of chronic users

115 When estimating expenditures by chronic drug users, the study weighted by the number of chronic drug users in a site. This seems like a sensible way to weight because it assigns a proportionately higher weight to sites that have more users. Those sites would also tend to have smaller sampling variance simply because they provided more data points. The same weighting procedure does not work for casual drug use, however, unless chronic users are proportional to casual users. Therefore, the study weighted by the inverse of the estimated sampling variances.

G.4 National Expenditure Estimates—Occasional Users of Cocaine, Heroin and Methamphetamine

To estimate expenditures for occasional users, the estimated number of occasional users was multiplied by the average expenditure on cocaine (heroin, methamphetamine, or marijuana) conditional on number of days of use during the month before the interview (from the regressions on ADAM data, described earlier).[116] That is, it was assumed that the average expenditure by an arrestee who used cocaine on one day per month was equivalent to the average expenditure by a household member who admitted to use on one day during the month. Given the unknown level of uncertainty surrounding the occasional user estimates, the study did not compute a confidence interval for expenditures by occasional users.

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[116] See the previous note. An ordinary least squares regression was estimated where the dependent variable was total expenditure on cocaine (heroin or methamphetamine) for the month and the independent variable was the number of days during the month when cocaine was used. The slope parameter was interpreted as the marginal expenditure on cocaine per day of use. The regression was repeated for each ADAM site, and the final estimate of expenditure per day of use was a weighted average across the ADAM sites. The estimated number of cocaine users was the weight for each site.

Appendix H: Drug Prices

The System to Retrieve Information from Drug Evidence (STRIDE) dataset provides data for computing estimates of the price of cocaine, heroin and methamphetamine. This dataset records undercover drug purchases by the Drug Enforcement Administration, other Federal agencies, and some state and local agencies. STRIDE records the type of drug, the quantity of the drug purchased in grams, the geographic area where the drug was purchased, the estimated price of the total amount purchased, the purity of the drug in the purchased sample, and the quarter in which the drug was purchased. Because STRIDE reports the DEA office, and as a result the Metropolitan Statistical Area code (MSA) where the purchase occurred, the MSA was used as a geographic identifier.

STRIDE data are assembled for enforcement purposes and for domestic intelligence analyses. There is no reason to expect STRIDE to represent illicit drug price/purity without making statistical adjustments. A six-step procedure was used to develop a national average price for drug purchases using a subset of the STRIDE data from 1998 to first quarter 2007.

- First, the study selected the required subset of data for each drug and excluded outlying observations from the sample. Sampled observations were limited to purchases of $200 or less because these were likely to be retail-level purchases.
- Some observations recorded zero purity, but sometimes this was because the laboratory did not conduct a test, and sometimes it was because the laboratory could not perform a test because the sample amount was too small. The second step was to apply a computing algorithm that excluded observations when the former occurred and imputed values when the latter occurred.
- Third, the study regressed the pure amount purchase per dollar paid onto the MSA (to account for price variation across places), quarterly dummy variables (to account for variation over time), and price paid (to account for quantity discounts for larger purchases).
- Fourth, predictions from this model were calculated, and interpreted as representative of the average purity conditional on place, time, and dollar paid.
- Fifth, a set of weights was developed to be used in aggregating individual estimates for MSAs and quarters to a national U.S. estimate.
- Finally, a national weighted average price for each drug was computed. The national estimate used purchase prices that were estimated from the Arrestee Drug Abuse Monitoring (ADAM) program data. The purchase prices, as will be seen, were different for each drug.

Step 1: Select the Required Subset of Data

The first step of the analysis involved selecting the required subsets of the STRIDE data. This step was different for each of the four drugs, as different subsets of the data were needed based upon the drug in question. Table H.1 below shows the impact of these different steps on the three subsets of the data.

Heroin

STRIDE records a total of 11,842 heroin purchases between January 1, 1998 and March 31, 2007 that were valued between $20 and $200. Estimation required purchases at the retail level; therefore the study selected cases where the total price of heroin was between $20 and $200. Tabulations of Arrestee Drug Abuse Monitoring (ADAM) data suggested that these are reasonable limits for retail purchases of heroin, although purchases over $100 certainly include some low-level dealer purchases. Second, selected purchases with between 0 and 10 pure grams of heroin in the sample were selected. This resulted in a sample of 11,828 observations.

