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Abt Associates Inc.

# Illicit Drugs: Price Elasticity of Demand and Supply



***Final Report***
***Revised***

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**FINAL REPORT**

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# Executive Summary

## Objectives

The 1998 National Drug Control Strategy established an ambitious national agenda for reducing illicit drug use by 25 percent as of 2002 and by 50 percent as of 2007. When it established those targets, the Office of National Drug Control Policy recognized that achieving its goals would require a multifaceted mixture of supply-based and demand-based programs. The nature of that mix was unknown, however, because there was no solid quantitative evidence of how supply-based and demand-based programs would interact to reduce substance abuse. Indeed, there was no compelling evidence that available technology – treatment, prevention, or law enforcement – provided the means to achieve those targets.

Are those targets achievable with the tools at the Nation's disposal? This study does not attempt to answer that general question, but it does address a more narrow one: How can supply-based programs, which restrict drug availability, consequently increase drug prices, and reduce the initiation and continuation of drug abuse in the United States? To answer that question, the study has four parts. This study:

1. Discusses how the prices of cocaine, heroin, marijuana and methamphetamine have changed over the last 20 years and assesses how law enforcement has affected those trends.

2. Estimates how changes in the prices of illicit drugs have influenced decisions by youth to initiate drug use.

3. Estimates how changes in the price of illicit drugs have affected continued use by hardcore and occasional drug users.

4. Projects the future prevalence of illicit drug use given different scenarios about the effectiveness of supply-based programs.

## Methods and Data

This is an empirical study. Estimates of trends in drug prices come from an earlier study done by Abt Associates Inc. for the Office of National Drug Control Policy. That earlier study used data from two Drug Enforcement Administration data sources: the System to Retrieve Information from Drug Evidence and the Domestic Monitor Program. Data about the initiation and continuation of drug use come from multiple administrations of the National Household Survey on Drug Abuse, mostly from the years 1988 through 1996. Those data, which identified the places for matching with the price data, were provided by the Research Triangle Institute by special agreement with the Substance Abuse Mental Health Services Administration. We thank both RTI and SAMHSA for their support. Data about drug use by hardcore users come from multiple administrations of the Drug Use Forecasting data, mostly from 1989 through 1998. We required raw data, before recoding done by a National Institute of Justice contractor, which NIJ provided by special request. We are also grateful to ICPSR and NIJ for their assistance.

We used a survival model, developed especially for this study, to analyze whether or not drug prices affect the eventual probability that a youth would experiment with drugs and the age of experimentation if he or she did try an illicit substance. We used an ordered probit model, also developed especially for this study, to study how drug prices influenced decisions to use illicit substances by those who, at some time, had tried drugs at an experimental level. Finally, we used an ordered logistic model to analyze the relationship between illicit drug prices and the level of substance abuse among arrestees.

Based on the statistical findings, we projected drug use into the years 2002 and 2007 based on different scenarios about how future drug prices will change from their present levels. The purpose of this simulation was to estimate how closely a supply-based program that successfully increased drug prices could approach the national target of reducing drug use by 50 percent as of 2007.

## Findings

### Drug Prices

There seems little doubt that the combination of source area programs, interdiction and domestic law enforcement have successfully increased the price of illicit drug products to levels that are many times higher than would otherwise prevail. Cocaine, heroin and marijuana are basically agricultural products that require minimal inexpensive chemical processing. If it were not for law enforcement, they might sell for prices that are comparable to aspirin. Instead, users pay many times the price of aspirin for typical doses.

Still, the Nation's ability to reduce drug availability and to increase drug prices appears to be limited. Since about 1988, the prices of cocaine, heroin and methamphetamine have all fallen or remained about the same, despite what was inaugurated in the late 1980s as a war on drugs. The price of marijuana increased into the early 1990s, apparently because of a successful program of interdiction, but prices have declined since then as domestic production has supplanted foreign production. Thus, while law enforcement efforts have maintained high domestic prices for illicit substances, an expansion of law enforcement resources in the 1990s has not had a commensurate effect on drug prices.

### Elasticity of Demand

*Marijuana*

When marijuana has been relatively unavailable, as reflected in high marijuana prices during the late 1980s and early 1990s, young Americans have been less likely to experiment with marijuana. Thus, Americans who came of age during the early 1980s, when marijuana was relatively inexpensive, were more likely to try marijuana than were Americans who came of age in the early 1990s, when marijuana cost more. Marijuana prices have fallen toward the end of the 1990s, while the best evidence, available from several sources, indicates that youth have increasingly returned to marijuana use. There seems to be strong evidence that price and availability influence the decisions of children and young adults to experiment with marijuana.

The evidence is also strong that adults are sensitive to the price of marijuana. The higher the price, the smaller the number of people who use marijuana at both weekly and occasional levels. This is true for members of households, who tend to use on an occasional basis, as well as for arrestees, who often use at a weekly level or higher.

*Cocaine*
There is some evidence that experimentation with cocaine is less frequent when cocaine prices are high, but the evidence is weak. It would be a mistake to conclude that cocaine prices do not matter, however, because these data are not well suited to answering the question. Because cocaine prices have decreased fairly steadily since 1981, with just a few short-term perturbations, we could not readily distinguish the effect of changes in cocaine prices from other secular trends.

We did not find household members to be sensitive to cocaine prices. However, arrestees reacted strongly to cocaine prices, decreasing their consumption when prices were high and increasing their consumption when prices were low.

*Heroin*
Heroin prices seemed to affect experimentation with heroin. However, the effect was difficult to quantify because prices decreased fairly steadily from 1981 through 1998. We may not have been able to distinguish price responsiveness from other trends.

It was not practical to study the demand for heroin using NHSDA data because so few respondents admitted heroin use. Arrestees seemed to be only mildly responsive to heroin prices (and this relationship was statistically significant only at the 10 percent level).

*Methamphetamines*
The NHSDA did not ask the requisite questions about methamphetamine use, so the NHSDA data did not enter this analysis. Data from five DUF sites that had an appreciable amount of methamphetamine use indicated that methamphetamine users were very responsive to prices. The prevalence of methamphetamine use, both by heavy and occasional users, was greatest when prices were low and least when prices were high.

**Projections**

*Marijuana*
The key question was whether or not the targets set by the National Strategy are obtainable. The good news is that the prevalence of marijuana use among household users is likely to fall toward the national goal even if marijuana prices remain about the same as they were during the latter 1990s. The projected decline in use is much less for arrestees. This follows because cohorts who came of age during the late 1970s and early 1980s were at the highest risk of experimenting with marijuana, but continued marijuana use is age sensitive. As those high-risk cohorts grow older, fewer of their members will be active marijuana users. Because initiation rates have been lower in the late 1980s and early 1990s, the disappearance of marijuana use by high-risk cohort members will not be offset by an equal increase in new marijuana users. Higher marijuana prices would reinforce this change, of course; as of yet there is no evidence of domestic programs that would substantially increase marijuana prices by increasing the production and distribution costs of domestic producers.

The uncertainty regarding this otherwise positive conclusion stems from recent increases in marijuana use by eighth, tenth and twelfth graders who reported substance use to the Monitoring the Future Survey. Although the analysis reported here identified the beginning of that upturn in experimentation with marijuana use, our data ended in 1996, so we may have understated this resurgence in marijuana use. The future may not be as bright as is painted here.

***Cocaine***

Similar patterns apply to cocaine, although for cocaine, the pattern is not so strong. We project a very gradual downward trend in cocaine use among household members. Higher cocaine prices would reinforce that trend, but the analysis showed little if any consumer responsiveness by household members to increased cocaine prices. On the other hand, the analysis showed very strong price responsiveness by arrestees, whose prevalence of cocaine use was diminishing anyway. Higher cocaine prices would reinforce that trend among heavy users, helping the Nation move toward its targets.

***Heroin***

We are less certain about projections for future heroin use. The NHSDA is not especially informative about heroin use, so we relied exclusively on the DUF data. Results suggested that the prevalence of heroin use would decline even without a price increase, apparently because heroin users are an aging population whose use would decrease naturally. This conclusion is tentative, because relatively low-priced high-purity heroin, available since about 1995, may have induced increased use of heroin.

***Methamphetamine***

We are much less certain about future levels of methamphetamine use because of the small and narrowly based sample of arrestees. Trends imply lower levels of future use among arrestees, and those trends would be reinforced by higher prices. A problem with that inference is that it is based on past reports, which are very cyclical and do not point clearly toward less use. Furthermore, methamphetamine use is currently limited to the West and (to a lesser extent) the Midwest. It is difficult to anticipate whether or not methamphetamine use will spread to the rest of the country. If it does, projections are probably in error.

## Conclusions

On the whole, prospective and confirmed drug users are sensitive to the price of drugs, so if the Nation can increase the effectiveness of source country programs, interdiction and domestic law enforcement, then drug abuse can be reduced appreciably. Given experiences since the beginning of the war on drugs, which initiated major expansions in expenditures on supply-based programs, it seems more reasonable to conclude that the Nation will not be able to have any large future influence on decreasing the availability and increasing the price of illicit drugs. Of course, this conclusions rests on observations of past trends, and it could be reversed by the introduction of technological advances, such as improved ways of detecting cocaine, better informed decisions about the placement of interdiction resources, and improved means of detecting domestic marijuana cultivation. But until those improvements happen, it is difficult to be sanguine that supply-based programs can be the major means by which the Nation reaches its 2002 and 2007 targets.

On the other hand, there are reasons to believe that those targets can be obtained. Excluding the use of alcohol and tobacco by youth, marijuana is by far the most widely abused illicit substance.

Evidence presented in this report finds that marijuana use will decrease in the future even if marijuana prices remain the same. If marijuana prices could be returned to near the levels they attained in the early 1990s, then drug use in the household population would decrease even more. Thus, targets that pertain to the drug use by household members are within the Nation's grasp, although supply-side programs alone cannot guarantee they will be reached.

Trends by hardcore drug users are also encouraging. If the Nation can hold the line on the initiation of illicit drug use, preventing it from returning to the epidemic proportions experienced during earlier decades, then as more hardcore drug users age out of their addictions, there will be fewer replacements to take their place. These trends, by themselves, do not appear adequate to reach the Nation's targets for reducing hardcore drug use. But with the reinforcement of supply-based and expanded demand-based programs (especially treatment), the Nation can be hopeful, if not expectant, that drug abuse and its sequela will abate.

The fly in this prediction ointment is that our data stopped in 1996 and, of course, predictions had to be based on data as of that date. In fact, the Monitoring the Future Survey (University of Michigan, 1999) shows that lifetime prevalence of any illicit drug use by seniors reached a peak (since 1975) with the class of 1981 and decreased more or less steadily until the class of 1993. Thereafter, experimentation has increased more or less steadily through the class of 1999. Our analysis may not fully account for this recent resurgence of use, although nothing in our findings contradict the recent trend reported by the MTF.

The final conclusion, then, is the inevitable call for further research. If it is important to monitor and explain trends, in order to predict the future, it seems imperative to do this with the most recently available data. This study provides a template for how data obtained through annual surveys might be analyzed, to gain a better understanding of drug abuse.

# Chapter 1 Introduction

Expenditures on anti-drug programs, made collectively at all levels of government, exceeded $30 billion dollars per year at the end of the 1990s. Those expenditures were made on a myriad of demand-based and supply-based programs, often with little knowledge of how those programs directly affected the supply of and the demand for drugs, and with even less knowledge of how they interacted to affect drug abuse. Understandably, as it fashioned its response to rising drug use, the Nation was unwilling to wait for hard scientific evidence of what "works" and "does not work." It was compelled to act.

Nearly fifteen years into what was inaugurated as a war on drugs, the Nation can reflect on the successes and failures of its response to increased substance abuse. This study examines part of the puzzle. Supply-based programs should reduce the availability of drugs to American consumers, either by preventing drugs from entering the country, or by increasing the cost of their production and distribution, or both. The success of supply-based programs should increase the price of illicit drugs, and if drug users act anything like the consumers of licit products, some should quit and others should reduce their use. Demand-based programs should reinforce this effect by preventing people from becoming drug users in the first place, and by encouraging and facilitating active users to stop.

Have supply-based and demand-based programs worked according to expectations as enumerated in the National Strategy? This study examines how illicit drug prices have changed over the last twenty years as the United States has increased its expenditures on source country interventions, other forms of interdiction, and domestic law enforcement – all in an attempt to restrict the availability of drugs to and within the United States. It examines how the resulting changes in prices have affected the initiation and continuation of illicit drug use, and it projects drug use based on differing scenarios about the future success of supply-based and demand-based programs.

This is an empirical study. Mathematical modeling and statistical analysis lead to inferences about how drug prices have affected and will affect the initiation and continuation of illicit drug use. Drug prices come from an analysis of data in the System to Retrieve Drug Evidence (1981 through 1998). Data about the initiation and continuation of marijuana, cocaine and heroin use come from the National Household Survey on Drug Abuse (1982 through 1996). The Drug Use Forecasting system (1989 through 1998) provides data about the use of cocaine, heroin, marijuana and methamphetamines by arrestees, many of whom are heavy users based on self-reports.

## Objectives of this Study

The 1998 National Drug Control Strategy specified five Goals and thirty-two supporting objectives that will guide the Government's anti-drug program over the next decade. The Strategy's five Goals are encapsulated in a summary statement: Reduce the supply of and the demand for illicit drugs 50 percent by year-2007. The Nation's ability to meet this summary goal depends partly on its ability to increase illicit drug prices through source country programs, transit zone interdiction, and domestic law enforcement. If the Nation is successful at reducing drug supply and hence increasing drug prices, the question becomes: How will increased prices affect the demand for illicit substances? That is the central question to be answered in this study.

In addition to that summary statement, the Office of National Drug Control Policy has set 97 performance targets and 127 associated measures. Twelve of these performance targets have been designated as Impact Targets. They provide a report card for the effectiveness of anti-drug programs.

Five of those twelve performance targets relate to drug users and drug use:

- By 2002, reduce the nationwide prevalence of illegal drug use by 25 percent as compared to the 1996 base year. By 2007, reduce prevalence by 50 percent as compared to the base year.
- By 2002, reduce the prevalence of past month use of illegal drugs and alcohol among youth by 20 percent as measured against the 1996 base year. By 2007, reduce this prevalence by 50 percent as compared to the base year. Reduce tobacco use by youth by 25 percent by 2002 and by 55 percent by 2007.
- By 2002, increase the average age for first time drug use by 12 months from the average age of first time use in 1996. By 2007, increase the average age of first time drug use by 36 months from the 1996 base year.
- By 2002, reduce the prevalence of drug use in the workplace by 25 percent as compared to the 1996 base year. By 2007, reduce this prevalence by 50 percent as compared to the base year.
- By 2002, reduce the number of chronic drug users by 20 percent as compared to the 1996 base year. By 2007, reduce the number of chronic drug users by 50 percent as compared to the base year.

Five additional targets involve supply-side variables. These targets are instrumental toward increasing the price of illicit drugs, reducing the supply of illicit drugs, or both. They are important because reduced availability and higher prices should promote less drug use.

- By 2002, reduce drug availability in the United States by 25 percent as compared with the estimated 1996 base year. By 2007, reduce illicit drug availability in the U.S. by 50 percent from the base year.
- By 2002, reduce the rate of outflow of illicit drugs from the source zone by 15 percent as compared to the 1996 base year. By 2007, reduce the outflow rate by a total of 30 percent measured against the base year.
- By 2002, reduce the rate at which illegal drugs successfully enter the United States from the transit and arrival zones by 10 percent as compared to the 1996 base year. By 2007, reduce this rate by 20 percent as measured against the base year
- Domestic production – By 2002, reduce the production of methamphetamine and the cultivation of marijuana in the United States by at least 20 percent as compared to the 1996 base year and by 2007, reduce by 50 percent the production of methamphetamine and the cultivation of marijuana as compared to the base year.
- Domestic trafficker success – By 2002, reduce by 10 percent the rate at which illicit drugs of U.S. venue reach the U.S. consumer, as compared with the 1996 base year. By 2007, reduce this rate by 20 percent over the base year

The final two targets are consequences of reducing the number of drug users and the level of drug use.

- By 2002, reduce by 15 percent the rate of crime and violent acts associated with drug trafficking and use, as compared with the 1996 base year. By 2007, reduce drug-related crime and violence by 30 percent as compared with the base year.
- By 2002, reduce health and social costs associated with illegal drugs by 10 percent, as expressed in constant dollars, as compared to the 1996 base year. By 2007, reduce such costs by 25 percent as compared to the base year.

There is an implicit causal connection among and between these targets. Successful supply-based programs will increase the price of illicit drugs and reduce their availability. If this happens, then young children will have less access to illicit drugs: Fewer children will experiment with drugs, and whatever experimentation happens will occur at a later age. Over time, fewer children will advance to occasional and chronic drug use. Adults who would otherwise be drug users will reduce their use or stop altogether as drugs become harder to get, more expensive, and generally less appealing. Workplace programs, and presumably other prevention programs (which do not have associated impact targets), are expected to reinforce the supply-side effect. Treatment, and presumably compulsion, will further reduce the number of chronic users.

Is this causal mechanism plausible? Can the Government appreciably increase the price of illicit drugs and otherwise decrease their availability? Will children, young adults, and other adults respond by reducing or stopping their drug use? Are the targets believable? This study intends to provide some answers.

## Methodology

This study begins with interpretation of trends in the level of drug prices: cocaine, heroin, methamphetamine and marijuana. Trends are taken from a report prepared by Abt Associates for the Office of National Drug Control Policy (Johnston, Rhodes, Carrigan and Moe, 1999), and interpretations are supported by additional studies done by Abt Associates for ONDCP. However, the interpretations themselves are a product of this report.

Using the drug prices, most of this report is focused on the demand for illicit drugs. As pointed out by a recent panel of the National Academy of Sciences (Manski, Pepper and Thomas, 1999) , the demand for drugs does not take a single form. The National Drug Control Strategy recognizes this when it sets separate impact targets for children and for adults, and when it distinguishes chronic users from other users. Thus, this is not a study of the demand for drugs, but rather, a study of the demands for drugs.

It first investigates the initiation of drug use separately for marijuana, cocaine and heroin. Data about initiation are not available for methamphetamine because data come from several administrations of the National Household Survey on Drug Abuse, and the survey did not ask the requisite questions about methamphetamine use. We use a fixed-effects split-population survival model to analyze initiation rates. A methodological exposition appears later; here, we provide a summary.

By *fixed-effects* we mean that the analysis always includes a variable that represents the place where the interview occurred. Initiation rates are likely to vary across the nation, and the fixed-effects control for that variation. This also means that all inferences are based on the covariation between drug prices and demand within a county. None of the evidence comes from variation across places in the United States.[1]

[1] Reliance on cross-sectional variation can be a specification error that leads to a biased estimate of how prices affect demand. Consider a simple, although contrived, illustration. Because of Mormon customs, the use of intoxicants – including illicit drugs – is low in Salt Lake City. The prices of drugs are relatively high in Salt Lake City, because drug markets are poorly developed and inefficient due to the lack of scale economies. In contrast, drug markets are efficient in New York City, so drug prices are comparatively low. The ethos in New York City is supportive of illicit drug use, at least when compared with the ethical climate in Salt Lake City. Even if prices had no affect on consumption, cross-sectional variation would imply a strong price elasticity. The use of the fixed-effects prevents cross-sectional correlation from affecting the estimates.

By *survival model* we mean statistical procedures that analyze the time until an event occurs, where the event is the first time that the respondent tried a drug. The data were *censored on the right*, meaning we could not observe use that happened after the survey. Survival models commonly deal with such censoring.

By *two-population* we mean that, conceptually, the population could be divided into two parts. The first part comprises people who will try a drug eventually given sufficient time. The survival model only applies to them. The second part comprises people who will not try the drug even if they were given an infinite length time to do so. The survival curve does not apply to them.[2]

The fixed-effect two-population survival model is useful for the study of initiation, for two reasons. The first is that it represents a sensible way to think about how people initiate drug use. The second is that this model works well given the Strategy's impact targets, expressed as the probability that people will ever try a drug and the age at which they start.

Second, this study investigates the current level of drug use by household members who have ever tried the drug. For this purpose, we use a fixed-effects two-staged ordered probit model. Analysis is limited to marijuana and cocaine because the NHSDA has too little data about heroin and has not asked the requisite questions about methamphetamine.

As before, *fixed-effects* means that the analysis was conditioned on where a person lived at the time that he answered the interview. All inferences are based on the variation in drug prices within the place of residence over the period spanned by the interviews, 1988 through 1996.

The basic model was an *ordered probit* model. The dependent variable fell into one of three categories: (1) did not use during the year before the survey, (2) used less than weekly during the year before the survey, and (3) used at least weekly during the last year. The probit model is commonly used when a dependent variable takes ordered categories. The term *two-staged* means that the analysis was conditioned on the observation that the respondent had tried the drug some time in the past. Conditioning was more than just limiting the analysis file to those who had tried drugs in the past. The model recognized that the second stage decision (deciding whether or not to use currently and at what level), was stochastically dependent on the first stage decision (electing to try a drug at some time), and the model takes that stochastic dependence into account.

The two-staged ordered probit model affords an examination of drug use within the general population, which includes special groups, especially members of the workforce, targeted by the National Strategy for special attention. But the NHSDA misses large numbers of hardcore drug users – the chronic users identified by the impact targets. For them, we turned to a second data source, the Drug Use Forecasting data.

To study drug use as reported in the DUF data, we used a fixed-effects ordered logistic regression model. The use categories were: (1) no use during the month before the interview, (2) use on 10 or fewer days during the month before the interview, and (3) use on 11 or more days during that month. The ordered

[2] Of course, we cannot tell who belongs to the group who will ever use drugs and who belongs to the group that will never use drugs. We can only assess the probability of belonging to one group or the other, and that is done by statistical inference.

logistic model, which is much like the ordered probit model, is often used to analyze dependent variables that fall into ordered categories. Preferences of two different analysts explain why we used a probit model in the first case and a logistic model in the second.

Finally we used a simulation to project drug use into the year 2002 and 2007. The simulation was based on trends observed in the analysis discussed above and varying assumptions about what would happen to drug prices between 1996 (the base year) and 2002 and 2007. The years 2002 and 2007 were chosen because they are identified in the impact targets.

## Data

The NHSDA data is a national probability sample of household members. (Recent administrations have expanded the survey to include people who live in group quarters, but this is a small sample and probably has little effect on any analysis.) The survey has been administered every year since 1990. It was also administered in 1979, 1982, 1985, and 1988.[3] Given the relatively small samples and infrequent administration before 1988, we make most use of data from 1988 and later.

The survey's administration has changed over time. Some questions have been added and some deleted. Questions about substance use have undergone subtle changes over time, but basically, the most important questions remained the same. Nevertheless, we did a great deal of data cleaning to assure data were consistent from year to year. This means that response categories were collapsed to a lowest common denominator. For example, at one survey administration, a respondent might have been allowed to answer 1, 2 or 3 to a specific question. At another administration, 2 and 3 might have been collapsed into a single allowable category. We recoded the 2 and 3 response from the first survey into a single category. Appendix A provides a list of variables used in the resulting analysis file.

Somewhat different questions are asked about different drugs. For example, there is more detail about marijuana use than about heroin. Although some versions of the NHSDA have asked about expenditures, or amount used, we are skeptical of responses based on what we know about drug use from other sources. Regardless, those questions are not asked for all periods, so we did not analyze expenditures for this study. The kinds of questions asked consistently are about lifetime use, yearly use, and monthly use. These are typically in the form: Did you use the drug? How frequently? Elasticity estimates have to be based on such responses, so we seek to learn whether initiation of drug use, participation in drug use, and frequency of drug use vary with drug prices and other variables.

The survey has a multi-stage complex sampling design, so inferences based on tabulations are not straightforward. Computation of standard errors for tabulations can be based on design-factor adjustments, or by using special computing software, such as SUDDAN. Although the point is arguable (see DuMouchel and Duncan, 1983; Deaton, 1997), regression-based studies can safely ignore the complex sampling design, provided covariates include stratification variables and the estimates are understood to be conditional on the sample, so regressions are based on unweighted data. We will take this approach because the use of special computing software was too limiting given that the complexity of our models necessitated, for the most part, the writing of our own computer code.

The NHSDA is well-suited to the analysis contemplated here. Its cluster sampling design selects some places with certainty, guaranteeing that those same places will be in the sample over time. This is

[3] We do not have the 1985 survey data.

essential, because, as discussed, statistical inference is based on a time-series of usage patterns within an area. By using a fixed-effects design, we should be able to identify whether drug use changes with the price of illicit drugs and other factors.

All regression results reported here used a fixed effects design, so it was important to have a suitable sample from each place for an extended period. We excluded places that had data for one or at most, a few years, which left us with 28 places consisting of 72,000 observations. We seldom used all data from these selected places. Frequently we restricted the data by age group, and sometimes by gender and race/ethnicity. Because of concerns for confidentiality, the Office of Applied Studies requested that we not identify places selected for the study.

The NHSDA has major limitations. The survey seems to miss many hardcore drug users, and those respondents who answer the survey often deny their drug use.[4] This does not seem like a crucial problem for a study of the demand for drugs provided the truthfulness of reporting is time-invariant, but time-invariance may be an unreasonable assumption. If people are more willing to report drug use when drugs are more socially acceptable, then trends in reported drug use would be an unreliable measure of actual drug use. We are unaware of anyone who has tested this assumption.

The NHSDA seems to be the best source for studying the initiation of drug use, participation in drug use, and continuation of drug use, but the survey misses the heaviest or hardcore drug users. To study the drug use patterns of hardcore drug users, we used the Drug Use Forecasting/Arrestee Drug Abuse Monitoring

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

Available evidence indicates that NHSDA's respondents understate heavy drug use. A. Harrell, K. Kapsak, I. Cisin, and P. Wirtz, "The Validity of Self-Reported Drug Use Data: The Accuracy of Responses on Confidential Self-Administered Answer Sheets," paper prepared for the National Institute on Drug Abuse, Contract Number 271-85-8305, December 1986. M. Fendrich, T. Johnson, S. Sudman, J. Wislar and V. Spiehler, " Validity of Drug Use Reporting in a High-Risk Community Sample: A Comparison of Cocaine and Heroin Survey Reports with Hair Tests," *American Journal of Epidemiology* 149(10): 955:62, 1999. Consistent with these observations, the Substance Abuse Mental Health and Services Administration reports that virtually no heroin addicts answer the National Household Survey on Drug Abuse. Substance Abuse Mental Health and Services Administration, *Preliminary Estimates from the 1993 Household Survey on Drug Abuse* (June 1994).

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

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

data, which are available since 1989. Twenty-four cities are represented in DUF, with some cities having participated in the DUF program for longer than others. Table 1 shows the number of observations from each DUF site. The number of participating cities for male arrestees is larger than the number of participating cities for female arrestees. We do not use juvenile DUF, because the NHSDA is more representative of drug use by youth.

**Table 1**

**DUF/ADAM INTERVIEWS BY SITE BY YEAR**

| SITE | YEAR | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Total |
| New York City | 1294 | 1242 | 1320 | 1022 | 1478 | 1032 | 1376 | 1381 | 1399 | 2323 | 13867 |
| Washington, D.C. | 1302 | 1302 | 1295 | 1212 | 1175 | 1308 | 1148 | 1267 | 1331 | 615 | 11955 |
| Portland | 1345 | 1141 | 1118 | 1093 | 1347 | 1407 | 1431 | 1404 | 993 | 1087 | 12366 |
| San Diego | 1165 | 1369 | 1314 | 1293 | 1222 | 1169 | 1231 | 1162 | 1146 | 914 | 11985 |
| Indianapolis | 1023 | 1151 | 1205 | 1236 | 1272 | 1289 | 1353 | 1415 | 1341 | 904 | 12189 |
| Houston | 968 | 1379 | 1346 | 1319 | 1340 | 1274 | 1251 | 1155 | 1215 | 915 | 12162 |
| Fort Lauderdale | 654 | 1263 | 1281 | 1218 | 1312 | 1324 | 1274 | 1287 | 1314 | 877 | 11804 |
| Detroit | 753 | 1145 | 1184 | 1398 | 638 | 280 | 891 | 746 | 967 | 593 | 8595 |
| New Orleans | 1200 | 1292 | 1261 | 1304 | 1316 | 1299 | 1322 | 1349 | 1346 | 1314 | 13003 |
| Phoenix | 1111 | 1515 | 1589 | 1620 | 1561 | 1539 | 1544 | 1505 | 1580 | 878 | 14442 |
| Chicago | 401 | 867 | 823 | 865 | 862 | 855 | 832 | 839 | 614 | 1196 | 8154 |
| Los Angeles | 940 | 1783 | 1969 | 2133 | 1784 | 1451 | 1534 | 1622 | 1422 | 1856 | 16494 |
| Dallas | 1395 | 1353 | 1290 | 1371 | 1416 | 1374 | 1338 | 1313 | 1358 | 785 | 12993 |
| Birmingham | 893 | 1052 | 1190 | 995 | 1021 | 982 | 1211 | 1189 | 1063 | 780 | 10376 |
| Omaha | 0 | 601 | 851 | 843 | 831 | 944 | 997 | 983 | 1004 | 862 | 7916 |
| Philadelphia | 1629 | 1569 | 1567 | 1574 | 1525 | 1514 | 1320 | 814 | 864 | 875 | 13251 |
| Miami | 209 | 0 | 681 | 908 | 660 | 900 | 847 | 891 | 859 | 421 | 6376 |
| Cleveland | 795 | 1069 | 1115 | 1130 | 1099 | 1075 | 1052 | 1026 | 946 | 674 | 9981 |
| San Antonio | 1210 | 1117 | 904 | 963 | 1341 | 1250 | 1298 | 1311 | 1291 | 1205 | 11890 |
| St. Louis | 1182 | 1294 | 1263 | 1231 | 1198 | 1234 | 1213 | 889 | 1032 | 742 | 11278 |
| Kansas City | 1273 | 1205 | 1218 | 1252 | 0 | 0 | 0 | 0 | 0 | 0 | 4948 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| San Jose | 666 | 1350 | 1364 | 1392 | 1429 | 1430 | 1366 | 1230 | 1285 | 583 | 12095 |
| Denver | 0 | 1336 | 1325 | 1356 | 1310 | 1308 | 1349 | 1300 | 1325 | 1375 | 11984 |
| Atlanta | 0 | 447 | 1693 | 1448 | 1226 | 1050 | 1054 | 961 | 1113 | 303 | 9295 |
| Total | 21408 | 27842 | 30166 | 30176 | 28363 | 27288 | 28232 | 27039 | 26808 | 22077 | 269399 |

We are well aware of DUF's limitations. DUF is not a probability sample. If DUF's sampling plan had not changed over time, the fact that it is a non-probability sample would have little significance, because elasticity estimates could be conditional on whatever sampling had been in place. A different problem arises, however, when the sampling plan changes over time, because we would not be able to distinguish between changes in drug use and coincident changes in arrestees who are sampled. Unfortunately, we were unable to identify when sampling procedures changed in each of the DUF site samples, so estimation had to proceed as if those changes were insignificant. The DUF data provide self-reports of frequency of use for drugs of principal interest to us. Arrestees often refuse to report their drug use, especially their most recent drug use. Our analysis is based on the *truth tellers*, that is, those people who are willing to report how recently and how frequently they have used drugs. Of 13,759 arrestees who tested positive for opiates, 8,342 said they had used heroin during the 30 days before the interview.[5] This implies a truthful reporting rate of about 0.61 for heroin users. Of 73,504 arrestees who tested positive for cocaine, 41,346 said they had used cocaine or crack during the 30 days prior to the interview. This suggests a truthful reporting rate of 0.56.

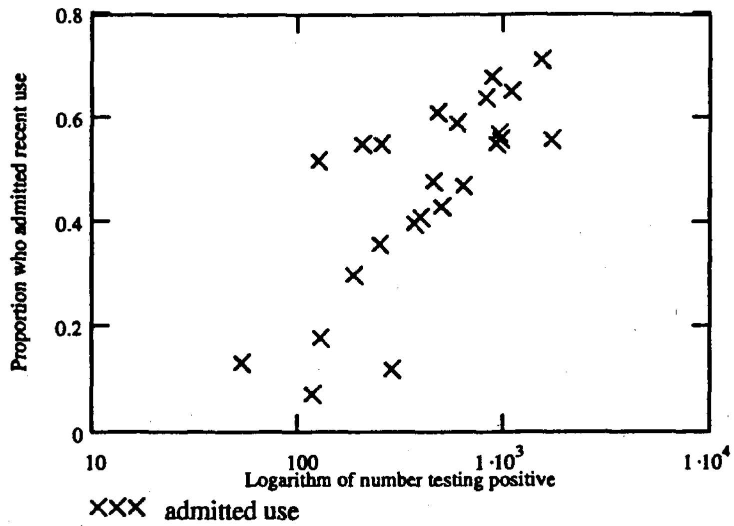
This approach—restricting data to truth tellers—should have no important bias provided truthfulness rates have remained constant over time. To our knowledge, NIJ has not tested this important assumption. We have conducted some informal inspection tests by graphing truthfulness rates (based on urine tests) as a function of time. Excluding the first year of DUF program operation, truthful reporting has not changed much over time. Consequently, restricting the analysis to truth tellers is probably innocuous.

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

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

**Figure 1**

Proportion of Arrestees Admitting Use as a Function of the Number Who Tested Positive




The pattern is clear: The larger the number of arrestees who tested positive for heroin, the larger the proportion of those who tested positive who also admitted recent use. The interpretation is less clear. Certainly we would expect false positive rates on the urine screen to be larger when the prevalence of heroin use is relatively low. Consistent with this explanation, 7 percent of arrestees who test positive for opiates in Omaha (only 116 positive urine tests) admitted 30-day use of heroin and 18 percent of those who tested positive in Fort Lauderdale (only 130 positive urine tests) admitted 30-day use. In contrast, we see reporting rates of 71 percent in New York (1493 positive urine tests) and 65 percent in San Diego (1069 positive urine tests). This same problem with truthful reporting does not seem to affect cocaine, whose prevalence is fairly high everywhere.

A second problem was suggested by the ADAM program. The DUF survey is being replaced by the Arrestee Drug Abuse Monitoring (ADAM) survey. When pretesting the ADAM instrument, the ADAM team found that many people who tested positive for a drug denied use during the last three days but admitted use during 27 or 28 days during the last month. Apparently they simply wanted to avoid an admission of the drug use episode most associated with their arrest, but they were willing to report about other use. This phenomena would cause hardcore drug users to be more truthful than occasional drug users, so estimates of truthfulness may be understated for hardcore users.

At any rate, the rate of truthful reporting for heroin use would seem to be higher than 61 percent, and the rate for cocaine use would seem to be higher than 0.56, but we are uncertain how much higher. Another way to look at these data is to ask: Of those people who tested positive for opiates, what percentage of them were willing to admit to illicit use of *any* drug during the month before the survey. Unless there is some reason to expect people to deny heroin use but admit other use, this percentage would seem to be a reasonable measure of being truthful. For this purpose, we excluded marijuana, because its use is less stigmatized or possession laws are not enforced in many places, so there is less reason to deny its use. Of those who tested positive for opiates, 73 percent were willing to admit *some* illicit drug use other than marijuana. For those who tested positive for cocaine, 61 percent reported that they used *some* illicit drug other than marijuana during the month. Given this alternative criterion for truthful reporting, truthfulness by heroin users is greater than truthfulness for cocaine users.

This analysis relied on answers to the question about the number of days during the last month that the respondent used a specified drug. We have worked in other contexts with a separate question about expenditures on drug use, and we know that interpreting answers to this question poses some problems: The question lumps together all drugs, so it is impossible in many cases to identify expenditures on specific drugs.[6] Another problem is that the responses to this question are highly skewed and the extreme values lack credibility. Consequently, our analysis was based on responses to the frequency question.

These problems aside, the DUF data were very useful for our analysis. DUF provides a lengthy time-series of reported drug use by a population that is at an especially high risk of heavy substance abuse. Again, the analysis is based on a fixed-effect model, so a lengthy time-series over a suitable cross-section of data was crucial.

Table 1, which outlines the number of DUF interviews by year by site, is deceptive about the size of the sample for parts of this analysis. To be included into this study, a place had to have a credible price-series estimate. This was always the case for cocaine use, so most of these DUF data entered into our analysis of the demand for cocaine. That was the case for methamphetamine prices in only five places. This is not as limiting as it might seem, however, because these five were the only DUF sites for which arrestees reported an appreciable amount of methamphetamine use. Inclusion of other sites would not have told us much.

Of course, the above analysis assumes that we have credible price series for the cost of illicit drugs. Abt Associates staff have developed price series for cocaine, heroin, marijuana and methamphetamine. These estimates provide a good basis for supporting this analysis. They are discussed later in this report.

Data on the price of alcohol were taken from the Consumer Price Index for all Urban Consumers (CPI-U) published monthly by the Bureau of Labor Statistics. The Bureau of Labor Statistics defines the Consumer Price Index as "a measure of the average change in prices over time in a fixed market basket of goods and services" (U.S. Department of Labor 1992). The Bureau of Labor Statistics includes beer, wine and distilled spirits, consumed both "at home and away," in the "alcoholic beverages" category. Data are collected in 85 urban areas, from about 57,000 households and 19,000 retail establishments (U.S. Department of Labor 1992). Bureau of Labor Statistics researchers visit stores to assess prices monthly or bimonthly, depending on the location and the item to be priced. Important for our purposes, the Consumer Price Index includes taxes in the price, and changes in tax rates account for sharp changes in alcohol prices.

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6 Many users receive their drugs as gifts, for example from a partner, or as income in kind, for example as payment for serving as a dealer's lookout. Similarly, expenditure can include expenditures for the consumption of others, including the customers of dealers. The analysis will need to take these issues into account, perhaps by eliminating outliers that would seem to be associated with the above phenomena.

The above discussion covers the data used for demand elasticity. Our approach to supply-based elasticity is different from our approach to demand-based elasticity estimates. We follow the approach of Rydell and Everingham (1994), Caulkins and Reuter (1997), and our own work to construct a supply curve from its component parts.

To explain, the price that drug dealers charge their clients must cover the costs of selling drugs. As economists use the term, or at least as we are using the term here, costs include factor costs such as labor, capital and raw materials and also what might be seen as profit. In the drug world, apparent profits actually cover the special costs of doing business, including the costs associated with the risk of law enforcement, the costs associated with a physically dangerous working environment, and the risk of operating in settings where contract law is unavailable for settling disputes.

Being precise about the cost components is beside the point. The important issue here is to learn how street-prices change with public interventions intended to restrict drug supply and increase the costs of dealing. For close to a decade, Abt researchers have been working with ONDCP to develop flow models for illicit drugs (Layne, Rhodes and Johnston, 1999; Rhodes, Layne and Johnston, 1999). At this time, we have credible flow models for cocaine and heroin, and a nascent model for marijuana. ONDCP has recently asked us to work with National intelligence agencies to develop models that will become the Government's official estimates. The data used for supply-based elasticity estimates come partly from that assignment.

# Chapter 2 The Supply and Demand for Illicit Drugs

This Chapter provides a brief literature review in three areas: Estimates of the demand for illicit drugs, estimates of the supply for illicit drugs, and estimates of the price of illicit drugs.

## The Demand for Illicit Drugs: Literature Review

Price elasticity of demand for illicit drugs is the percentage change in demand for illicit drugs per percentage change in price of illicit drugs. There are few direct empirical studies on the price elasticity of demand for cocaine, marijuana, heroin, and other illicit drugs. Nisbet and Vakil (1972) provided an early estimate of price elasticity of demand for marijuana. Their data on both the quantity purchased monthly and the purchasing price were from an anonymous mail survey of UCLA students. Conditional on purchasing, their estimate was in the range from –0.37 to –1.51, depending on whether the regression's functional form was double-log or linear.

Several authors have estimated price elasticities using national survey data. Based on pooled data from the 1988, 1990 and 1991 NHSDA surveys and Drug Enforcement Administration's STRIDE price data, Saffer and Chaloupka (1995) found that the annual participation price elasticities for heroin and cocaine are –0.90 and –0.55, respectively, and monthly participation price elasticities are –0.80 and –0.36, respectively. Assuming that the use price elasticity conditional on participation is about the same size as the participation price elasticity, they claimed that heroin's price elasticity is about –1.80 to –1.60 and cocaine's is about –1.10 to –0.72.[7] Based on data from the Monitoring the Future (MFT) surveys, Chaloupka, Grossman, and Tauras (1996) estimated both the participation price elasticity and the use elasticity conditional on participation, separately, using Cragg's two-part regression models. Their results showed that for annual data, the participation and use price elasticities are –0.89 and –0.40, respectively; for monthly data, they are –0.98 and –0.45, respectively.

Critics argue that national survey data fail to represent hardcore drug consumption, so Caulkins (1995) based his estimates on data from DUF. After making specific assumptions on the relationship between drug use and the probability of arrest, and by using the percentage of arrestees testing positive for cocaine and heroin as a proxy for drug use, he estimated that the price elasticity of demand for illicit drugs is large: –2.50 for cocaine and –1.50 for heroin.

The above studies did not use the recent development of economic theory on addictive behavior. According to Becker and Murphy (1988), an economic model based on rational choice predicts that drug consumption is negatively correlated with past, current, and future prices; that current drug consumption is positively correlated with past and future consumption; and that the long-run price elasticity is greater than the short-run elasticity. Grossman, Chaloupka, and Brown (1996) applied this theory to the demand for cocaine by young adults in the MTF panel. Their findings were

[7] They also estimated that marijuana decriminalization increased the probability of marijuana participation by about 4 to 6 percent.

consistent with predictions from the rational addiction models: the long-run unconditional price elasticity of demand for cocaine is –1.18 and the short-run unconditional price elasticity is –0.71.

The above studies are direct estimates of demand elasticity, but the effects of prices on illicit drug consumption can also be studied indirectly. For example, Silverman and Spruill (1977) found that property crimes were positively correlated with, but other crimes were independent of, the price of heroin. This suggested an inelastic demand for heroin. Rhodes (1996) found that decreases in heroin prices are weakly linked to an increased number of heroin addicts appearing in jails and lockups. Hyatt and Rhodes (1995) reported a significant negative relationship between the estimated street price per gram of cocaine and the level of cocaine-related medical emergencies and deaths, as well as the number of arrestees who test positive for cocaine, suggesting that cocaine consumption is sensitive to its price. This kind of inference, nonetheless, does not provide an estimate of price elasticity.

Studies on price elasticity of demand for other addictive goods such as alcohol and cigarette can also shed some light on the price elasticity of demand for illicit drugs. For instance, using disaggregated data, Chaloupka (1991) found a short-run price elasticity of demand for cigarettes at –0.20 and long-run elasticity at –0.45. Using state-aggregated data, Becker, Grossman, and Murphy (1994) found a short-run price elasticity of demand for cigarettes at –0.44 and long-run elasticity at –0.78. For alcohol, Manning and Mullahy (1997) estimated that the price elasticity of any drinking is –0.37, that for frequency if a current drinker is –0.34, that for quantity per drinking day is +0.09, and that the overall unconditional frequency of drinking is –0.70. Applying the rational addiction model, Grossman, Chaloupka, and Sirtalan (1998) estimated that the long-run price elasticity of demand for alcohol ranges from –0.26 to –1.26, and the short-run price elasticity ranges from –0.18 and –0.86. The ratio of the long-run elasticity to the corresponding short-run elasticity varies from 1.44 to 1.77.

In summary, the literature suggests that the price elasticity of demand for illicit drugs is large (perhaps around –1) and that the long-run elasticity is larger than the short-run elasticity. The existing studies, however, suffer from several problems.

As mentioned earlier, the NHSDA and MTF surveys probably miss most hardcore drug users, but those surveys provide the best available data about the initiation of and continuation of drug use by members of the general population. Consequently, many researchers have used the NHSDA and MTF to study the demand for cigarettes, alcohol, and illicit drugs within the general population. When used this way, the survey data suffer from a serious problem: the surveys have identified the respondent's State (e.g., California) but not the respondent's specific location (e.g., San Francisco) within that State. Consequently, when estimating price elasticity, these researchers have had to use a State-average price despite the fact that drug prices seem to vary widely from city to city. This measurement error will bias parameter estimates. Our study deals with that problem by using the NHSDA's places.