The price-purity of a purchase measured as pure grams of heroin obtained for the price paid was then calculated. Formally,

$$PGPR_i = \frac{PG_i}{PR_i};$$

where PGi measures the pure grams of heroin in purchased sample i and PRi represents the STRIDE report of the price of the purchased heroin. PRPG or price per pure gram is the inverse of this value.

The purity-price variable was then used to remove outlying observations in the dataset. Outliers were located using box-plots of pure grams of pure heroin per dollar across quarter years to locate outlying observations. After inspecting these plots, pure grams per price values greater than 0.1 were identified as outliers and deleted. This resulted in a dataset of 11,826 observations.

Crack Cocaine

The same selection procedure was used for crack cocaine as for heroin except that only observations recorded as crack cocaine were selected. First, all purchases of crack cocaine that occurred between January 1, 1998 and March 31, 2007 and whose reported value was between $20 and $200 were selected. This resulted in a sample of 11,993 cases. Second, purchases that recorded between 0 and 10 pure grams of crack cocaine in the purchase were selected, and this reduced the sample to 11,928 cases. Third, outlying observations were identified on the aforementioned box-plot and observations with pure grams per dollar price greater than 0.1 were deleted from the sample, reducing the sample to 11,922 purchases.

Powder Cocaine

Powder cocaine purchases were selected using the same procedure. First, all purchases of powder cocaine that occurred between January 1, 1998 and March 31, 2007 and whose reported value was between $20 and 200 were selected. This resulted in a sample of 2,201 cases. Second, purchases that recorded between 0 and 10 pure grams of pure powder cocaine in the sample were selected, and this reduced the sample to 2,172 cases. Finally, outlying observations where pure grams per price was greater than 0.1 were excluded. This reduced the sample to 2,169 observations.

Methamphetamine

The methamphetamine sample was selected using the same initial process as heroin and cocaine. First, all observations coded as methamphetamine purchased between 1998 and 2007 that were valued between $20 and $200 were selected. This resulted in sample of 1,884 cases. Second, purchases with between 0 and 10 grams of methamphetamine were selected, reducing the sample to 1,868 cases. Third, the observations were further limited to purchases of d-methamphetamine and methamphetamine. These two types of methamphetamine are identified by several primary drug codes in STRIDE and this reduced the sample to 1,676 cases. Finally, those purchases with pure grams per price greater than 0.1 were identified and deleted as outliers. This reduced the sample to 1,675 cases.

Table H.1: Selecting Required Samples of Cocaine, Heroin, Methamphetamine and Marijuana

	Crack Cocaine	Powder Cocaine	Heroin	Methamphetamine
Full Dataset	977,634	977,634	977,634	977,634
Select purchases between 2001–2007 valued at between $20 and $200	11,993	2,201	11,842	1,884
Select 0 ≤ PG ≤10	11,928	2,172	11,828	1,868
Select only methamphetamine and d-methamphetamine				1,676
Remove PG/PR outlier (>0.1 for cocaine, heroin , and methamphetamine and >2 for marijuana)	11,922	2,169	11,826	1,675

Step 2: Excluding Actual Zero Purity Purchases

The Drug Enforcement Administration stated that purchases in STRIDE identified as having zero purities implied that often the sample was not large enough to identify the degree of purity in the sample. This logic is slightly problematic as there are some large samples with zero purity and these observations could actually have non-zero purity observations that should not be excluded from the analysis. The study therefore implemented a logistic regression model to determine the probability of a purchase really having zero purity versus a purchase where the sample was too small to determine the degree of purity. The model took the following form:

$$\Pr(Pure=1)=\frac{\exp\left(\beta_0+\sum_{i=1}^{K}\beta_i BulkLevel_i\right)}{1+\exp\left(\beta_0+\sum_{i=1}^{K}\beta_i BulkLevel_i\right)}$$

Where Pure is a dummy variable coded as 0 if the purity of the sample is reported as zero and 1 if the reported purity of the sample is greater than 0. As would be expected, this adjustment was most important for small samples.