Another problem is that there are few studies about the cross elasticity of demand for illicit substances (for an exception, see Caulkins, 1995) and apparently there are no studies of the cross elasticity of demand for alcohol and illicit drugs. This latter omission is especially important when considering drug use by youths, for whom alcohol is an illicit substance, and for whom single drug consumer behavior is rarely established. The NHSDA and DUF/ADAM data allow us to compute cross elasticity estimates for the following drugs: cocaine, heroin, marijuana, methamphetamine, and alcohol because we have price estimates for these different substances. The NHSDA data allow us to focus on youths, because the survey over-samples children age twelve and older.

We also question the statistical methodology used in some of these studies, although we should be clear that the methodology might have been appropriate for the more limited data available to earlier researchers. Most researchers have used a two-part model, which assumes that the decision to use drugs is independent (in some regards) of the decision about how much to use. The limitations to a two-part model are familiar to quantitative criminologists, who recognize the problem as that of selection bias.

## The Supply of Illicit Drugs: Literature Review

Reuter's seminal work on drug supply (for example, Reuter, Crawford and Cave, 1988) challenged the effectiveness of source country and interdiction activities. This case has been reinforced by Rydell and Everingham (1994). In brief, these arguments rest on one key observation and one basic assumption. The observation is that the costs of producing and transporting cocaine to the United States and across its borders is a small fraction of the retail price of cocaine. The assumption is that the price markup from the U.S. border to U.S. city streets is additive. That is, the retail price $P_R$ is a linear function of the price at the border $P_B$ and a markup: $M_1$, so:

$$P_R = P_B + M_1$$

Thus, even if source country and interdiction programs are effective at (say) doubling the cost of cocaine at American borders, the effect on street prices will be minimal because $M_1$ is large relative to $P_B$.

Others (for example: Crane, Rivolo and Comfort, 1997) have challenged this conclusion, finding to the contrary, that source country programs have had a significant effect on street prices for cocaine. They argue that street prices are a multiple of prices at the border. That is, the retail price is a multiplicative function of the border price, so:

$$P_R = P_B M_2$$

While they do not necessarily agree with Crane and his colleagues, others (Caulkins and Padman, 1993; Rhodes, Hyatt and Scheiman, 1994; DeSimone, 1998) present evidence that is consistent with the multiplicative model, thereby adding support to Crane's position.

Recent discussions at a National Research Council workshop (Manski, Pepper and Thomas, 1999) seem to suggest that neither the Rydell and Everingham nor the Crane, Rivolo and Comfort positions are convincing. There is much to learn about the costs of producing, transshipping and distributing illicit drugs. There exists a need to better understand how drug prices are marked-up from the border to the street.

Researchers have made remarkable progress during the last decade at developing price series for illicit drugs. Notable is the work of Caulkins and Padman (1993) and several other papers by Caulkins and his colleagues, as well as the work of Rhodes, Hyatt and Scheiman (1994) and several other papers by Rhodes and his colleagues, including Johnston, Rhodes, Carrigan and Moe (1999).

According to that latter paper, domestic price markups for cocaine and heroin appear to be additive at the lower distribution levels and multiplicative at the higher distribution levels. In effect, the retail price is a mixture of multiplicative and additive elements, best written as:

$$P_R = P_B M_2 + M_1$$

The question, then, is the relative size of $M_1$ and $M_2$. We use the results from the Johnston, Rhodes, Carrigan and Moe study below.

## The Interaction between Supply and Demand

Estimating a demand curve places subtle but important demands on the analysts. Over time we can observe that drug purchases increase or decrease as drug prices decrease and increase. We might be inclined to infer that the size of the decrease in drug use that results from an increase in drug prices is a measure of buyer's responses to higher prices. Unfortunately, this inference may be very wrong, and certainly it does not hold unless we are willing to make additional assumptions. Econometricians call this *the identification problem*. But rather than provide a technical exegesis, which can be found in any econometrics textbook discussion of the estimation of simultaneous equations, a more intuitive interpretation may prove more useful.

A demand curve is a function that relates the amount of a good – such as cocaine – that consumers are willing to buy at various prices. A supply curve is a separate function that relates the amount of a good – cocaine again – that suppliers are willing to provide at different prices. An equilibrium is established at the unique price at which the amount that consumers want is the amount that suppliers are willing to sell. If the price were too low, then buyers would want more than suppliers would be willing to supply. Those consumers who were willing to pay more would bid the price upward. If the price were too high, then buyers would want less than the suppliers offered. To get rid of their stock, supplier would lower their price.

*We assume that the supply of cocaine is highly elastic.* This means that suppliers will provide about as much cocaine at a set price as consumers are willing to buy at that price. Cocaine is inexpensive to produce. It is basically an agricultural product that requires minimal inexpensive chemical processing. The product is fairly easy to transport, and only about 300 metric tons satisfies the entire U.S. domestic market. Apparently the largest cost involved in transporting cocaine is reimbursement for the risk of transporting and distributing it. Some of these risks are imposed by the industry itself, which has to rely on violence in the absence of legitimate contracting vehicles. Other risks result from interdiction and law enforcement, activities that force dealers to contend with substantial prison terms and loss of assets when caught. Over the long run,[8] suppliers can increase the amount of cocaine without substantially changing the above costs, so the supply curve seems quite elastic.

[8] A major expansion in product would require an increase in cultivation. Coca is grown in regions that are unsuitable for all but a few other agricultural products. Fields can be brought into cultivation by burning rain forests. Crops can be harvested in one to two years, depending on the strain of cocaine. Moreover, it appears that the amount of coca harvested exceeds the amount shipped by a substantial amount. Presumably, suppliers can draw on that extra harvest to satisfy an expanding market. It would appear that suppliers could expand their product without increasing its per unit cost.

If the demand curve remained constant, we could estimate consumer's responsiveness to drug prices as the supply curve – and hence drug prices – increased and decreased over time. But suppose that the demand curve itself changed so that consumers would demand more or less of a drug at the same price. Depending on the exact shape of the supply curve, we would see a price change and also a change in consumption. For example, if the supply curve sloped upwards, then price would increase while the amount purchased would decrease. Or, if the supply curve were perfectly flat, then the price would remain the same while consumption fell. Either way, the change in consumption that accompanies the change in price would not reflect how consumers respond to price! If we allowed it, the shift in the demand curve would fool us into thinking that we had measured price elasticity when in fact we had measured something entirely different.

To estimate the elasticity of demand we have to hold the demand curve constant and allow the supply curve to shift. This demanding requirement is difficult to satisfy. We try to hold the demand curve constant statistically by introducing covariates into the analysis. This is not particularly satisfying because the data are not rich in covariates and, furthermore, important variables such as social acceptability of drug use and perceptions of the danger of drug use are not observable, yet these seem to change over time.[9]

We cannot altogether solve this problem. It is probably not a serious problem for hardcore drug users, because their numbers have not decreased much over time. That is, we suspect there have been no large shifts in demand by hardcore users. It is a more serious problem for casual users because, over the period studied here, the demand curve seems to have shifted substantially. The only way we have to deal with this problem is to introduce age cohorts as control variables. For reasons explained subsequently, this is not a very satisfactory solution.

## Limitations of this Study

Several problems arise when estimating demand elasticity for illicit drugs. We have already discussed the "identification problem" above. Some other problems are conceptual, and still others stem from data limitations. We discuss those problems here.

Cocaine and heroin are exchanged at nominal prices that vary little if at all over time. For example, five years ago a New York addict might have bought a nickel ($5), dime ($10) or quarter ($25) bag of heroin. He could buy at the same nominal prices today. The difference is that nickel/dime/quarter bags contain more heroin today than they contained five years earlier.

Recognizing that nominal prices are invariant, we represent prices in standardized units, computed by dividing the nominal price by the pure amount of drug in the purchase. Although this way of representing prices imparts variation to the price data, we are uncertain about how consumers respond to price changes that really reflect variation in the quality of the product, not its price. Clearly consumers must be sensitive to quality issues, because otherwise dealers would always seek to provide a low quality product. Also, consumers who are habituated physically will not readily

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9 Even if they were observable, there are questions of simultaneity. Does a negative attitude, as expressed on a survey, cause a person to avoid drug use? Or do drug users tend to have positive attitudes toward using drugs?

tolerate a diminution in quality. Nevertheless, we suspect that many buyers, especially those who have yet to establish a minimal usage threshold, will be slow to perceive changes in quality. Variation in the quality of drugs sold on the street is already so great that distinguishing a change in mean price from random variation must be difficult. The way that drugs are transacted, then, may imposed special problems when we try to identify demand elasticity.

A second problem is that drug prices have not changed in ways that would be desirable for estimating elasticity. Cocaine and heroin prices both declined sharply until about 1988, and since then, the decline has been gradual. Because this change in prices has been basically monotonic, estimation has a difficult time distinguishing price effects from secular trends in drug use.

Still a third problem is that price estimates are subject to significant measurement error. The estimates are good enough to detect trends, but short-term variation is uncertain. This is unfortunate, because short-term variation is essential for detecting price elasticity given that long-term trends are monotonic. Additionally, random variation in the price variable imparts a downward bias to the parameter estimate of greatest interest to us, namely, the effect that price has on demand.

These problems are worse for some drugs than for others. Unlike the nominal price for heroin and cocaine, the nominal price of marijuana does change. Furthermore, marijuana prices increased from the early 1980s into the early 1990s and then declined, as domestic growers replaced many foreign providers. This increase, followed by a decrease, portends greater promise for distinguishing price responsiveness from secular trends. On the other hand, marijuana price estimates have less precision than their heroin and cocaine counterparts, which partly offsets the advantages that otherwise accrue when estimating consumer responses to marijuana prices.

Another problem when studying the demand for drugs is that, while the market price is observable, another aspect of price is not observable – namely, the risk of being a purchaser. This risk varies with the level of law enforcement and the consequences of being caught and punished.

Still another problem is that people do not report exactly what we would like to know about their consumption. They tell us the frequency of use expressed in days per stipulated period. They do not tell us how much they used during a day, and conceivably a users might react to prices by reducing daily use but not the number of days during which he uses. Or, he may use smaller quantities per use episode. This would certainly be the case if users reacted only to nominal price, because then they would use just as frequently but at lower dosage units.

A final problem, at least in this discussion, is that the apparent relationship between price and demand may be just a reflection of market disequilibrium. A short-run shortage in cocaine, for example, will necessitate that people use less. If prices have sufficient time to adjust, then consumption decisions will reflect the demand curve. But prices may not reach a new equilibrium, so that the quantity purchased is not the amount that users choose to buy at a prevailing price, but rather the amount that is forced upon them.

These are serious problems, but they do not mean that we cannot develop meaningful measures of consumers' responsiveness to drug prices. We can observe variation in usage patterns, even if the ways that people report their use is not exactly what we want to know. We can observe trends and short-term variation is drug prices, even if those price estimates have less temporal variation, and more measurement error than we would like. Identification is a problem, not easily solved, but we feel reasonably comfortable assuming that factors exogenous to the consumption decision have the greatest effect on prices, so while estimates of a negative correlation between prices and drug use are subject to interpretation, we feel confident that the parsimonious explanation is that higher prices cause people to use drugs at lower levels.

# Chapter 3 The Supply of Illicit Drugs to the United States

Americans use roughly 300 metric tons of cocaine and 12 to 13 metric tons of heroin every year (Layne, Rhodes and Johnston, 1999; Rhodes, Layne and Johnston, 1999). We know a great deal about the origins of those drugs and how they get into the United States. Americans use over 100 metric tons of marijuana every year and another 10 to 12 metric tons of methamphetamine. We know less about the origin (much of which is domestic) of these drugs and how they get into the United States. Most of the detail about those drug flows is of marginal interest to this study, but we are most interested in one aspect of those flows – how they determine prices paid in the United States for illicit drugs. Specifically, how are those prices affected by Federal, State and local anti-drug programs?

Our assumption is that those programs work by making drugs more expensive than they would be otherwise, so that observed prices are a reflection of the cost of doing business. Of course, this is at best an approximation. Prices are affected by demand as well as by supply. However, since the late 1980s, the number of heavy drugs users has not changed much in the United States, and the number of people who use drugs at more moderate levels has not changed much since about 1990 (Rhodes, Layne, Johnston, Hozik, 1999). We therefore doubt that much of the change in drug prices has been demand driven. Instead, changes in drug prices seem to have resulted from systemic changes in drug marketing that have nothing to do with counter-narcotic efforts. For example, the large drops in cocaine prices from the early to the late 1980s may have resulted from dramatic changes in how cocaine was trafficked to the United States and how it was marketed (as crack) on American streets. As another example, the continued fall in heroin prices, and the emergence of high purity heroin sold at retail, was coincident with a growing dominance of South American suppliers of heroin (Rhodes, Layne, and Johnston, 1999; Rhodes, Truitt, Kling and Nelson, 1998). One cannot say that these changes were necessarily independent of law enforcement efforts. For example, focused attention on Southwest and Southeast heroin dealers may have created an environment conducive to Colombian heroin producers. Thus, cocaine and drug prices seem to have changed for reasons that have nothing to do with a shift in demand.

## The Price of Illicit Drugs

Any study of the elasticity of demand for illicit drugs necessarily rests on estimates of the market prices of those illicit drugs. Market prices are different to estimate and estimates are uncertain (Manski, Pepper and Petrie, 2001). Thus study uses estimates provided by Abt Associates Inc. to the Office of National Drug Control Policy. The limited scope of this present study precludes our providing a detailed methodological explanation here. We refer interested readers to Johnston, Rhodes and Kling, 2001. A summary appears below.

## Cocaine

Figure 2 represents the estimated price of cocaine across several hypothetical distribution levels. Those levels are hypothetical because neither cocaine nor any other illicit substance is traded across clearly demarked distribution levels, but these hypothetical distinctions are nevertheless useful when telling a story about cocaine prices. The curve shows border prices, expressed as 1998 equivalent price per pure gram. In the late 1990s, cocaine at the border sold for under $25,000 per pure kilogram, and given that cocaine is imported at about 85 percent purity, this represents a price of about $20,000 per bulk kilogram. These estimates may be a few thousand dollars higher than actual border prices (see Johnston, Rhodes, Carrigan and Moe, 1999), but their accuracy is sufficient for present purposes.

Cocaine is much more expensive when bought by final consumers – roughly about $175 per pure gram ($200,000 per kilogram). When sold at retail, cocaine is about 75 percent pure, on average, so the price per bulk gram is closer to about $130 per gram. Price and purity vary widely from purchase to purchase and from purchaser to purchaser, so the $130 should be seen as a rough measure of a typical price.

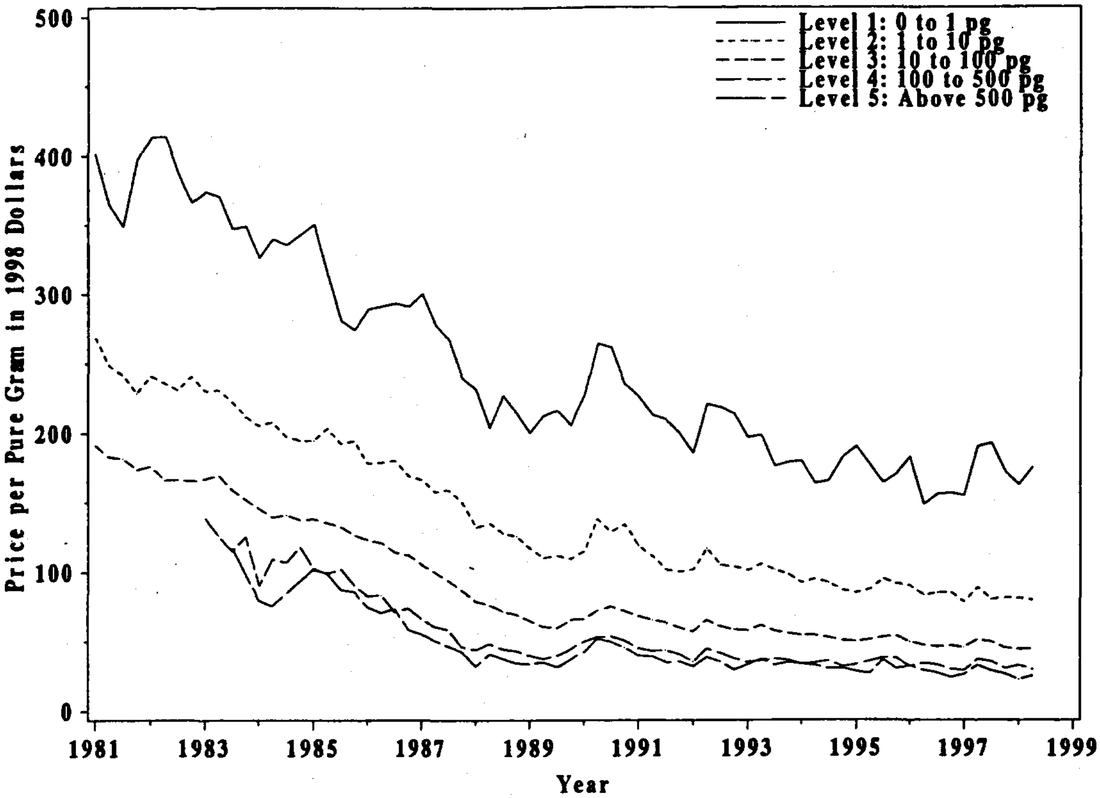
Cocaine is basically an agricultural product that requires minimal and inexpensive chemical processing to convert coca leaves into paste, base and HCl. It does not perish easily, and about 300 metric tons satisfies current consumption in the United States, so absent law enforcement cocaine might have a price similar to aspirin. Source country and other interdiction programs, and other forms of law enforcement, must account for most of the $25,000 border price. In this regard, law enforcement has been a resounding success at reducing the supply of cocaine to the United States.

A glance at Figure 2 shows that the price of cocaine fell sharply from the early to the late 1980s. Thereafter, prices declined less sharply, and much of the post 1988 decline resulted from an increase in the consumer price index. We might date the inauguration of the current war on drugs with late 1987 implementation of the Anti-Drug Abuse Act of 1986, which greatly increased mandatory minimum terms for drug trafficking, and with the concomitant increase in drug-law prosecutions by the Reagan Administration. Figure 2 implies that implementation of the war on drugs had a meritorious effect on halting cocaine's price slide.

After 1988, expenditure on law enforcement continued to increase, but those expenditures may have entered a period of diminishing returns, during which additional expenditures proved unable to reverse the decline in cocaine prices. Inferences are uncertain, because other factors played a role. The number of Americans who used cocaine declined starting in 1988 as increasing numbers of Americans recognized the dangers of cocaine use and as an increasing number of heavy users entered prison. Decreased demand probably worked to further reduce prices that, otherwise, might have increased as law enforcement expanded. Furthermore, cocaine producers and shippers constantly adapt to law enforcement efforts, as shown by recent shifts in cultivation from Peru to Colombia (as base shipment from Peru to Colombia became increasing uncertain), and by temporal shifts from air and maritime to transshipment across the Southwest Border. We cannot know for certain how lower levels of law enforcement would have affected cocaine prices.

**Figure 2**

**Estimated Cocaine Prices at Five Levels of Distribution**




Regardless of what we conclude about the long-run effectiveness of interdiction, there are short-term success stories. Figure 2 shows several spikes in cocaine prices. Some of these are random fluctuations, but others seem real because spikes in border prices cascade throughout the distribution chain. Because each of the curves represented in Figure 2 was estimated independently of each of the others, there seems to be no reason to explain this cascading effect except by attributing it to interdiction. (For a more rigorous analysis that supports this presumption, see Layne, Bruen, Johnston and Rhodes, 2000.) This evidence points toward the short-term success of interdiction programs that, unfortunately, have typically lasted about three months. There is less evidence of a sustained impact of marginal increases in interdiction resources.

Note that cocaine's street price is much higher than its border price. The cost of distributing cocaine to final users would seem to be an insignificant proportion of the street price in a legal marketplace, so most of the difference between the border price and the street price must result from cocaine's being illegal. Because cocaine is illegal, the law provides no recourse to enforcing contracts, leading to extra-legal means including violence. Substituting violence for legal contracts increases the cost of doing business because dealers have to be compensated for the risk of physical harm and death. In this regard, the law is passive, reducing drug trafficking by failing to recognize it as legal economic intercourse. Law enforcement increases the price of cocaine in another, more obvious way, by imposing risks of those who produce and sell the product. But while expenditure on law enforcement has increased over time, the cost of doing business – especially the return from bearing the risk of selling cocaine – has remained remarkably resilient.

The cost of doing business domestically is estimated by the distance between the curve representing retail level price and the curve representing border price. Earlier we reported that the street price was determined by a formula:

$$P_S = P_B M_1 + M_2$$

We can estimate the parameters of this regression using the border price and street price reported in Figure 2. Table 2 summarizes results for this and two other related models.

**Table 2**

**Regression Results: Relationship between Street Prices and Border Prices for Cocaine**

| Variable | Estimate | t-value | Estimate | t-value | Estimate | t-value |
|---|---|---|---|---|---|---|
| CONSTANT | 123.582605 | 17.730255 | 232.850626 | 13.401628 | 355.770279 | 10.404359 |
| BORDER | 2.247582 | 16.265400 | 1.271089 | 7.029982 | 1.009375 | 4.874395 |
| TIME | | | -110.827641 | -6.595377 | | |
| TIME^0.4 | | | | | 223.302587 | -6.868248 |
| R-SQUARE | 0.823 | | 0.901 | | 0.908 | |

This model fits the data reasonably well ($R^2$ =0.82) and implies that the additive markup is about $124 per pure gram and the multiplicative markup is about 2.24, meaning that a price of $25 at the border increases street prices by $25x2.24. A second model allows the additive markup to vary linearly over time, with the result that the additive markup averages about $175 per pure gram and the multiplicative markup is about 1.27, meaning that a border price of $25 increases the street price by $25*1.27. A third model gives the "best fit" of these data. To get it, we raise time to the power 0.4, and then estimate the regression. This implies that the current additive markup is about $130 and that the multiplicative markup is very close to one.

Not all these inferences can be true. Either the border price markup is large – 2.24 – or it is small – 1.01; but it cannot be both. Unfortunately, we cannot tell from these data, because inferences are very sensitive to how we model the relationship.

Certainly there are some models that show an appreciable multiplicative markup, implying that source country and interdiction programs can be effective at increasing street prices provided those programs can increase the border price. Because border prices are so high, relative to the underlying cost of marketing and exporting cocaine, source country and interdiction programs must have been successful at elevating the border price. However, these figures provide little evidence that large expansions in expenditure on interdiction have paid large dividends.

Short-term changes have been more successful, however. In the short-run a spike in border prices has a much larger effect on street prices than is implied by the multiplier M1. Apparently what happens is that dealers continue to honor contracts for delivery to the borders at the agreed price, or with modest markups, in the face of cocaine shortages. As those shortages cascade through the system, however, low-level dealers take advantage of market shortfalls to increase prices and profits. The shortages have not been sustainable, but there have been short-term success stories.

The bottom line is that the supply of cocaine increased from the early 1980s into the late 1980s. Although direct evidence is lacking, circumstantial evidence is strong, because cocaine prices fell as demand grew. Only an increased supply of cocaine would seem to explain that pattern. Starting in the early 1990s, we have both direct and indirect evidence of a relatively constant supply of cocaine as measured in pure units. The direct evidence is that the production of coca changed very little over time, so that after discounting for crop eradication and seizures, the supply to the United States has been fairly constant. The indirect evidence – based on a slight fall in both the price of cocaine and the number of users – has been discussed already.

## Heroin

As was true of cocaine, heroin is a basically agricultural product who conversion from poppy to gum to base requires simple and inexpensive chemical processing. Much of the price at the border must reflect the success of interdiction. Much of the markup from border prices to street prices must result from successful law enforcement.

There are some similarities between trends in heroin prices and trends in cocaine prices. The highest price seemed to predate the drug war's inauguration, and the explanations would seem to be the same for cocaine as for heroin. Thereafter the pattern for heroin differs from the pattern for cocaine, because heroin prices continued to fall through the 1990s.[10] Changes in supply-side forces may explain these differences. Before 1995, most heroin came from Southwest and Southeast Asia; thereafter, South America became the dominant supplier. Currently about 50 percent of the heroin used in the United States comes from South America (essentially Colombia) and another 25 percent comes from Mexico. It seems reasonable that Colombian dealers had to cut prices in order to supplant Southeast and Southwest Asian sources as the principal American suppliers.

Another difference between cocaine and heroin is that the latter seems to have developed a bifurcated market. Some heroin users continue to purchase low purity heroin, suitable only for injection, at prices represented by the highest curve in Figure 3. Other heroin users purchase high purity heroin, suitable either for injection or snorting (or repackaging and resale), at prices represented by the second highest curve in Figure 3. Over time, more and more purchases may have been made at this higher purity level,[11] so the actual price paid at retail declined more than is shown by either line alone.

Another difference between heroin and cocaine is that the occasional peaks, which seem to be characteristic of the trends in cocaine prices, do not appear in the heroin price series. That is, estimated heroin prices show considerable variation from period to period, but there are no patterns of price spikes, observed first at the importation level, that cascade through to the retail level. This

10 South American heroin may have made earlier inroads on Asian suppliers. It is difficult to tell, because knowledge about the source of heroin comes from the Drug Enforcement Administration's Heroin Signature Program and Domestic Monitor Program. Before about 1995, DEA lacked a "signature" for South American heroin, so it could not tell how much of seizures and purchases actually came from South America instead of Asia. See Rhodes, Truit, Kling and Nelson, 1998.

11 Information is mostly anecdotal. However, over time, a higher proportion of DEA purchases came from the higher purity level. We cannot be sure whether this results from a change in the availability of heroin on American streets or from a change in DEA enforcement practices.

finding is sensible. While specific cocaine interdiction efforts can be identified, and perhaps associated with specific cocaine price spikes (Layne, Bruen, Johnston and Rhodes, 2000), the same is apparently not true for heroin.

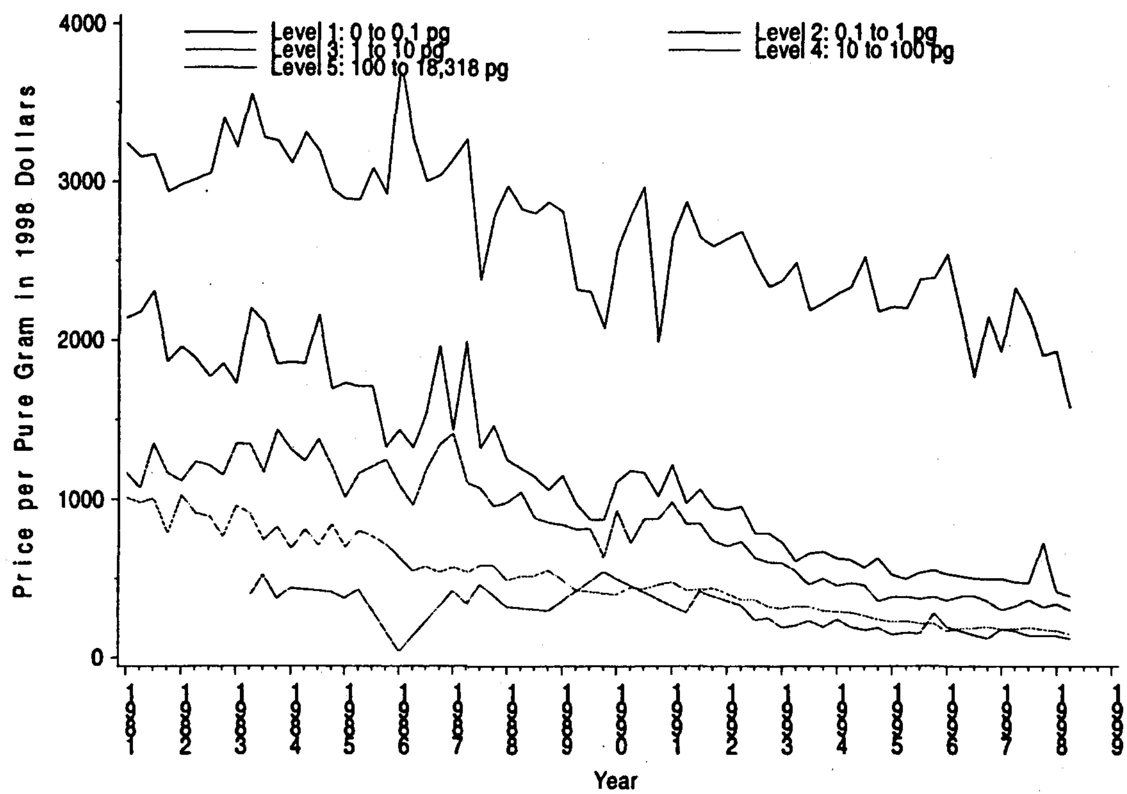
The price markup for heroin could be estimated from the curve:

$$P_S = P_B M_1 + M_2$$

However, this seems like a much less interesting problem for heroin. First, the border prices for heroin are more difficult to determine, because heroin is imported in a variety of small amounts, presumably by personal couriers who often swallow the drug. Consequently we lack a good benchmark for border prices. Second, the border price appears to be a small fraction of the street price. Very roughly, the border price is probably around $150 per pure gram. Injectors might pay close to $2000 per pure gram when they buy drugs of low purity, and this suggests that the border price is a small component of the street price. Some users, those who purchase higher quality heroin, pay much less per pure gram, perhaps closer to $200 per pure gram. In this case, street prices appear to be a significant multiple of border prices. Nevertheless, public authorities have not had a great deal of success increasing the border price, so the size of the markup would seem to be a moot point.

**Figure 3**

## Estimated Price per Pure Gram of Heroin at Five Levels of Distribution




Note: Prices are based at mean sizes (0.04pg, 0.34pg, 4.1pg, 27pg, 358pg) and purities (13%, 39%, 39%, 59%, 73%)

## Marijuana

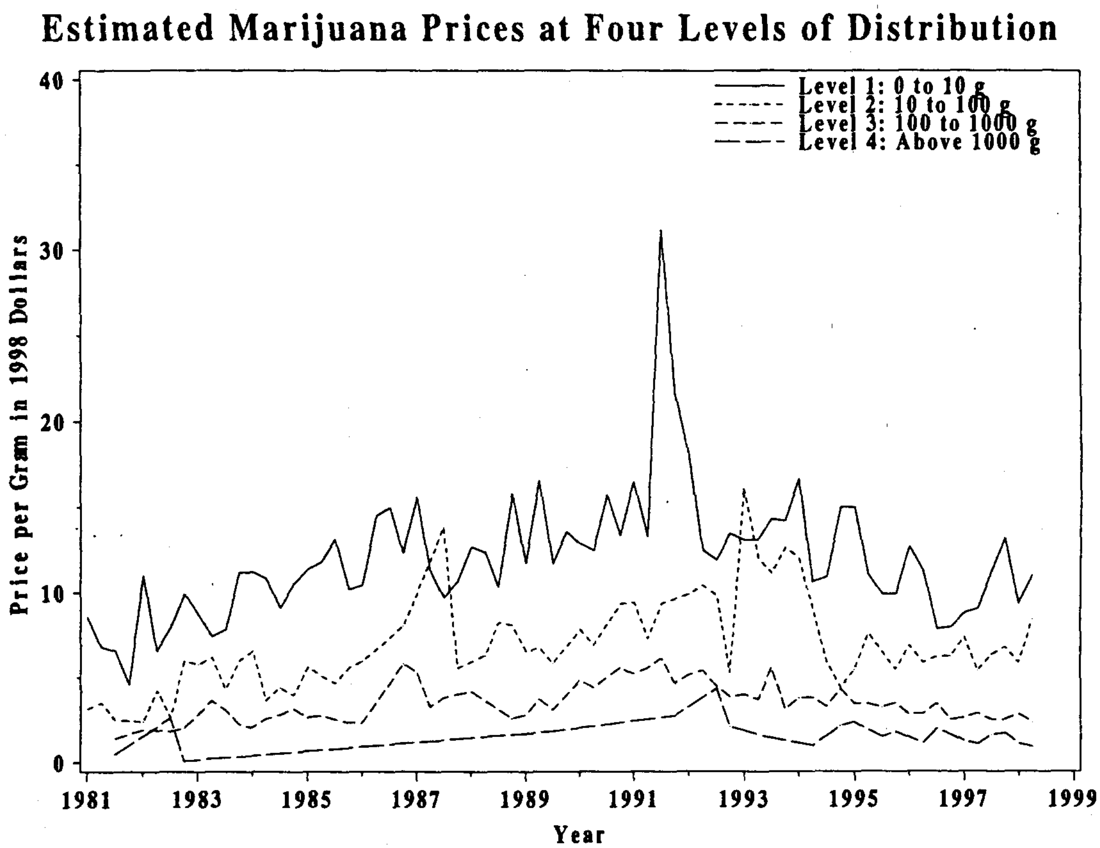
Trends in marijuana prices follow an entirely different pattern from trends in cocaine and heroin prices. In the early 1980s, marijuana prices were relatively low, and foreign supplies seemed readily available. But interdiction programs have been more successful with marijuana, for reasons that are readily understood. Marijuana is bulky. While 12 metric tons of heroin satisfies the U.S. market, it takes about 100 to 130 metric tons of marijuana to meet consumer demands. Heroin has no odor, but marijuana smells and is easily detected. Thus, interdiction was successful at intercepting marijuana, with the consequence that marijuana prices increased.

Higher marijuana prices seemed to have attracted increased domestic production, including indoor and hydroponic production, which would have been cost-prohibitive without price increases and relief from foreign competition. Marijuana prices peaked at all distribution levels sometime around 1992. Since then, as domestic production has grown, prices have fallen.

The trends are deceptive, because the quality of marijuana has not remained constant. The level of marijuana's active ingredient, THC, seems to have increased from the 1980s into the 1990s. Apparently the THC content has not changed as much during the 1990s although it is possible to find reports of marijuana purchases with exceptionally high THC content.

The size of the markup would seem to be less meaningful than its counterpart for heroin and cocaine. The latter two necessarily have foreign sources, so we can meaningfully ask how border prices affect street prices. In contrast, much if not most marijuana comes from many domestic sources. The principal impact of foreign interdiction may be to encourage development of a domestic industry, so the regression does not represent what we purport it to represent.

## Figure 4

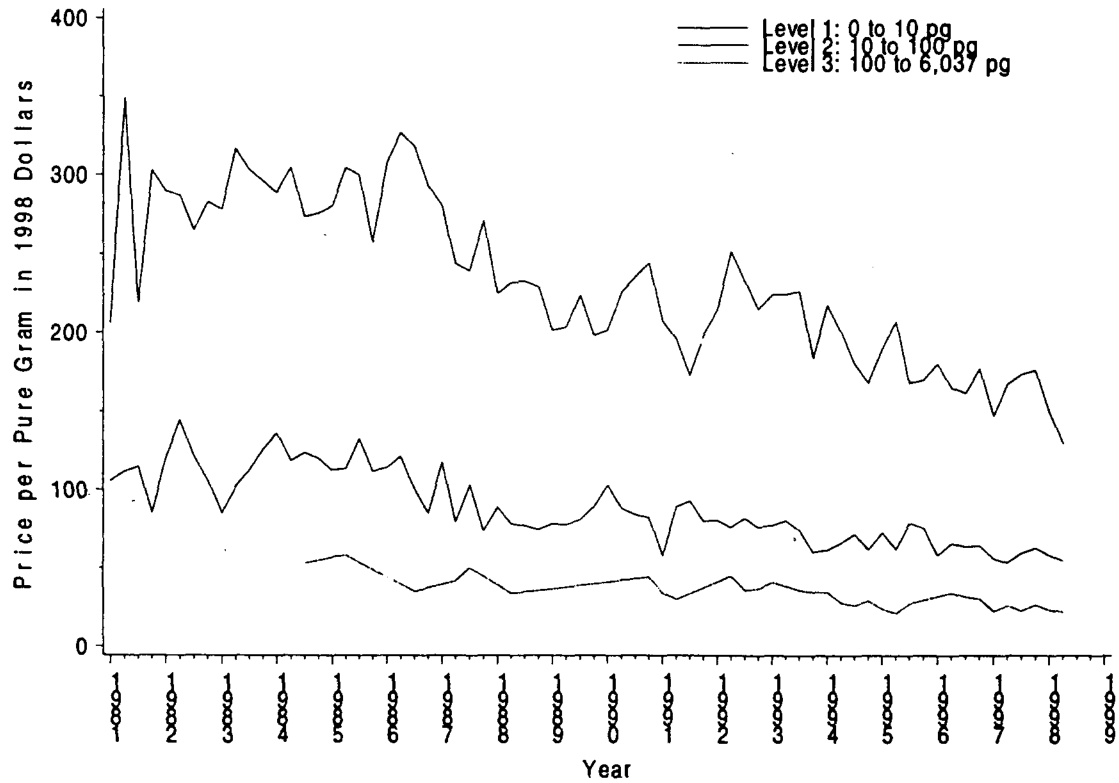



### Methamphetamine

A similar explanation may apply to the methamphetamine market. Mexico has been a principal foreign source of methamphetamine shipped into the Unites States, mostly to the West Coast. A nascent domestic industry has begun to develop, based mostly on many small-time operations that probably supply a small number of users, but also including a few large-scale operations. Figure 5 seems to show that street prices have declined much more rapidly than importation prices. This seems sensible if small-scale domestic industry has increasingly provided methamphetamine to American users.

**Figure 5**

**Estimated Price per Pure Gram of Methamphetamine at Three Levels of Distribution**




Note: Prices are based at mean sizes (2.94pg, 31pg, 321pg) and purities (41%, 55%, 71%)

# Chapter 4 The Demand for Illicit Drugs

## Overview

According to the National Strategy, prevention programs can reduce the initiation and continuation of drug use by youths and young adults. Law enforcement and treatment can reduce the prevalence of drug use by those who are habituated. Supply-based programs reinforce these effects by reducing the availability and increasing the price of illicit drugs. But by how much do prices affect drug use decisions? That is the question addressed in this chapter.

This chapter first turns to the initiation of drug use, reporting trends in initiation rates, and providing estimates of how increases and decreases in drug prices have affected those trends. It then takes the next step to study the prevalence of continued drug use by those who had tried drugs in the past. Finally, it reports findings about trends in drug use by those whose hardcore use (and other factors) result in legal entanglements with the criminal justice system.

### Initiation of Drug Use

There must be a "first time" for anyone who uses an illicit substance, so we can meaningfully identify a time when a survey respondent first tried marijuana, cocaine and other drugs. The National Household Survey on Drug Abuse poses this question to members of households, so data are readily available for 1982 through 1996. This study uses responses to that question to study trends in the initiation of drug use and whether or not changes in drug prices have any effect on those trends.

A problem seems apparent. Trying a drug for the first time is probably not the same thing as initiating drug use, at least as social scientists and policy makers think of those terms. Initiation would seem to require some unspecified degree of repeated behavior. Unfortunately, with one exception, the NHSDA provides no additional indication about repeated behavior, and we have to use the "first time" response to study initiation of drug use. The exception is that respondents who said they tried a drug for the first time during the same year as they were interviewed also answered a question about how frequently they used the drug during that year. For them, we can determine how frequently "first-time" use implies repeated behavior. Table 3 provides estimates taken from the NHSDA.

For this study, we assigned every survey respondent to an *age cohort* based on the respondent's age at the time of the 1996 survey. For example, if a respondent was 16 at the time of the 1996 survey, he or she was identified as a member of the sixteen-year-old age cohort. Note that a respondent who was 15 at the time of the 1995 survey was also a member of the sixteen-year-old cohort, as was a respondent who was 14 at the time of the 1994 survey.

Cohort identity is an important variable in most of the following analysis because patterns of drug use vary markedly with cohort identity. It is extremely important to remember that cohort identity is a marker for time periods, and therefore, is a basic control variable for factors that we cannot otherwise observe, yet that have a strong influence on drug use. Even a casual inspection of time-series from the Monitoring the Future Survey shows that the risk of trying drugs is cyclical, so that some cohorts are at higher risk of trying illicit drugs than are other cohorts. We cannot observe that risk directly; we use cohort identity as a proxy variable.

This study used a two-population survival model to study the time until initiation of drug use. Recall from earlier that the two-population model divides the population into two parts: those who will try the drug at some time and those who will never try the drug. The statistical analysis estimates the probability of ever trying the drug. It also estimates the timing of first use conditional on being a member of the first group—those who will try the drug at some time. For a technical exposition of the two-population survival model, see..... The probability of ever trying a drug was first modeled as a function of age-cohort (AGE) and place (PLACE). That is:

| | |
|---|---|
| AGE | The respondent's age at the time of the 1996 survey divided by 100. The division plays no substantive role in the analysis but it facilitates the computing algorithm. |
| $AGE^2$ | The square of the respondent's age at the time of the 1996 survey. |
| $AGE^3$ | The cube of the respondent's age at the time of the 1996 survey. |
| PLACE | Place dummy variables represent the place where the interview took place. There were 26 places which we do not identify by request of the Office of Applied Studies. |

We completed some of the analysis for separate race/ethnic groups (White, African-American, Hispanic and other) and gender. That is, there were eight distinct analyses. Patterns of initiation seemed so similar for White and African-American men and women that we combined them and introduced additional variables into the analysis:

| | |
|---|---|
| MEN | A dummy variable denoting men |
| BLACK | A dummy variable denoting African-American |

Likewise, patterns of initiation were similar for Hispanic and other men and women, but very different from the patterns for Whites and Blacks. We combined Hispanic and other men and women and introduced two additional variables into the analysis:

| | |
|---|---|
| MEN | same as above |
| HISPANIC | A dummy variable denoting that the respondent was Hispanic. |

The split-population model has three basic ingredients. First, there is a probability that a respondent will ever try a drug, modeled here as a logistic distribution. This is modeled as a function of cohort membership (AGE, $AGE^2$ and $AGE^3$), place (PLACE), gender and race/ethnicity. Second, there is failure rate for those who ever fail, assumed to be distributed as log-normal. The mean for the log-normal distribution is modeled as a function of cohort membership (AGE and $AGE^2$), gender and race/ethnicity, but not place. Third, the standard deviation in the log-normal distribution is modeled as a function of cohort membership (AGE and $AGE^2$), gender and race. It was impractical to include $AGE^3$ and PLACE as variables that affect the log-normal distribution because the estimation was too slow to converge. The specification was linear-additive in these arguments.

Once we settled on a model that represented trends in initiation rates, we introduced a drug price variable into the analysis. The price variable might have been included as a time-varying covariate, but this was very complicated and beyond the scope of this study. Instead, we determined the average drug price for the period between the respondent's 14th and 18th birthday, reasoning that prices during this period would have the strongest effect on the respondent's decision to initiate drug use.

The $AGE^2$ and $AGE^3$ variables were dropped from the analysis once drug prices were introduced into the models. This raises a difficult problem. The introduction of cohorts into the analysis is necessitated by ignorance of time-varying factors that actually affect peoples' decisions to initiate drug use. The age cohort variables represents factors that are specific to cohorts, and if that representation is thorough, then the age cohort variable already represents the influence of temporal price variation. Because of a technical problem know as collinearity, however, the inclusion of both drug prices and age cohort can mask the effect of the factor of greatest interest in this study – changes in drug prices. By dropping the $AGE^2$ and $AGE^3$ cohort variables (but retaining the AGE cohort variable), we hope to be able to identify the effect that prices have on initiation decisions.

Dropping $AGE^2$ and $AGE^3$ is problematic, however. To the extent that the age cohort represents factors other than drug prices, the statistical model is misspecified. The consequence is that the drug price variable might be accounting for other factors (attitudes about the social acceptability of drug use, for example) that both vary coincidentally with drug prices and that affect decisions about initiating drug use. We cannot be sure of whether or not excluding the age cohort variables provides a better or worse picture of the relationship between drug use initiation and drug prices.

Finally, with respect to the analysis of the decision to start marijuana use, the NHSDA has differential selection probabilities based on place, race and age. We did not weight the data in the analysis. Because these variables entered the model as covariates, parameter estimates are consistent without weighting. Whatever advantages accrue from weighting the data, estimates of the covariance matrices would have been extremely complicated if weighting had been employed. (See Deaton, 1997, for a discussion.) We chose to avoid this complication and to focus on the questions of greatest interest.