$BulkLevel_i$ is a dummy variable that codes the size of the bulk sample purchased. The variable is coded as 1 if the purchase falls into that specific bulk level variable. There are K dummy variables for the bulk level representing each level of the quantity: K = 25 levels for crack cocaine and heroin, K = 13 levels for methamphetamine and K=5 levels for powder cocaine. The number of levels differ by the drug because of the intervals used to define the bulk levels. For crack cocaine and heroin, the intervals were 0.025 bulk grams. Therefore, level 1 was 0 to 0.025 bulk grams, level 2 was 0.025 to 0.05 bulk grams and so forth. Methamphetamine used 0.05 bulk gram intervals and powder cocaine used intervals of 0.1 bulk grams. These intervals were selected after experimentation.

Figures H.1 through H.3 show the plots of these probabilities as a function of the bulk amount of the drug purchased. The figures appear to indicate that the laboratory has approximately a 5 percent chance of being unable to determine the amount of the pure quantity of the drug irrespective of the bulk quantity level. This proportion was used to randomly discard 5 percent of purchases coded as zero purity, assuming that the lab made an error in a random 5 percent of the zero purity values. This also assumes that the remaining 95 percent of observations coded as zero purity need to have an imputed purity.

The purity for these zero purity purchases was imputed by using the minimum detectable purity for the particular drug after excluding zero purity. The lowest 2 percent of purities in each level of the bulk quantity were discarded, and the minimum detectable purity in each level of the bulk quantity was estimated. The minimum detectable purity for crack cocaine was estimated to be 30 percent of the bulk quantity, 7.5 percent of bulk quantity for powder cocaine, 3.5 percent of bulk quantity for heroin and 1 percent of bulk quantity for methamphetamine. PGPR was then imputed for the remaining 95 percent of zero purity observations as follows:

Crack Cocaine: 0.3*Bulk Quantity
Powder Cocaine: 0.075*Bulk Quantity
Heroin: 0.035*Bulk Quantity
Methamphetamine: 0.01* Bulk Quantity

Figure H.1: Probability of Identifying Purity in Crack Cocaine a Function of Bulk Quantity

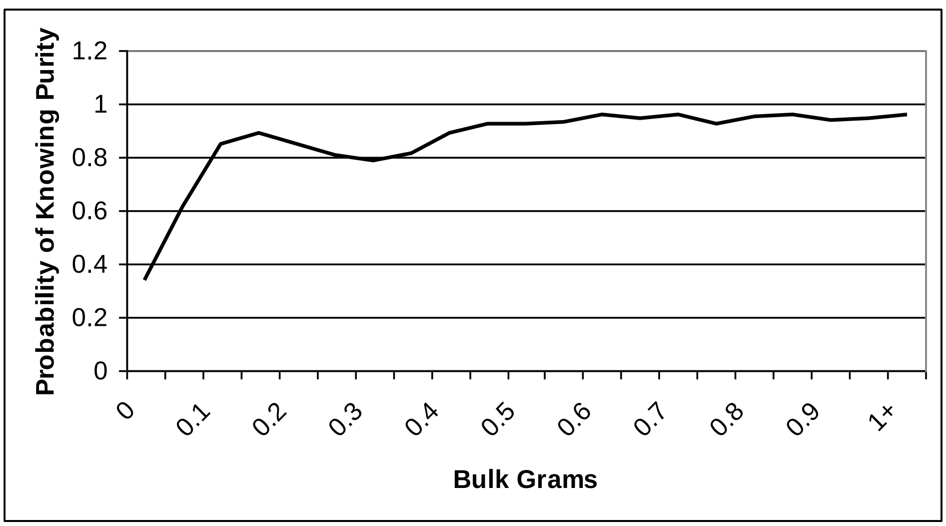


Figure H.2: Probability of Identifying Purity in Powder Cocaine a Function of Bulk Quantity