#### Continuation of Drug Use

It is tautological that only those who had initiated drug use at some time could continue drug use at a later date, so this part of the analysis was limited to data about reported drug use by those who said they had tried the drug. The dependent variable in this part of the analysis was the frequency of drug use during the last year, defined as none, less than weekly, and weekly.[12] The analysis used an ordered-probit model that adjusted for the first-stage selection bias. (The requirement for an adjustment stemmed from the decision to limit the analysis file to those who had initiated drug use. In fact, the adjustment seemed to have very little effect on the analysis and could have been ignored.) Details are provided in Appendix B. The model was linear-additive in its arguments.

Many additional variables enter into the analysis of the continuation of drug use:

| | |
|---|---|
| DRUGAGE | This is the respondent's age at the time he or she first used the drug. For marijuana, this variable is MJAGE and for cocaine it is COCAGE. |
| EDUC | Education level, coded as years of school completed |
| EDUC2 | The square of education level |
| MARRIED | A dummy variable denoting that the respondent was married |
| EMPSTAT2 | A dummy variable denoting that the respondent was employed. |
| FAM_INC | Family income |
| MALE | A dummy variable denoting men |
| AGE | Age at the time of the interview (not cohort age) |
| AGE2 | The square of age at the time of the interview |
| WHITE | A dummy variable denoting White |
| BLACK | A dummy variable denoting African-American |
| HISPAN | A dummy variable denoting Hispanic |
| PLACE | A dummy variable denoting where the interview took place |
| MJ PRICE | Marijuana prices |
| ALCPRICE | Alcohol prices |
| COCPRICE | Cocaine prices |

We used reported consumption during the last year because the professional literature (and our own experience) with self-report data shows that people are more willing to report more distant drug use

12 The NHSDA imputes responses for individuals who say they did not use in the last year yet gave contradictory information elsewhere during the interview. We discarded those imputations, thereby accepting the individual's original response. Between 1994 and 1996, imputations were only 3 to 4 percent for marijuana, so this decision probably was irrelevant. But imputations were close to 7 percent for cocaine and between 8 and 12 percent for heroin. How to treat imputations is more troubling for cocaine and heroin.

than they are to report more recent drug use. The price variables conform to that definition of the dependent variable. That is, prices are the average price for a specified drug during the year before the respondent was interviewed.[13] For example, if the respondent was interviewed during the first quarter of 1998, then the price was the average price for the last three quarters of 1997 and the first quarter of 1998. All three prices – marijuana, alcohol and cocaine – entered into the analysis to test for cross-price effects. The Substance Abuse Manual Health Service Administration imputes positive responses for some respondents. We chose to assume that those respondents had not, in fact, used the drug. This affected about five percent of the reported drug users.

### Hardcore Drug Use

The analysis of hardcore drug use used an ordered-logistic model. The differences between an ordered-probit model (used above) and an ordered-logistic model (used here) are negligible. The probit model assumes a normal distribution, a convenient assumption because of our desire to develop a two-step estimator, as explained in the technical appendix. We could not readily accomplish this without being able to assume a bivariate normal distribution for error terms. See the appendix. On the other hand, the logistic distribution allows us to deal with over-dispersion. This is not readily accomplished with the probit model.

We completed separate analyses for each of four drugs: cocaine, heroin, marijuana and methamphetamine. In each case, the dependent variable was the number of days that the respondent used the drug during the month before the survey, coded as "none," "1-10 days," and "more than 10 days." The first category was labeled as "no use," the second as "occasional use," and the third as "heavy use." The analysis might have used different categories, but these corresponded to categorizations used in other reports, so they were convenient.

Excluding drug price variables, the independent variables were:

| | |
|---|---|
| ILLEGCAT | Income from illegal sourced |
| INCOME | Income from legitimate sources |
| AGE | Age in years |
| AGE2 | Age squared |
| HIGRADE | Highest grade achieved |
| HIGRADE2 | The square of highest grade achieved. |
| TIME | Time, coded zero at the beginning of the period and increasing by 1 per quarter. |
| TIME_6 | Time, coded 0 before the 6th quarter, coded 1 at the beginning of the 6th quarter, and increasing by 1 per quarter thereafter. |
| TIME_24 | Time, coded 0 before the 24th quarter, coded 1 at the beginning of the 24th quarter, and increasing by 1 per quarter thereafter. |
| BLACK | Coded 1 for African-American and coded 0 otherwise. |
| WHITE | Coded 1 for White and coded 0 otherwise. |
| HISP | Coded 1 for Hispanic and coded 0 otherwise. |
| SEX | Coded 1 for Male and coded 0 otherwise. |

13 We did not have a price estimate for every city that entered the analysis. When the price was unknown, we substituted the national average price. This would seem to be innocuous because, in a fixed-effects model, the level of prices does not matter – just the trends.

Note the coding of the time variable. This assume a linear time trend that has a different slope at the beginning of the 6th quarter of data and another new slope at the beginning of the 24th quarter. Coding the time trend as a quadratic gives results that are substantively the same as those reported based on this linear spline, but the spline gives more reasonable projections. Hence we report results based on the spline.

### Place Identifiers for the NHSDA

The Office of Applied Studies of the Substance Abuse Mental Health Service Administration provided Abt Associates with the means to match price data with the place where the NHSDA respondent was interviewed. OAS was particularly concerned that NHSDA interviews remained confidential, and OAS felt the best way to protect confidentiality was to mask the place identifiers used in this study. We had no objections to this reasonable restriction because reporting statistics specific to place identifiers was peripheral to the principal finding reported here. However, the reader should be aware that the place identifier (in the form of a dummy variable) always entered the statistical analyses. We never report the parameter estimated associated with the dummy variables.

## Demand for Marijuana

We analyzed the demand for marijuana in three stages. The first stage was the initiation of marijuana use. For this purpose, we used data from the NHSDA. The second stage was the continuation of marijuana use. For this purpose, we also used the NHSDA. The final stage was hardcore drug use among arrestees. For this final purpose, we used the DUF data.

### Initiation of Marijuana Use

The NHSDA asks respondents when they first tried marijuana. The answer to that question was the dependent variable in this analysis.

Using marijuana for the first time is not the same thing as becoming a marijuana user. Table 3 tabulates the frequency of marijuana use during the year when a respondent said that he or she had tried marijuana for the first time. The table shows the survey years down its rows and it shows the number reporting use in each user category across the columns. Just over 40 percent of the respondents said they used marijuana once or twice during the year that they tried marijuana for the first time, and just over 70 percent said they used it less frequently than once per month. About 11 percent had become weekly users.

**Table 3**
**First Time Use MJ Was During Survey Year**
**(Weighted)**

| YEAR | FREQUENCY USED MARIJUANA PAST 12 MONTHS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | daily | 3-6 days /wk | 1-2 days /wk | 25-51 days/year | 12-24 days/year | 6-11 days/year | 3-5 days /year | 1-2 days /year | Total |
| 1990 | 29267 | 18777 | 85593 | 56057 | 120258 | 153919 | 261269 | 527439 | 1252579 |
| 1991 | 56139 | 18163 | 62466 | 106525 | 146473 | 148591 | 174790 | 778104 | 1491251 |
| 1992 | 32966 | 9513.9 | 73381 | 37404 | 181058 | 94314 | 186889 | 565874 | 1181400 |
| 1993 | 52808 | 51618 | 86859 | 198409 | 195512 | 221740 | 375385 | 672767 | 1855097 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1994 | 29287 | 132103 | 119047 | 186399 | 180198 | 399253 | 459694 | 1225984 | 2731965 |
| 1995 | 54194 | 140950 | 125945 | 218184 | 305444 | 360591 | 654365 | 948575 | 2808248 |
| 1996 | 30669 | 145190 | 123863 | 211732 | 281142 | 294101 | 491308 | 1049242 | 2627246 |
| Total | 285331 | 516314 | 677154 | 1014710 | 1410085 | 1672509 | 2603699 | 5767984 | 1.395E7 |

The findings are a little deceptive, because someone who tried marijuana for the first time during the latter part of the last year would have been unable to say that he or she had been a regular user. That is, there is a bias toward reporting infrequent use. Nevertheless, these findings show that many if not most of those youths who try marijuana do not progress to using it at an appreciably rate during the year that they tried it. We would like a better indicator of when a person first started using marijuana, but regrettably, a better indicator is unavailable. We begin with an analysis of trends in initiation rates.

Using the split-population survival model described earlier, we estimated separate regressions for four racial/ethnic groups and two genders. Those regressions included AGE and $AGE^2$, but not $AGE^3$. Because of the exclusions of $AGE^3$, the regressions failed to show the recent increase in initiation rates for teenagers, but the regressions were nevertheless useful. They demonstrated that White and African-American men and women have similar initiation rates. Apparently, White and Black men and women could be combined into a single analysis provided that dummy shift variables were included for each race and gender. Likewise, the initial analysis showed that Hispanic and other men and women had similar initiation rates. Apparently Hispanic and others could be combined into a single analysis provided dummy variables were included as controls for race and gender.

We do not show the results from the initial analysis here. Instead, we focus on the results for initiation of drug use for White and Black men and women combined and on the results for Hispanic and Other men and women combined. The variable $AGE^3$ does enter this analysis, which allows the estimated trends to follow an S-shaped curve. That is, the model might show that lifetime initiation rates are especially high for the youngest cohorts, lower for cohorts who are somewhat older, higher for cohorts who are much older, and lowest for the oldest cohorts. Exclusion of the $AGE^3$ variables affords a model of trends that increase and then decrease with AGE, or a model of trends that decrease and then increase with AGE, but inclusion of the $AGE^3$ variable affords a more complicated model of trends.

Table 4 shows the means and standard deviations for variables that entered the analysis. One place was excluded from the place variables as the residual category to prevent multi-collinearity.

**Table 4**

**Age at First Use of Marijuana: Descriptive Statistics**

| | WHITE and BLACK | | HISPANIC and OTHER | |
|---|---|---|---|---|
| Variable | Mean | Std Dev | Mean | Std Dev |
| MALE | 0.4431 | 0.4968 | 0.4666 | 0.4989 |
| BLACK | 0.4361 | 0.4959 | | |
| HISPANIC | | | 0.9021 | 0.2972 |
| OBSERVATIONS | 36581 | | 28272 | |

Table 5 shows results for the regressions for White and Black men and women. The first series of parameters (QCONST to BLACK) is associated with the probability of ever trying marijuana. A positive parameter means that the probability of ever using marijuana increases. The second series (TCONST to BLACK) is associated with the median time until trying marijuana for those who elect to try the drug. A positive parameters means that the median age for first use increases. And the third series (SCONST to BLACK) is associated with the standard deviation of the time until trying the drug. Table 6 shows results for a companion regression for Hispanic and other men and women.

**Table 5**

**Age at First Use of Marijuana: White and Black Males and Females**

Number of cases 36581

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| QCONST | 5.8328 | 0.7004 | 8.328 | 0.0000 |
| AGE | -50.1281 | 6.1933 | -8.094 | 0.0000 |
| AGE_2 | 151.2611 | 17.9281 | 8.437 | 0.0000 |
| AGE_3 | -149.9006 | 16.9131 | -8.863 | 0.0000 |
| MALE | 0.2856 | 0.0170 | 16.810 | 0.0000 |
| BLACK | -0.4330 | 0.0185 | -23.356 | 0.0000 |
| TCONST | 3.7543 | 0.0356 | 105.466 | 0.0000 |
| AGE | -6.1129 | 0.2041 | -29.949 | 0.0000 |
| AGE_2 | 9.7740 | 0.2889 | 33.833 | 0.0000 |
| MALE | -0.0304 | 0.0032 | -9.580 | 0.0000 |
| BLACK | 0.0348 | 0.0035 | 10.064 | 0.0000 |
| SCONST | -0.3055 | 0.0808 | -3.781 | 0.0001 |
| AGE | -7.6715 | 0.4909 | -15.628 | 0.0000 |
| AGE_2 | 10.1890 | 0.7378 | 13.809 | 0.0000 |
| MALE | 0.0456 | 0.0116 | 3.930 | 0.0000 |
| BLACK | 0.0107 | 0.0124 | 0.858 | 0.1954 |

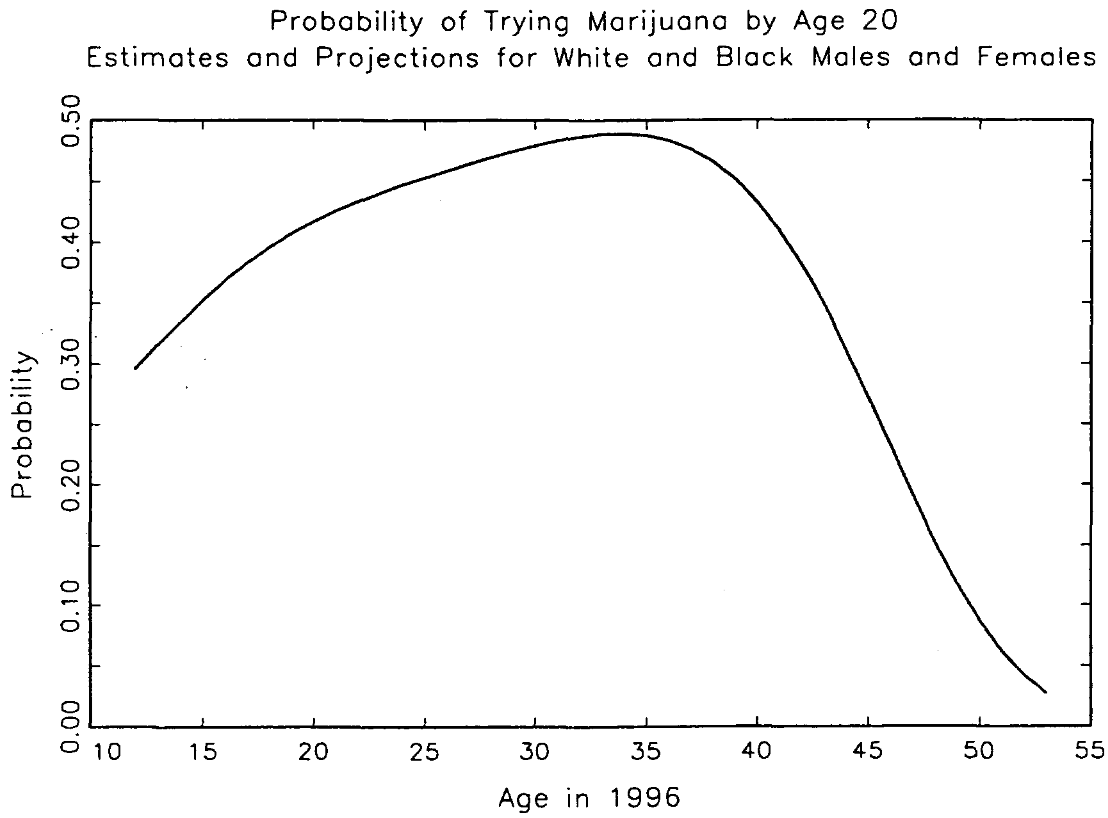
This is a large sample, so it probably is not surprising that parameters are statistically significant. The parameters associated with places are relatively easy to interpret.[14] Other variables are more difficult to interpret, because the same variables affects the probability of every trying marijuana, the average time until trying marijuana for those who do try it, and the standard deviation for time until trying marijuana. These three effects have to be combined to make sense of them, and that combination is nontrivial.

A figure is more helpful for interpreting the statistics. Figure 6 shows the estimated probability of trying marijuana by the age of 20 as a function of age cohort membership. To derive these estimates, we set all variables except AGE equal to their mean values. We did not weight the data to reflect the NHSDA's higher selection probability for African-Americans, so the actual relationship may be somewhat higher or lower than depicted here. Nevertheless, we are interested in the trend, which is reflected in the unweighted curve.

[14] The place identification was determined at the time of the interview, not at the time that the person tried the drug. Thus, we should assume that the place variable is measured with considerable imprecision.

The risk of trying marijuana by age twenty seems to be highest for the 35-year-old cohort. The risk is much lower for older cohorts, and it is somewhat lower for younger cohorts. It appears to be relatively low for the youngest cohorts, but we must remember that the estimates for the youngest cohorts are almost pure projections. For example, we cannot see any drug use beyond age twelve for members of the age twelve cohort because they were twelve at the time of the last (1966) interview.

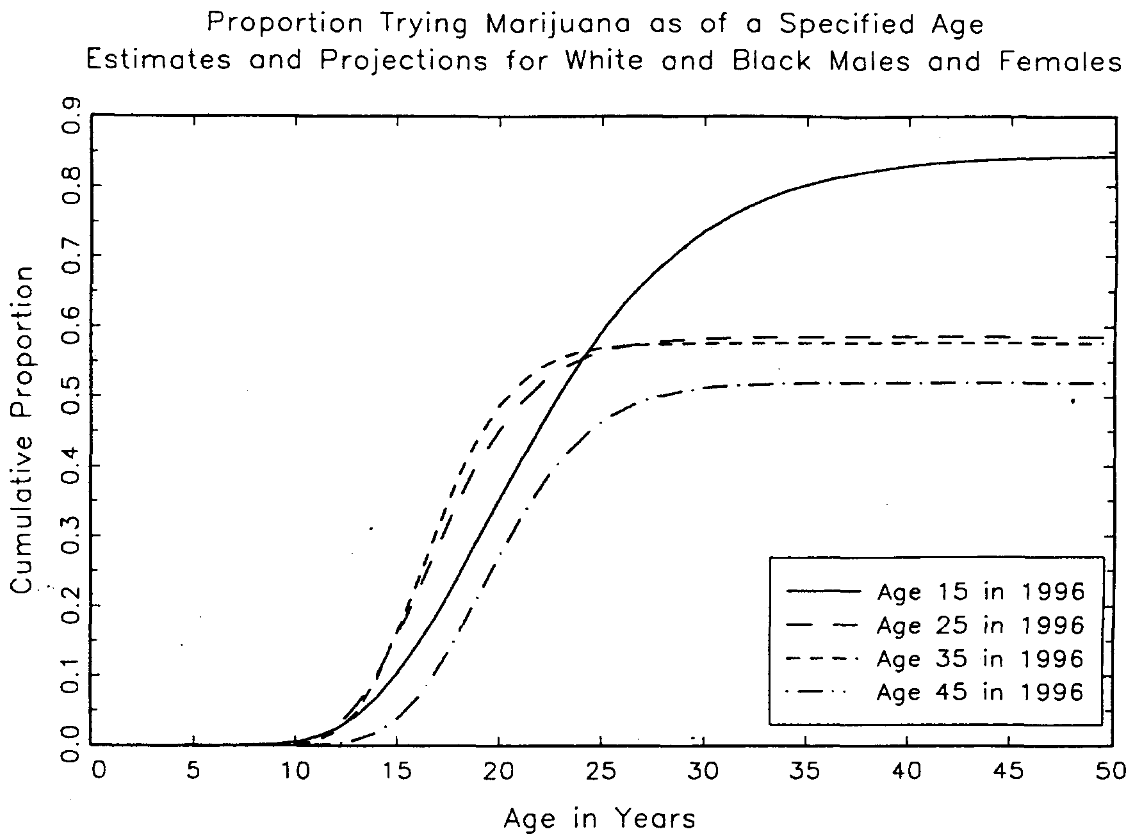
**Figure 6**




Another problem with this figure is that it understates drug use by the older cohorts. Others have shown that as people age they become increasingly likely to deny that they had tried a drug in the past. The size of the resulting bias is not so large that it would offset the trends observed here, but it would reduce the differences between the initiation rates for younger and older cohorts.

Figure 7 provides a different view of the same phenomena. This figure shows the estimated timing of first marijuana use for members of four different cohorts. The youngest was age 15 in 1996; the oldest was age 45 in the same year. (Note that a vertical line drawn at 20 years will intersect each of these lines at the estimates reported in the previous figure.) The youngest cohort seems to experiment with marijuana at an older age than the 25 and 35-year-old cohort members, but the youngest cohort also seems to have the highest projected lifetime probability of ever using marijuana. The estimated lifetime probability of trying marijuana should be heavily discounted, because we cannot accurately predict that lifetime probability from just three years of data for that youngest, age 15 cohort.

**Figure 7**




Indeed, we are skeptical about the accuracy of the predictions for the youngest cohorts. They seem to come from a period of elevated drug use (The University of Michigan, December 1999), but the 1996 survey is too soon to learn much of the increase that had become more apparent by the time of the 1997 and 1998 surveys.

The pattern of initiation of drug use is different for Hispanic and other men and women. Table 6 reports parameter estimates and standard errors.

**Table 6**

**Age at First Use of Marijuana: Hispanic and Other Males and Females**

Number of cases 28272

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| QCONST | 4.9699 | 0.6669 | 7.453 | 0.0000 |
| AGE | -51.5535 | 6.1534 | -8.378 | 0.0000 |
| AGE_2 | 152.4842 | 18.5238 | 8.232 | 0.0000 |
| AGE_3 | -151.0520 | 18.1205 | -8.336 | 0.0000 |
| MALE | 0.4912 | 0.0203 | 24.238 | 0.0000 |
| HISPANIC | 0.2979 | 0.0382 | 7.793 | 0.0000 |
| TCONST | 3.3174 | 0.0469 | 70.736 | 0.0000 |

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| AGE | -3.2090 | 0.2814 | -11.402 | 0.0000 |
| AGE_2 | 5.7965 | 0.4290 | 13.512 | 0.0000 |
| MALE | 0.0014 | 0.0053 | 0.267 | 0.3949 |
| HISPANIC | -0.0617 | 0.0120 | -5.159 | 0.0000 |
| SCONST | -1.2701 | 0.1183 | -10.738 | 0.0000 |
| AGE | -2.0905 | 0.7438 | -2.811 | 0.0025 |
| AGE_2 | 3.5491 | 1.1680 | 3.039 | 0.0012 |
| MALE | 0.1035 | 0.0184 | 5.624 | 0.0000 |
| HISPANIC | -0.0840 | 0.0378 | -2.221 | 0.0132 |

As before, some of the parameters have a straightforward interpretation, but others do not. Figures are more useful when interpreting results. Figure 8 shows the estimated probability of trying marijuana by the age of 20 for Hispanic and other males and females. The cohort effect is very different from that observed for White and African-American males and females. Initiation rates decrease monotonically as cohorts get older. That is, members of the youngest cohorts seem to be at the highest lifetime risk of experimenting with marijuana.