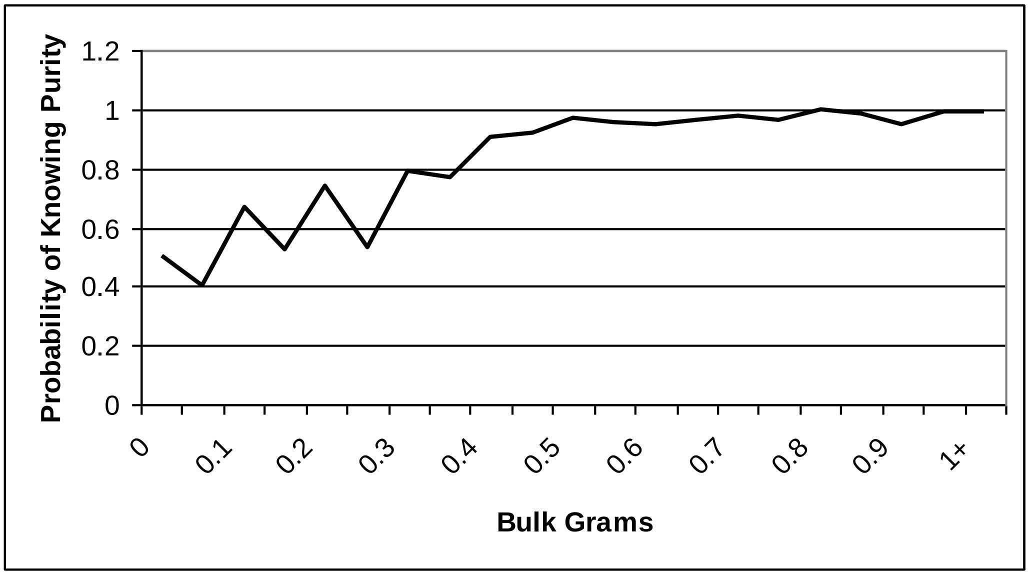
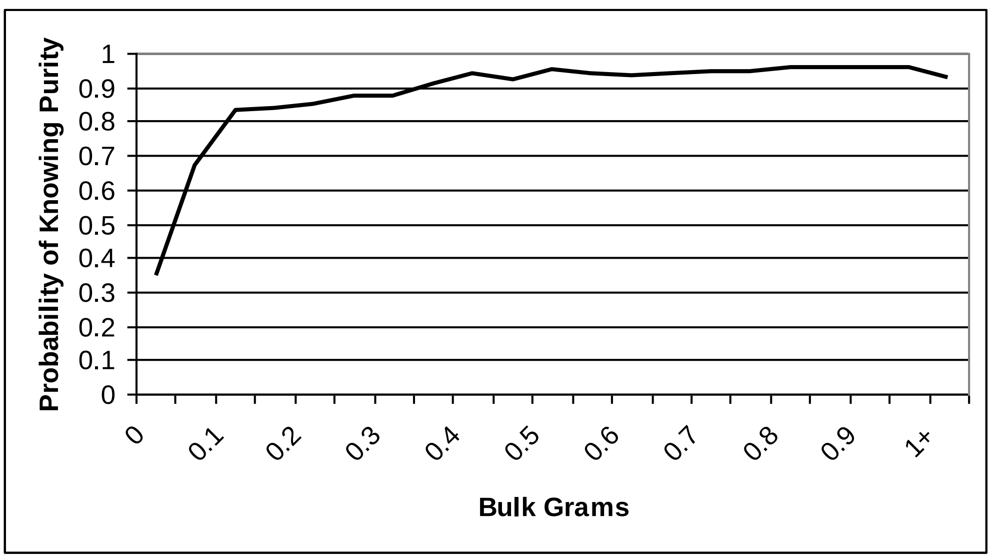


Figure H.3: Probability of Identifying Purity in Heroin a Function of Bulk Quantity



Step 3: Estimating the Statistical Model

The analysis used the surviving observations from Step 1 to estimate the following regression model:

$$PGPR_{ijt} = \alpha + \sum_{j=1}^{J} \beta_j MSA_{ij} + \sum_{t=1}^{T} \delta_t Time_{it} + \sum_{j=1}^{J} \beta_1 PR_{ijt} * MSA_{ij} + \varepsilon_{ijt}$$

[H.1]

In vector form, this might be written as:

[H.2] $$PGPR = X\xi + \varepsilon$$

where:

$PGPR_{ijt}$ refers to the pure grams per price of the drug for observation i in MSA j during quarter t multiplied by 1,000. The purity per dollar is a very small number that is hard to graph and interpret. Multiplying it by 1,000 provides an estimate per thousand dollars that is easier to graph and interpret.

MSA_{ij} refers to a dummy variable representing MSA j. This variable is coded as 1 if the observation was recorded in the respective MSA and 0 otherwise. MSAs with 10 or more observations were given a dummy variable of their own and other MSAs were grouped into a residual MSA called "Rest of the United States."