**Figure 8**

Probability of Trying Marijuana by Age 20
Estimates and Projections for Hispanic and Other Males and Females

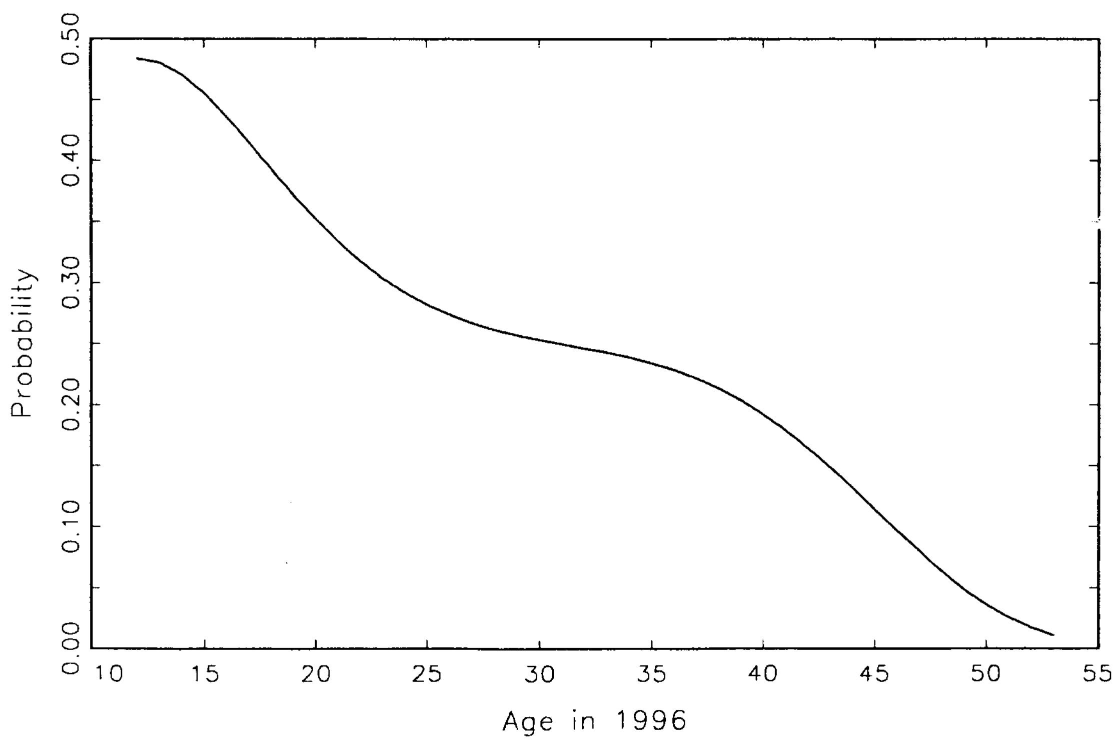
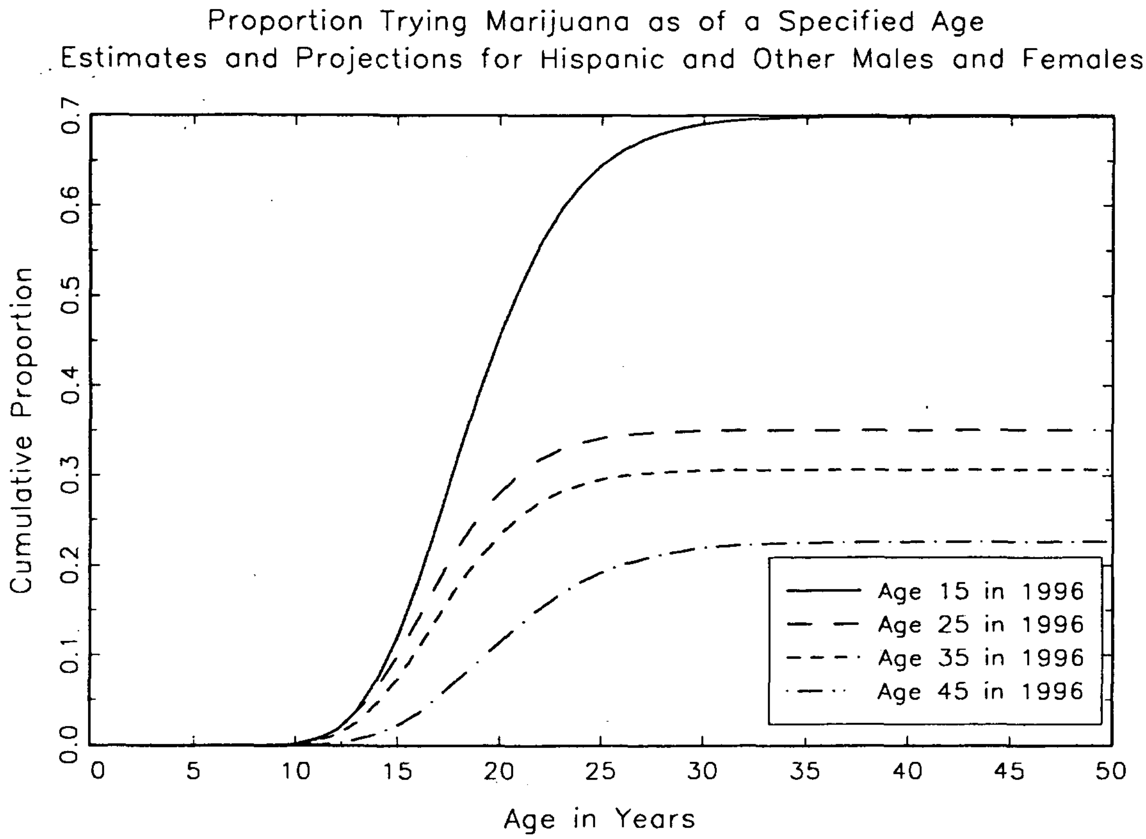



Figure 9 shows the estimated age at initiation of marijuana use for Hispanic and other males and females. (Slicing this figure at the age of 20 gives the same estimates as the previous figure for the probability of trying marijuana by age 20.) The figure implies that young Hispanic (and other) men and women are at an especially high risk of experimenting with marijuana. As was true for Whites and African-Americans, we are skeptical about the estimates for the youngest cohorts, because they are based on few years of data. Still, the trend toward greater risks among the youngest cohorts seems apparent from these findings.

Figures 7 and 9 show differences across cohorts in the initiation of marijuana use, but they do not tell us anything about how marijuana prices have affected those initiation rates. For this purpose, we drop $AGE^2$ and $AGE^3$ from the model and substitute a new variable: MJPRICE, the average price for marijuana when members of a cohort were between the ages of 12 and 18 as well as for White and African-American males and females. Table 7 reports descriptive statistics. Table 8 reports regression results for white and African-American males and females. Table 8 reports the same for Hispanic and other males and females. The analysis was restricted to age-30 cohorts and younger because we did not have adequate price data for older cohorts.

**Figure 9**




We also simplified the estimator for the standard error by assuming that the standard error was constant across cohorts, races and genders. Consequently, the price of marijuana enters the statistical model at two places. The first time, it affects the probability of ever using marijuana. If the probability of ever using marijuana falls as the price of marijuana increases, then the parameter estimate associated with marijuana prices should be negative. The second time that marijuana price enters the model, it affects the median time until first use. If marijuana prices cause people to begin use at a later age, then this parameter associated with marijuana prices should be positive.

Table 7 provides descriptive statistics of the variables that entered this analysis. CENSOR is the proportion of respondents who had not tried marijuana at the time of the survey. MJPRICE is the marijuana price divided by 10. This division facilitated the computing algorithm but otherwise has no effect on the analysis.

**Table 7**

**First Time Marijuana Use as a Function of Marijuana Price: Descriptive Statistics**

| Variable | WHITE and BLACK Mean | WHITE and BLACK Std Dev | HISPANIC and OTHER Mean | HISPANIC and OTHER Std Dev |
|---|---|---|---|---|
| CENSOR | 0.6911 | 0.4621 | 0.7874 | 0.4092 |
| MJPRICE | 1.2208 | 0.1442 | 1.2210 | 0.1429 |
| MALE | 0.4623 | 0.4986 | 0.4844 | 0.4998 |
| BLACK | 0.4640 | 0.4987 | 0.9003 | 0.2996 |
| AGE | 0.2262 | 0.0452 | 0.2219 | 0.0459 |
| AGE_2 | 0.0532 | 0.0205 | 0.0513 | 0.0206 |
| AGE_3 | 0.0130 | 0.0072 | 0.0123 | 0.0072 |

For White and African-American men and women, the price of marijuana has a negative (parameter estimate equal to –0.6180 ) and statistically significant (t-score equals –3.387) effect on the probability of ever using marijuana. The price of marijuana has an unexpected negative (parameter equals –0.0308) effect on the median age of first marijuana use, but that effect is not statistically significant (t-score equals –1.360). See Table 8.

**Table 8**

**First Time Marijuana Use as a Function of Marijuana Price**
**White and Black Men and Women**

Mean log-likelihood -1.19266
Number of cases 19660

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| QCONST | 1.9305 | 0.5090 | 3.793 | 0.0001 |
| MJPRICE | -0.6180 | 0.1824 | -3.387 | 0.0004 |
| MALE | 0.2555 | 0.0310 | 8.230 | 0.0000 |
| BLACK | -0.4637 | 0.0336 | -13.821 | 0.0000 |
| COHORT | -2.4137 | 1.1416 | -2.114 | 0.0172 |

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| TCONST | 3.1165 | 0.0476 | 65.457 | 0.0000 |
| MJPRICE | -0.0308 | 0.0227 | -1.360 | 0.0869 |
| MALE | -0.0232 | 0.0059 | -3.947 | 0.0000 |
| BLACK | 0.0352 | 0.0064 | 5.500 | 0.0000 |
| COHORT | -0.9651 | 0.1080 | -8.940 | 0.0000 |
| SCONST | -1.5159 | 0.0127 | -119.416 | 0.0000 |

Looking at the results for Hispanic and other males and females, marijuana prices have a negative (parameter estimate equals –0.4973) and statistically significant (t-score equals –3.174) effect on the probability of ever using marijuana. These results show a perverse effect of marijuana prices on the timing of initiation. The parameter is negative (–0.0521) and statistically significant (t-score equals 1.957). Taken literally, these findings imply that when marijuana prices are high, fewer people try marijuana, but those who do try it at any earlier age. A literal interpretation is probably inappropriate, however, for reasons discussed elsewhere (Rhodes, 1989). We should just take these findings to mean that high prices have a salubrious effect on reducing experimentation with marijuana because the effect associated with the probability of ever using marijuana sets a ceiling on eventual use.

**Table 9**

**First Time Marijuana Use as a Function of Marijuana Price**
**Hispanic and Other Men and Women**

Mean log-likelihood -0.930866
Number of cases 17060

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| QCONST | 1.3506 | 0.4003 | 3.374 | 0.0004 |
| MJPRICE | -0.4973 | 0.1567 | -3.174 | 0.0008 |
| MALE | 0.3721 | 0.0315 | 11.805 | 0.0000 |
| HISPANIC | 0.3183 | 0.0608 | 5.235 | 0.0000 |
| COHORT | -4.9647 | 0.8528 | -5.822 | 0.0000 |
| TCONST | 3.1214 | 0.0522 | 59.782 | 0.0000 |
| MJPRICE | -0.0521 | 0.0266 | -1.957 | 0.0252 |
| MALE | -0.0027 | 0.0075 | -0.360 | 0.3596 |
| HISPANIC | -0.0625 | 0.0153 | -4.094 | 0.0000 |
| COHORT | -0.6871 | 0.1123 | -6.119 | 0.0000 |
| SCONST | -1.5321 | 0.0161 | -95.202 | 0.0000 |

The substantive effect that higher marijuana prices have on initiation rates is difficult to infer from the tables, but graphs are helpful. Figure 10 plots the relationship between marijuana prices and the probability of trying marijuana by age 20 for White and African-American males and females. Figure 11 is the counterpart for Hispanic and other males and females. All variables except marijuana prices were held constant at the average values observed in these data. The marijuana prices depicted here represent the range of marijuana prices observed between 1981 and 1998, but this range is wider than that observed for the price variable used here, that is, the average price that prevailed when cohort members were between the ages of 12 and 18 ($9.15 per gram to $13.89). Consequently, we should be skeptical about the estimates made at the extreme prices and focus instead on how the probability of use falls as marijuana prices increased from $9.15 to $13.89.

**Figure 10**

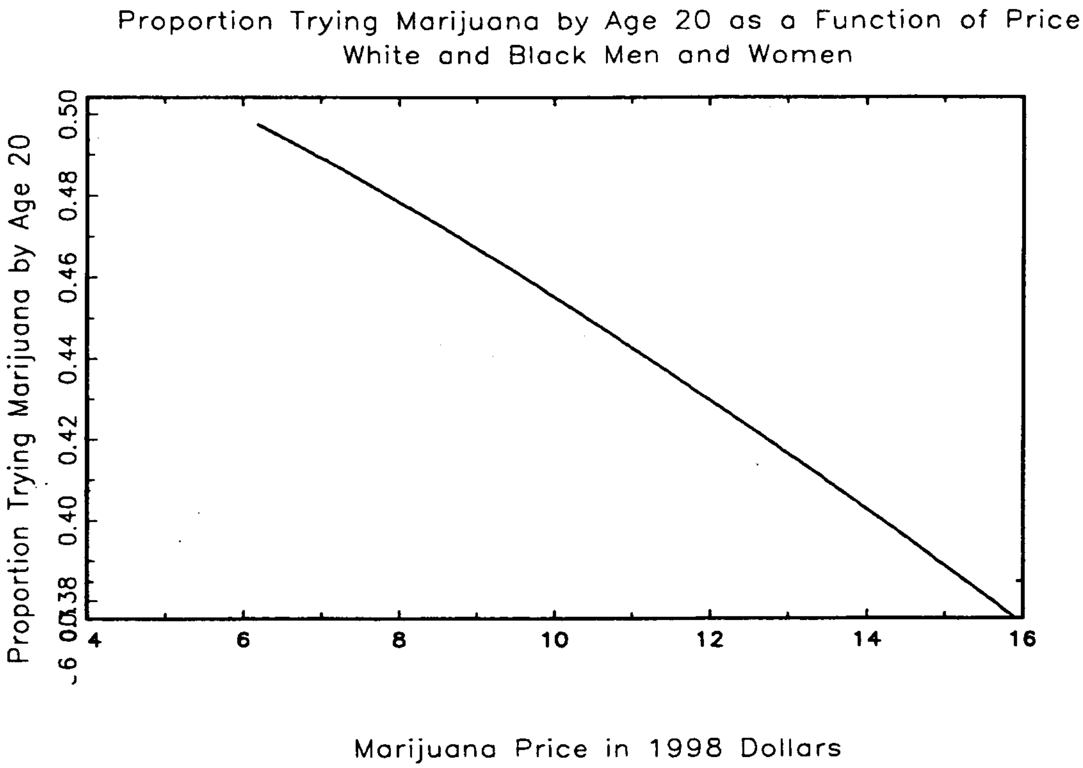
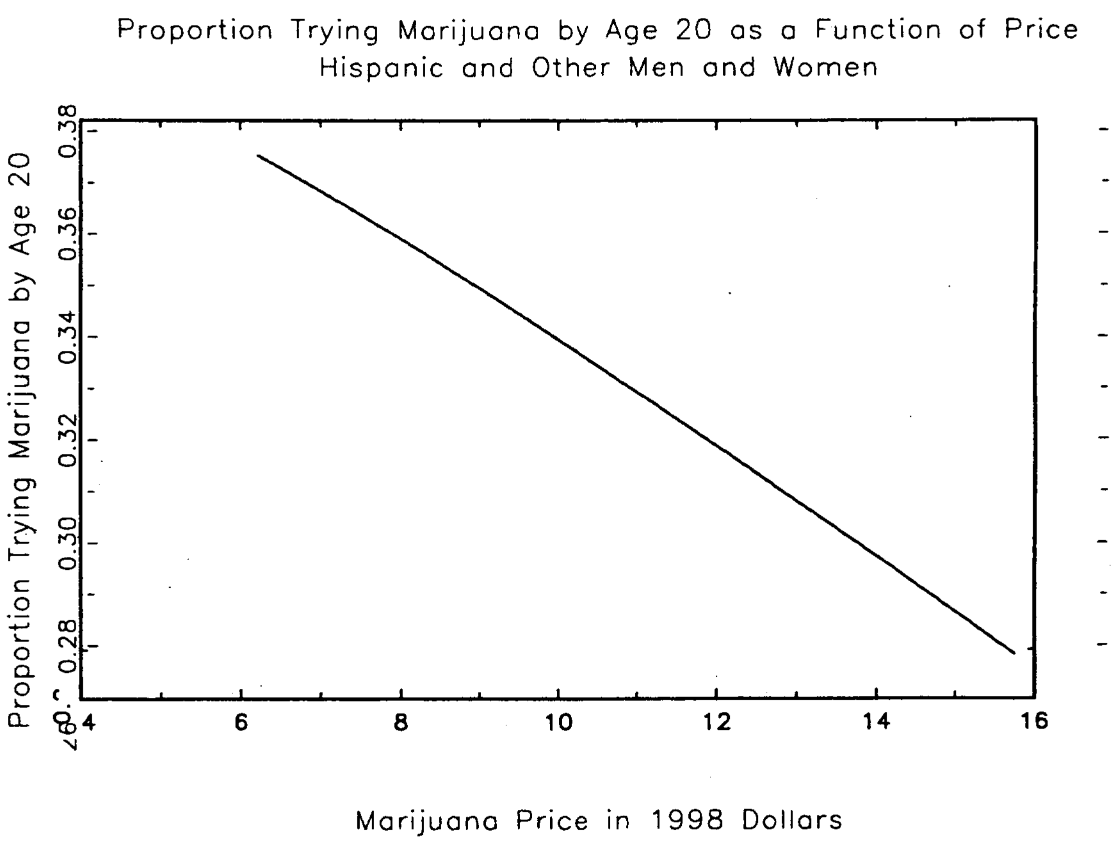


**Figure 11**

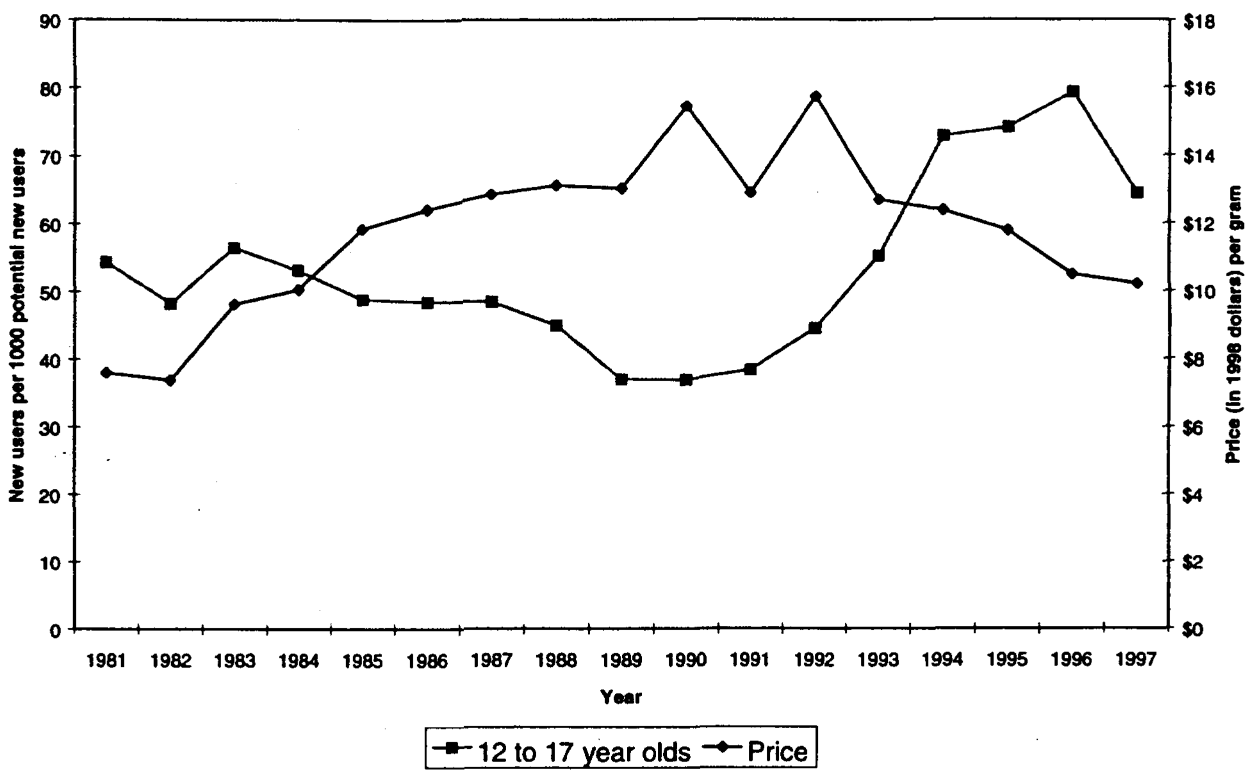



These findings imply that the likelihood of trying marijuana decreases as marijuana prices increase. Perhaps children and young adults are truly sensitive to marijuana prices, but these findings might imply that prices were high during periods when marijuana was relatively scarce. The scarcity rather than the price per se could produce the results reported here.

Is there external verification for these findings? We know of no other researchers who have studied the relationship between prices and the decision to try marijuana, but a simple reanalysis of more expansive NHSDA data provides independent evidence that initiation rates are lower when prices are high. See Figure 12.

Figure 12

**Smoothed Price of Marijuana and First Time Use of Marijuana**




In Figure 12, the first-time use of marijuana estimates are taken from the 1998 National Household Survey on Drug Abuse, Table 41. "The numerator of each rate is the number of persons in the age group [12 to 17] who first used the drug in the year (times 1,000), while the denominator is the number of person who were exposed to the risk of first use during the year, adjusted for their estimated exposure time (exposure time was expressed in years)." (NHSDA, p. 24). The price of marijuana was derived from estimates in the price series report. We took the price per gram estimates for the retail sample (< 10 grams), and to smooth the curve, calculated a three-year moving average.

Marijuana prices increased from 1981 through 1990; initiation rates decreased over that same span of time. Prices seemed to have reached a plateau in the early 1990s, although it is difficult to tell, because estimates from the early 1990s have high sampling variation. Initiation rates were stable during most of this period, although they increased in 1992. Marijuana prices decrease from 1993 through 1997; with the exception of the last year of data, marijuana initiation rates increased during that same period. These findings are consistent with the statistical analysis – higher marijuana prices imply lower initiation rates.

### Continuation of Marijuana Use

Does the price of marijuana affect current marijuana use for those who have tried marijuana at some time in the past? To answer this question, we selected from the NHSDA all respondents who were between 12 and 50 at the time of the survey. We categorized responses about use during the last year as "did not use in the last year," "used but less than weekly," and " used at least weekly."

We analyzed these data separately for respondents who were older than 18 and for respondents who were younger than 19. This was a pragmatic decision, because we had more measured covariates for adults than we had for youths, and those variables had different meanings when applied to youths and adults.

A total of 18,760 adults said they had tried marijuana. About 70 percent of them had not used in the year before the survey, about 19 percent had used at less than a weekly rate, and 10 percent had used at a weekly rate. A total of 2,630 youths said they had tried marijuana. Of those who had tried, 25 percent had not used in the last year, about 50 percent used less than weekly, and about 24 percent said they used weekly. Table 10 reports other descriptive statistics for adults (19 and over) and youths (under 19).

**Table 10**

**Past Year Use of Marijuana as a Function of Marijuana Prices Descriptive Statistics**

| Variable | Over 18 Mean | Over 18 Std Dev | 18 and under Mean | 18 and under Std Dev |
|---|---|---|---|---|
| NTL_MARF | 14.3963 | 2.7618 | 14.1760 | 2.7969 |
| ALC_PRCF | 1.3885 | 0.2781 | 1.3749 | 0.3105 |
| COCPRCF1 | 2.0082 | 0.4736 | 2.0174 | 0.5014 |
| MJAGE | 0.1756 | 0.0403 | | |
| MJAGE2 | 0.0325 | 0.0175 | | |
| EDUC | 0.7700 | 0.1446 | | |
| EDUC2 | 0.6139 | 0.2149 | | |
| MARRIED | 0.3824 | 0.4839 | | |
| EMPSTAT2 | 0.7595 | 0.4274 | | |
| FAM_INC | 8.7945 | 3.1138 | 8.3520 | 3.1341 |
| MALE | 0.5060 | 0.5000 | 0.5372 | 0.4987 |
| AGE | 0.3022 | 0.0742 | 0.1624 | 0.0149 |
| AGE2 | 0.0968 | 0.0496 | | |
| WHITE | 0.4936 | 0.5000 | 0.3542 | 0.4784 |
| BLACK | 0.2218 | 0.4155 | 0.1982 | 0.3988 |
| HISPAN | 0.2630 | 0.4402 | 0.4251 | 0.4945 |
| CASES | 18760 | | 2623 | |

Table 11 reports parameter estimates, standard errors, and t-scores for two models: a model that adjusts for selection of those who had used marijuana in the past and a model that does not adjust for that selection. In fact both models lead to the same conclusions, but before comparing them, note that the models have different parameterizations. In the model that adjusts for selection, a positive parameter means that marijuana use falls as the variable associated with that parameter increases. In the model that does not adjust for selection bias, a positive parameter means that marijuana use increases.

Recognizing that the signs are different in these two models, the first inference is that marijuana use falls as marijuana prices increase. Elasticity[15] estimates can be based on the average price and usage level that prevailed between 1988 and 1996. About 10 percent of all adults who had tried marijuana used it on a weekly basis. A 10 percent increase in marijuana prices would reduce weekly use to 9 ½ percent. This is an elasticity of –0.50. About 20 percent said they had used less frequently than weekly. A 10 percent price increase would reduce occasional use to 19 ½ percent, which is an elasticity of –0.25. Overall, then, a 10 percent price increase would reduce use from 30 percent to about 29 percent, with the elasticity being –0.33.

It may be reasonable to expect a larger elasticity for heavy users than for occasional users. Marijuana is a larger part of the market basket of the former, and that may be why they are more responsive to a price change. Also, some of the heavy users become occasional users, and this partly offsets the number of occasional users who quit, so elasticity would be less for occasional users.

These elasticity estimates are smaller than estimates reported by others (see the earlier literature review), but that would be expected because these estimates use a different base. The numerator in an elasticity calculation is the change in the use group (a number like –0.005 here) divided by the percentage of people in that use group (a number like 0.10 here). The base is relatively large in our estimates, because it is limited to people who have tried marijuana. Others have included everybody in the base, which will inflate the elasticity estimate, causing it to be larger than our estimate. Of course, this does not mean that our estimate is correct and the estimates of others are wrong, because the base chosen for calculation depends on what the researcher seeks to measure, and for that there is no universal standard.

15 The estimates are based on a nonlinear model, so elasticity varies with price. Evaluating elasticity at the mean is convenient, but evaluation at other values would produce somewhat different results.

Table 11

**Past Year Use of Marijuana as a Function of Marijuana Price**
**Adults 18 and Older**

Number of cases 18760

| Parameters | With Selection Adjustment Estimates | Stnd. Error | T-score | Without Selection Adjustment Estimates | Stnd. Error | T-score |
|---|---|---|---|---|---|---|
| CONST | -1.2003 | 0.3637 | -3.300 | | | |
| MJ PRICE | 0.0200 | 0.0036 | 5.498 | -0.0198 | 0.0036 | -5.46 |
| ALCPRICE | 0.0773 | 0.1376 | 0.561 | -0.0993 | 0.1375 | -0.72 |
| COCPRICE | 0.1324 | 0.0653 | 2.027 | -0.1286 | 0.0663 | -1.94 |
| MJAGE | 7.7853 | 1.5710 | 4.956 | -13.7411 | 1.0751 | -12.78 |
| MJAGE2 | -16.6100 | 3.0376 | -5.468 | 24.8671 | 2.6329 | 9.44 |
| EDUC | -1.0411 | 0.4333 | -2.403 | 1.0976 | 0.4409 | 2.49 |
| EDUC2 | 1.0753 | 0.2937 | 3.662 | -1.1194 | 0.2982 | -3.75 |
| MARRIED | 0.3700 | 0.0228 | 16.249 | -0.3718 | 0.0223 | -16.65 |
| EMPSTAT2 | 0.1257 | 0.0246 | 5.107 | -0.1262 | 0.0249 | -5.08 |
| FAM_INC | 0.0271 | 0.0036 | 7.537 | -0.0271 | 0.0036 | -7.43 |
| MALE | -0.3783 | 0.0199 | -19.033 | 0.3744 | 0.0200 | 18.68 |
| AGE | 5.2976 | 1.0341 | 5.123 | -6.8879 | 0.9975 | -6.91 |
| AGE2 | -3.0269 | 1.6553 | -1.829 | 6.1346 | 1.5454 | 3.97 |
| WHITE | -0.2223 | 0.0694 | -3.203 | 0.1731 | 0.0695 | 2.49 |
| BLACK | -0.2842 | 0.0712 | -3.989 | 0.2527 | 0.0711 | 3.56 |
| HISPAN | -0.0384 | 0.0708 | -0.543 | 0.0006 | 0.0706 | 0.01 |
| CORR | 0.0482 | 0.0093 | 5.186 | | | |
| Alpha | -0.2091 | 0.0151 | -13.882 | | | |
| Alpha_1 | | | | -2.9881 | 0.3104 | -9.63 |
| Alpha_2 | | | | -2.1774 | 0.3100 | -7.02 |

We have less interest in other variables entering this statistical model, but some comment may be useful. There is some variation in the prevalence of marijuana use by place. One place has a parameter of -0.3439 and another place has a parameter of 0.0587. But variation by place does not seem especially large as judged by the size of the t-scores, which generally do not approach significance.

The earlier that a respondent tried marijuana (MJAGE), the higher the probability that he will have used it during the current year. This inference is based on the observation that the parameter associated with MJAGE is positive, implying that current marijuana use is lower when age first tried marijuana is higher. The negative size associated with the square of MJAGE is noteworthy because it implies that, at some age, the relationship between current use and MJAGE reverses itself. However, MJAGE equals actual age at first use divided by 100, so the relationship is monotonic over the range of interest to us here.

Education is years of education completed. Practically, then, the negative sign associated with education (EDUC) and the positive sign associated with its square (EDUC2) implies that marijuana use falls as education increases. Males are more likely to use marijuana than are females. Marijuana use is lower if a person is married; it is lower if he is employed; use falls as income increases.

Finally, marijuana use decreases with age. The positive coefficient associated with age (AGE) dominates the negative coefficient associated with age-squared (AGE2), because AGE was coded as age at the time of the interview divided by 100.

**Table 12**

**Past Year Use of Marijuana as a Function of Marijuana Price**
**Youths under 18**

Number of cases 2623

| | With Selection Adjustment | | | Without Selection Adjustment | | |
|---|---|---|---|---|---|---|
| Parameters | Estimates | Stnd. Error | T-score | Estimates | Stnd. Error | T-score |
| CONST | -0.3196 | 0.5040 | -0.634 | | | |
| MJ_PRICE | 0.0062 | 0.0082 | 0.746 | -0.00597 | 0.0082 | -0.72 |
| ALPRICE | -0.2043 | 0.2758 | -0.740 | 0.19853 | 0.2751 | 0.72 |
| COCPRICE | 0.3331 | 0.1421 | 2.344 | -0.33754 | 0.1403 | -2.41 |
| FAM_INC | 0.0196 | 0.0073 | 2.672 | -0.02000 | 0.0073 | -2.73 |
| MALE | -0.0877 | 0.0472 | -1.858 | 0.10866 | 0.0449 | 2.42 |
| AGE | 1.6815 | 1.6552 | 1.016 | -2.58929 | 1.5529 | -1.67 |
| WHITE | -0.1787 | 0.1520 | -1.176 | 0.16992 | 0.1509 | 1.13 |
| BLACK | -0.1295 | 0.1580 | -0.820 | 0.11971 | 0.1562 | 0.77 |
| HISPAN | -0.1254 | 0.1552 | -0.808 | 0.08344 | 0.1503 | 0.56 |
| CORR | 0.0239 | 0.0185 | 1.290 | | | |
| Alpha | 0.3293 | 0.0227 | 14.518 | | | |
| Alpha_1 | | | | -1.93362 | 0.4724 | -4.09 |
| Alpha_2 | | | | -0.54404 | 0.4713 | -1.15 |

Looking at the analysis of drug use by people under 18, there is no evidence that children and young adults (under 18) are sensitive to the price of marijuana, at least when they decide how frequently to use the drug. In fact, with some exceptions, few variables in this model seem to be strong predictors of current marijuana use. Males are more likely than female to be current users. Marijuana use decreases as family income increases. Some places may have lower use rates than the excluded place, but these effects are not large. Curiously, the use of marijuana has a negative association with the price of cocaine.

Overall, then, it appears that adults who have tried marijuana some time in the past reduce current level consumption when marijuana prices are high and increase current level consumption when marijuana prices are low. Children and young adults do not seem to be sensitive to marijuana prices, nor is there a cross-price elasticity with respect to alcohol prices. Note that the sample size was much smaller (2,623) for children than it was for adults (18,760). Perhaps a larger sample for children would yield different results.

### Hardcore Marijuana Use

Across the DUF sites, 64 percent of arrestees said they had not used marijuana in the month before the interview. Another 24 percent said they had used it on 10 of fewer days during that month, and 12 percent said they had used it on more than 10 days.

Table 13 reports the results of the cumulative logit analysis:

**Table 13**

**Marijuana Use by Arrestees**

Number of Observations: 165980

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| INTERCP1 | 1 | -0.8506 | 0.2663 | 10.2013 | 0.0014 | . |
| INTERCP2 | 1 | 0.6572 | 0.2663 | 6.0896 | 0.0136 | . |
| MARPRCF1 | 1 | -0.2763 | 0.0363 | 57.8506 | 0.0001 | -0.046854 |
| COCPRCF1 | 1 | -0.3165 | 0.0622 | 25.9284 | 0.0001 | -0.128563 |
| HERPRCF1 | 1 | -0.1570 | 0.0338 | 21.5192 | 0.0001 | -0.098957 |
| ALCPRCF | 1 | 0.2246 | 0.1290 | 3.0305 | 0.0817 | 0.019225 |
| ILLEGCAT | 1 | 0.8522 | 0.0135 | 3971.6628 | 0.0001 | 0.179804 |
| INCOME | 1 | 0.00167 | 0.00222 | 0.5695 | 0.4504 | 0.002132 |
| AGE | 1 | -0.0514 | 0.00364 | 199.3055 | 0.0001 | -0.255684 |
| AGE2 | 1 | 0.000039 | 0.000055 | 0.5002 | 0.4794 | 0.013613 |
| HIGRADE | 1 | 0.2088 | 0.0118 | 311.6243 | 0.0001 | 0.263964 |
| HIGRADE2 | 1 | -0.0113 | 0.000558 | 412.4360 | 0.0001 | -0.300882 |
| TIME | 1 | -0.0300 | 0.00913 | 10.7951 | 0.0010 | -0.170165 |
| TIME_6 | 1 | 0.0426 | 0.0106 | 16.2118 | 0.0001 | 0.231340 |
| TIME_24 | 1 | -0.0130 | 0.00286 | 20.7299 | 0.0001 | -0.028486 |
| BLACK | 1 | 0.7377 | 0.0567 | 169.1814 | 0.0001 | 0.200265 |
| WHITE | 1 | 0.7539 | 0.0569 | 175.5832 | 0.0001 | 0.170046 |
| HISP | 1 | 0.2554 | 0.0574 | 19.7728 | 0.0001 | 0.055181 |
| MALE | 1 | 0.4996 | 0.0124 | 1614.9548 | 0.0001 | 0.123084 |
| ATLANTA | 1 | -0.5052 | 0.0839 | 36.2433 | 0.0001 | -0.061624 |
| CHICAGO | 1 | -0.5525 | 0.0993 | 30.9402 | 0.0001 | -0.061936 |
| CLEVE | 1 | 0.0651 | 0.1271 | 0.2627 | 0.6083 | 0.008244 |
| DALLAS | 1 | -0.6601 | 0.1093 | 36.4770 | 0.0001 | -0.093472 |
| DC | 1 | -1.4594 | 0.1097 | 177.0568 | 0.0001 | -0.200800 |
| DETROIT | 1 | -0.3935 | 0.0823 | 22.8556 | 0.0001 | -0.045688 |
| HOUSTON | 1 | -0.2974 | 0.0354 | 70.4602 | 0.0001 | -0.041030 |
| LA | 1 | -0.9259 | 0.1299 | 50.7734 | 0.0001 | -0.146149 |
| MIAMI | 1 | -0.8894 | 0.1246 | 50.9492 | 0.0001 | -0.092066 |

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| NEWORL | 1 | -0.2232 | 0.1106 | 4.0766 | 0.0435 | -0.030781 |
| NEWYORK | 1 | -0.8595 | 0.1245 | 47.6927 | 0.0001 | -0.119383 |
| PHIL | 1 | -0.7415 | 0.1260 | 34.6353 | 0.0001 | -0.105442 |
| PHOENIX | 1 | -0.3418 | 0.0863 | 15.6753 | 0.0001 | -0.050488 |
| SANANTON | 1 | -0.4983 | 0.0468 | 113.5157 | 0.0001 | -0.066181 |
| SANDIEGO | 1 | -0.5664 | 0.1164 | 23.6967 | 0.0001 | -0.077357 |

mar. Reference site is STLOUIS . k1=6, k2=24

There was a very strong negative relationship between the price of marijuana and its level of use. On the logit scale, and with prices in $10 units, the parameter estimate was –0.2763 (p <0.0001). The implied elasticity (evaluated at the 1998 price of $10.2) for hardcore users and moderate users was –2.79 and –2.65 respectively. Thus a one percent increase in the price of marijuana reduces the proportion of hardcore marijuana users by 2.79%.

Arrestees appear to be sensitive to marijuana prices. This makes sense, because marijuana is potentially a large part of their market basket, so price increases are a potentially large part of their income. In addition, they have access to other intoxicants, including alcohol. Note that as the price of alcohol goes up, the consumption of marijuana goes up, apparently because marijuana users are willing to switch between marijuana and alcohol depending on relative prices.

The results imply additional cross-price elasticity effects. Marijuana use falls when cocaine or heroin prices increase. Several different interpretations are possible. Marijuana use may be a complement to cocaine and heroin use so that cocaine users use less marijuana when they restrict their cocaine use, and the same for heroin users. Another possibility is that an increase in cocaine/heroin prices has a strong income effect, and habitual users reduce all consumption (including marijuana) to compensate for having to spend more on cocaine/heroin. Still another explanation is that higher cocaine/heroin prices are the result of a tightening drug market, and this tightening might restrict access to marijuana.

We have less interest in the effect of other variables on the level of marijuana use. However, marijuana use falls with age, and increases and then decreases with education (maximum at grade 9). Males are heavier users than females, and use is higher for those with illegal income, although there is no relationship between use and amount of (legal or illegal) income. Whites, African-Americans and Hispanics all have higher use rates than "other" races. Use is higher in some places than others: for example, use is relatively high in St. Louis and low in Washington, D.C

## Demand for Cocaine

### Initiation of Cocaine Use

The analysis of the demand for marijuana provides a template for the study of cocaine use (including crack). Nevertheless, studying the demand for cocaine poses special problems, many of which stem from the low reported prevalence of cocaine use among members of households. The analysis begins with an estimate of how cocaine prices affect initiation rates. As before, the analysis used responses to the question: At what age did you first try cocaine? Table 14 shows that this is a very different question than asking when cocaine use was initiated.

**Table 14**
**First Time Use Cocaine/Crack Was During Survey Year**
**(Weighted)**

YEAR COCCRKFQ

| Frequency | daily | 3-6 days /wk | 1-2 days /wk | 25-51 days/year | 12-24 days/year | 6-11 days/year | 3-5 days /year | 1-2 days /year |
|---|---|---|---|---|---|---|---|---|
| 1990 | 0 | 1338 | 62839 | 49929 | 94602 | 15335 | 84970 | 511530 |
| 1991 | 7403.6 | 5231.2 | 38145 | 26536 | 22381 | 40394 | 73747 | 275595 |
| 1992 | 0 | 1732.7 | 52104 | 32454 | 72621 | 58615 | 58019 | 248004 |
| 1993 | 4406.7 | 4668.1 | 26301 | 4835.3 | 23900 | 20533 | 40593 | 184697 |
| 1994 | 13754 | 67935 | 8534.4 | 26688 | 70905 | 131119 | 82064 | 372031 |
| 1995 | 6467.7 | 13916 | 77268 | 27759 | 35787 | 72980 | 100184 | 553514 |
| 1996 | 3759.7 | 17952 | 14649 | 50469 | 35150 | 46208 | 222650 | 483597 |
| Total | 35792.2 | 112774 | 279840 | 218670 | 355346 | 385184 | 662226 | 2628967 |

The table shows the weighted number of respondents who said they used cocaine for the first time during the year of the interview. Note that almost 60 percent of those who tried cocaine for the first time during the year of the interview also said that they had used cocaine just 1 to 2 times during that year. Possibly, then, many if not most of those respondents did not use cocaine again during the year. Almost 80 percent of them said they had used less frequently than once per month, and fewer than 10 percent said they used weekly. The question about age at first use does not seem to indicate initiation of cocaine use, but nevertheless, it is the only measure at our disposal.

**Table 15**

**Age at First Use of Cocaine: Descriptive Statistics**

| | White and Black Men and Women | | Hispanic and Other Men and Women | |
|---|---|---|---|---|
| Variable | Mean | Std Dev | Mean | Std Dev |
| MALE | 0.4431 | 0.4968 | 0.4662 | 0.4989 |
| BLACK | 0.4360 | 0.4959 | 0.9021 | 0.2972 |
| CASES | 36614 | | 28271 | |

Descriptive statistics are reported in Table 15; regression results are reported in Table 16 for White and Black men and women.