$Time_{it}$ refers to a dummy variable representing quarter t. There are 37 dummy variables corresponding to the 37 quarters in the model. This observation is coded as 1 if the observation was recorded in quarter t and 0 otherwise.

$PR*MSA_{ij}$ is the price value of the purchased heroin MSA j. This interaction term was used instead of the non-interacted price variable alone because the price of a drug varies by the city and region of the country; an analysis using price as a single numeric variable would fail to capture this degree of heterogeneity. If purchase i occurred in MSA j then the observation for purchase i reflects the price of the heroin purchased. If the purchase i did not occur in MSA j then the observation is coded as 0.

e_{ijt} This is the error term. It is assumed to be distributed identically and independently across the sample.

The parameters of this model were estimated using ordinary least squares and weights were used to develop predicted values.

Step 4: Imputing Expenditure Values

The next step was to estimate the average purity of a purchase conditional on the MSA where the purchase occurred, the quarter when the purchase occurred, and the dollar expenditure. Estimation also required knowledge of the average price paid, which could not be determined from the STRIDE data because those data were not a random sample of all purchases. Weights were developed using the ADAM data.

Step 5: Developing the Weights

A regression model developed using the above data computed the estimated purchase amount per dollar paid conditional on place, time and price paid. These estimates cannot be simply averaged over the MSAS as there is no reason to suppose that the distribution of purchases appearing in STRIDE is the same as the distribution of purchases by drug users. One problem is that the Domestic Monitor Program necessarily skews the distribution by instituting a roughly equal sampling plan across DEA offices. A second problem is that the distribution depends on the intensity of street-level enforcement across DEA offices. A practical way to weight the MSA-specific predictions was therefore needed to develop national estimates of the average purity of heroin, cocaine and methamphetamine.

As a result, the proportion of observations in each MSA site was used as the weight for that site. For example, if an MSA accounted for 1 percent of the observations then it received a weight of 0.01. While computing these proportions Washington DC was excluded from the sample as Washington DC is overrepresented in STRIDE, and instead an arbitrary proportion of 0.01 for Washington DC was imputed. In the case of heroin, all observations from the Domestic Monitoring Program were also excluded before computing the MSA proportions.

Step 6: Computing Predicted Values

Steps 1 through 6 lead to a national estimate of pure drug purchased per dollar (PGPR) spent conditional on the dollar spent. The final step requires removing this conditioning using weights derived from the ADAM data.

The weighting is complicated. An explanation requires some notation.

P_i — This is the price paid for the last purchase according to the ith respondent to the ADAM interview.

DAY_i — This is the number of time during the day that the ith ADAM respondent said that he purchased the drug.

$MONTH_i$ — This is the number of days during the month that the ith ADAM respondent said that he purchased the drug.

WT_i — This is the sampling weight for the ith ADAM respondent.

In the aggregate, ADAM respondents spent:

$$EXPEND = \sum_i P_i DAY_i MONTH_i WT_i$$

Let:

$PGPR(P_i)$ be the amount of grams purchased conditional on the price paid.

PRPG be the average price paid per gram purchased.

In the aggregate, ADAM respondents purchased:

$$GRAMS = \sum_i PGPR(P_i) DAY_i MONTH_i WT_i$$

Then the best estimate of price paid per gram purchased is:

$$PRPG = \frac{EXPEND}{GRAMS}$$

Estimates were derived for crack, powder, heroin and methamphetamine. To be included in the analysis file, the respondent had to meet specific conditions:

- He must have spent between $1 and $200 for the reported purchase.
- He must have reported that he used 50 percent of more of the purchase for his own use.

If the product of DAY times MONTH exceeded 120, it was trimmed to 120.

There were no apparent trends in the numerator, so ADAM data from all ADAM sites over the years 2000 through 2003 were merged. This is equivalent to assuming that users always spend the same amount regardless of the real price of the drug. The data are not at variance with this assumption.

While EXPEND is constant between 2000 and 2003, and presumably while it remains constant from 2004 to 2006, GRAMS varies with PGPR. Therefore PRPG varies across the seven years.

Separate estimates were derived for crack and for powder cocaine. The two estimates were averaged using the expenditures on crack relative to powder as weights. Thereby a single PRPG was derived for cocaine.

PRPG estimates reported in this text are the averages for year Y and year Y-1. The justification for averaging is that it reduces some of the volatility in the estimates.