**Table 16**

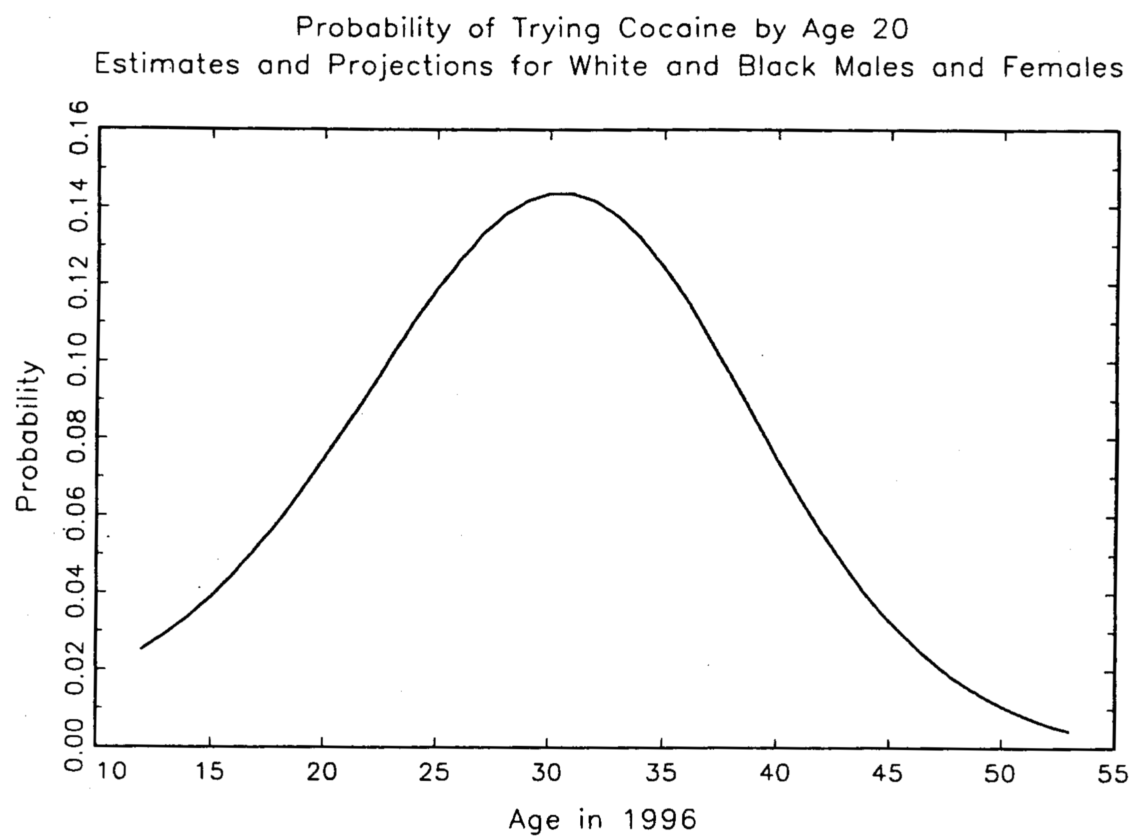
**Age at First Use of Cocaine: White and Black Males and Females**

Mean log-likelihood 1.00000E-100
Number of cases 36614

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. |
|---|---|---|---|---|
| QCONST | -1.7815 | 0.7334 | -2.429 | 0.0076 |
| AGE | -1.2669 | 6.5419 | -0.194 | 0.4232 |
| AGE_2 | 37.7734 | 19.1343 | 1.974 | 0.0242 |
| AGE_3 | -65.8194 | 18.2720 | -3.602 | 0.0002 |
| MALE | 0.2836 | 0.0183 | 15.484 | 0.0000 |
| BLACK | -0.4117 | 0.0216 | -19.058 | 0.0000 |
| TCONST | 3.2059 | 0.0753 | 42.576 | 0.0000 |
| AGE | -2.6856 | 0.4432 | -6.060 | 0.0000 |
| AGE_2 | 6.0632 | 0.6474 | 9.365 | 0.0000 |
| MALE | -0.0058 | 0.0047 | -1.250 | 0.1056 |
| BLACK | 0.0368 | 0.0067 | 5.525 | 0.0000 |
| SCONST | -0.7332 | 0.2065 | -3.551 | 0.0002 |
| AGE | -8.4972 | 1.2274 | -6.923 | 0.0000 |
| AGE_2 | 15.2317 | 1.8256 | 8.343 | 0.0000 |
| MALE | 0.0048 | 0.0205 | 0.236 | 0.4065 |
| BLACK | 0.2135 | 0.0251 | 8.507 | 0.0000 |

The place where a person lives has a large effect on his or her decision to try cocaine. The risk of trying cocaine is relatively high in some places (0.3611; 0.2830) and comparatively low in others (-0.3134; -0.3516). As was true when examining the initiation of marijuana use, cohort effects are statistically significant, but they are difficult to interpret, so we use graphics for understanding. Figure 13 reports the predicted probability of trying cocaine by the age of twenty for White and African-American males and females.

**Figure 13**




According to Figure 13, members of the age 30 cohort were at greatest risk of trying cocaine by age 20. This finding seems reasonable given what is known about the cocaine epidemic. People who were 30-years-old in 1996 were in their late teens and early twenties at the peak of the cocaine epidemic in the middle and later 1980s. Members of the youngest cohort appear to be at relatively low risk of trying cocaine, but caveats are necessary. We cannot see much of the drug use career for the youngest cohorts, but data that are more recent than were available for this study imply increased recent use among youths. Specifically, results from MTF (The University of Michigan, 1999) show that the lifetime prevalence of cocaine use has increased fairly steadily from 1991 to 1999 for 8$^{th}$, 10$^{th}$ and 12$^{th}$ graders.

**Figure 14**

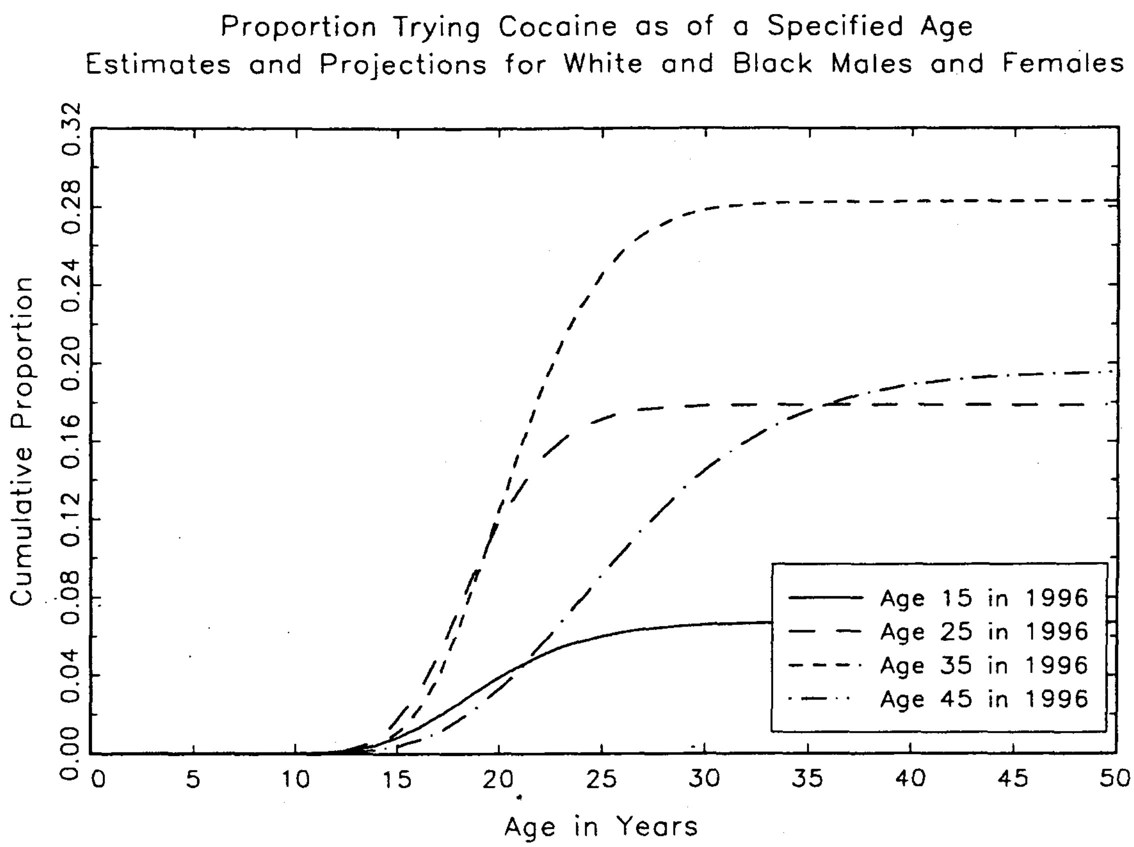



Figure 14 projects the age as first-time use for four age cohorts. If we were to draw a vertical line at age 20, it would intersect these four curves at the same estimates reported in the previous figure. The figure implies that the age 35 cohort is at the highest risk of trying cocaine. The age 25 cohort is somewhat lower. Older and younger cohorts are at lower risks, at least over the range of data for which we have much confidence – less than age 30.

Table 17 reports parameter estimates for the initiation of cocaine use by Hispanic and other men and women.

**Table 17**

**Age at First Use of Cocaine: Hispanic and Other Males and Females**

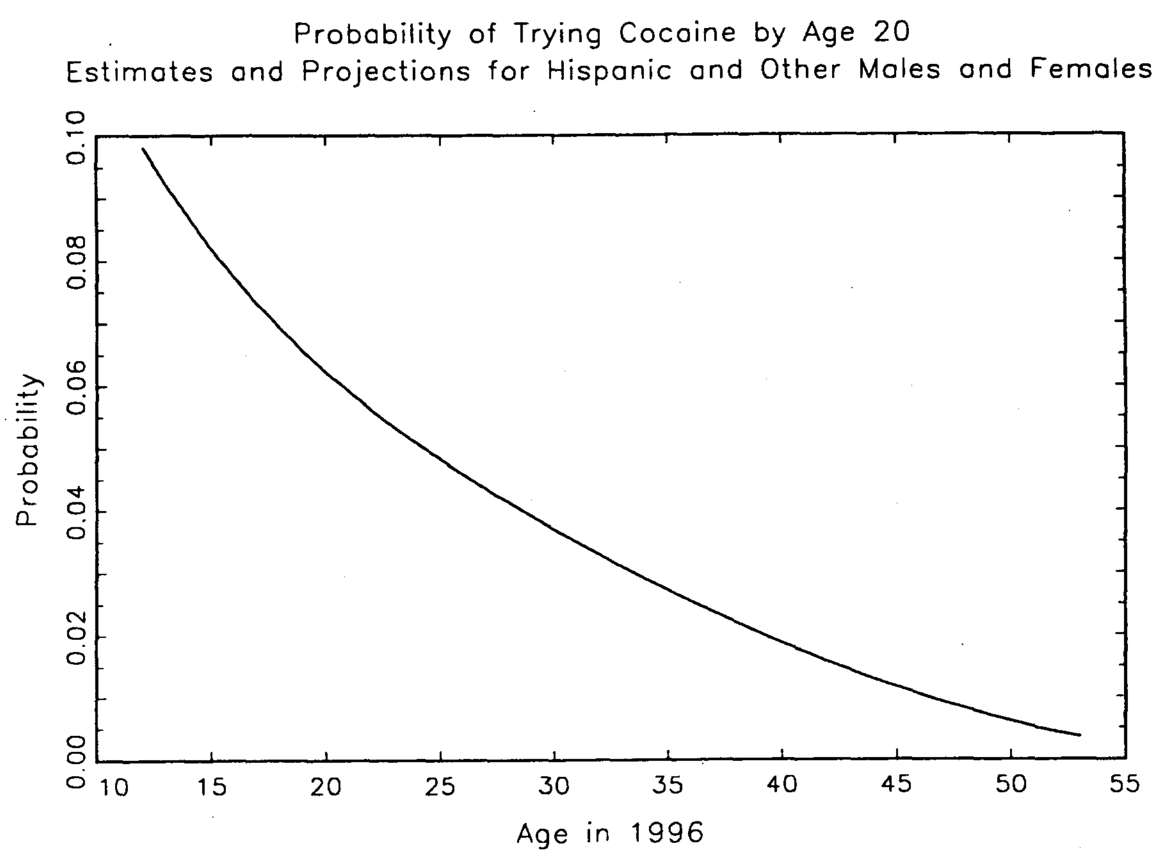
| Parameters | Estimates | Std. err. | Est./s.e. | Prob. | Gradient |
|---|---|---|---|---|---|
| QCONST | 0.2755 | 0.9338 | 0.295 | 0.3840 | -0.0000 |
| AGE | -13.2997 | 8.4412 | -1.576 | 0.0576 | 0.0000 |
| AGE_2 | 41.9158 | 24.9465 | 1.680 | 0.0465 | 0.0000 |
| AGE_3 | -47.5359 | 24.0753 | -1.974 | 0.0242 | 0.0000 |
| MALE | 0.4932 | 0.0274 | 18.028 | 0.0000 | 0.0000 |

| Parameters | Estimates | Std. err. | Est./s.e. | Prob. | Gradient |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| BLACK | -0.1725 | 0.1097 | -1.572 | 0.0580 | -0.0000 |
| TCONST | 2.9483 | 0.1011 | 29.172 | 0.0000 | 0.0002 |
| AGE | -1.1611 | 0.6430 | -1.806 | 0.0355 | 0.0000 |
| AGE_2 | 4.1577 | 1.0221 | 4.068 | 0.0000 | 0.0000 |
| MALE | 0.0443 | 0.0095 | 4.685 | 0.0000 | -0.0000 |
| BLACK | 0.1671 | 0.0651 | 2.566 | 0.0051 | 0.0002 |
| SCONST | -1.8650 | 0.2715 | -6.869 | 0.0000 | -0.0004 |
| AGE | -1.2664 | 1.7419 | -0.727 | 0.2336 | -0.0001 |
| AGE_2 | 6.0422 | 2.7755 | 2.177 | 0.0147 | -0.0000 |
| MALE | -0.0094 | 0.0363 | -0.260 | 0.3975 | 0.0000 |
| BLACK | 0.4961 | 0.1148 | 4.320 | 0.0000 | -0.0004 |

Again, there are important differences across places. The risk of trying cocaine is relatively high in one place (0.7450) and comparatively low in another (-0.7511). Figure 15 shows estimates of the probability of trying cocaine by age 20 as a function of cohort identity.

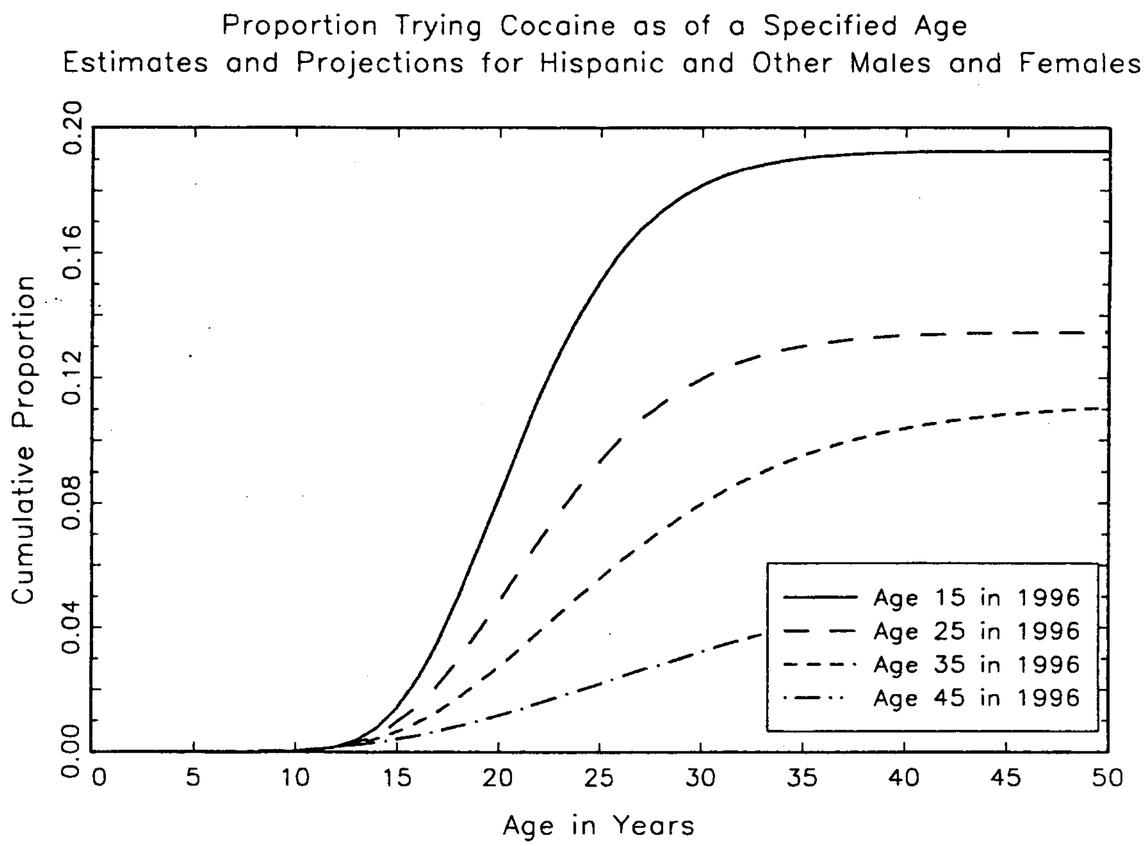
**Figure 15**




The estimated risk of trying cocaine is highest for the youngest cohorts and lowest for the oldest cohorts. Again we should be skeptical of the estimates for the youngest cohorts, because we see only a limited amount of data about them. Focusing on the risk for the age twenty cohort, the inference is that their risk was about the same as that for White and Black males and females (see Figure 13). Apparently, Hispanic and other men and women who are just entering adulthood are at about the same risk of trying cocaine as are their White and African-American counterparts.

Figure 16 provides a different view of the risk of trying cocaine as a function of age cohort.

**Figure 16**




The pattern is clear. Among Hispanic and other men and women, the oldest cohorts have the lowest risk of trying cocaine. The youngest cohorts seem to have the highest risk.

Given these findings about Hispanic and other men and women, we should revisit the MTF findings reported earlier. According to the MTF finding, lifetime use of marijuana was 8 percent for 12th graders in 1991 but close to 6 percent between 1992 and 1995. This "6%" group pertains to our age 19-22 age cohorts. Then in 1997-1999, about 10 percent of all seniors had tried cocaine. This "10%" group corresponds to our age 15-17. The MTF shows a clear upward trend in experimenting with cocaine. Perhaps Hispanic and other men and women account for this increase, so our findings are consistent with the MTF. Alternatively, our data – which end in 1996 – are too recent to capture what appears to be an increase in cocaine use by American youth.

Have prices influenced these initiation rates? We drop the AGE2 and AGE3 variables from the analysis and add the average price of cocaine experienced by each cohort between the ages of 12 and

18. That is, COCPRICE is the average price of cocaine over a period when individuals were 12 to 18 years old. The price was divided by 10 because the model converged better when price was scaled. Table 18 reports descriptive statistics.

**Table 18**

**First Time Cocaine Use as a Function of Cocaine Price**
**Descriptive Statistics**

| Variable | White and Black Men and Women Mean | White and Black Men and Women Std Dev | Hispanic and Other Men and Women Mean | Hispanic and Other Men and Women Std Dev |
|---|---|---|---|---|
| CENSOR | 0.9085 | 0.2884 | 0.9230 | 0.2667 |
| COCAGE | 18.4956 | 4.3176 | 18.6430 | 4.4790 |
| COCPRICE | 2.3462 | 0.5860 | 2.2965 | 0.5704 |
| MALE | 0.4616 | 0.4985 | 0.4845 | 0.4998 |
| BLACK | 0.4643 | 0.4987 | 0.8996 | 0.3005 |
| AGE | 0.2263 | 0.0453 | 0.2217 | 0.0461 |
| AGE_2 | 0.0533 | 0.0206 | 0.0513 | 0.0206 |
| AGE_3 | 0.0130 | 0.0073 | 0.0123 | 0.0072 |
| CASES | 19776 | | 17056 | |

Table 19 reports regression results for White and African-American men and women; Table 20 reports results for Hispanic and other men and woman. The first time that COCPRICE appears in these tables, it is associated with the lifetime probability of trying cocaine. For both White/African-Americans and Hispanic/Other the parameter has an unexpected positive sign, but it never approaches statistical significance (t = 0.08 for White/African-American and t = 0.89 for Hispanic/other). The second time that COCPRICE appears, it is associated with the median age of initiation for those who tried cocaine. The parameter is negative (but not significant) for Whites/African-Americans, but it has the expected positive sign for Hispanics/others and it is statistically significant (t = 2.50). So there is some evidence that cocaine prices have affected cocaine initiation rates, but the evidence is not very strong.

Although there is little evidence that initiation is affected by price, there is no reason to assume the null hypothesis – that cocaine prices have no effect on initiation rates. In fact, when prices are averaged over seven years periods (between the age of 12 and 18 for each cohort), cocaine prices have fallen fairly constantly. As was shown earlier, cocaine prices were high in the early 1980s and they fell sharply until about 1988. Thereafter, prices declined gradually, and most of that subsequent decline was attributable to the consumer price index. Greater variation in cocaine prices would have provided a stronger test of the hypothesis, but given this monotronic decrease in price, a linear trend may be indistinguishable from the cohort effect.

**Table 19**

**First Time Cocaine Use as a Function of Cocaine Price**
**White and Black Men and Women**

| | | | |
|---|---|---|---|
| Mean log-likelihood | -0.438663 | | |
| Number of cases | 19729 | | |
| Parameters | Estimates | Std. err. | Est./s.e. |
| QCONST | -2.7072 | 0.3787 | -7.148 |
| COCPRICE | 0.0138 | 0.1796 | 0.077 |
| MALE | 0.2418 | 0.0321 | 7.523 |
| BLACK | -0.5357 | 0.0380 | -14.098 |
| COHORT | 7.7640 | 3.2294 | 2.404 |
| PIMA | -0.0332 | 0.2302 | -0.144 |
| TCONST | 2.6688 | 0.0757 | 35.277 |
| COCPRICE | -0.0021 | 0.0367 | -0.057 |
| MALE | 0.0114 | 0.0076 | 1.501 |
| BLACK | 0.0076 | 0.0093 | 0.813 |
| COHORT | 0.9034 | 0.6496 | 1.391 |
| SCONST | -1.9124 | 0.0219 | -87.451 |

**Table 20**

**First Time Cocaine Use as a Function of Cocaine Price**
**Hispanic and Other Men and Women**

| | | | |
|---|---|---|---|
| Mean log-likelihood | -0.392474 | | |
| Number of cases | 17071 | | |
| Parameters | Estimates | Std. err. | Est./s.e. |
| QCONST | -1.1812 | 0.3879 | -3.045 |
| COCPRICE | 0.1716 | 0.1919 | 0.894 |
| MALE | 0.4278 | 0.0409 | 10.465 |
| HISPANIC | 0.4005 | 0.0803 | 4.988 |
| COHORT | -3.4320 | 3.3414 | -1.027 |
| TCONST | 2.9198 | 0.0656 | 44.517 |
| COCPRICE | 0.0881 | 0.0352 | 2.499 |
| MALE | 0.0644 | 0.0105 | 6.156 |
| HISPANIC | -0.0181 | 0.0231 | -0.785 |
| COHORT | -0.9248 | 0.5430 | -1.703 |
| SCONST | -1.7717 | 0.0291 | -60.954 |

### Continuation of Cocaine Use

Having examined initiation rates, we turn to continuation rates. Given that a person has tried cocaine, do current consumption decisions depend on the price of cocaine? To answer this question, we created an analysis file comprised of people who said they had tried cocaine. We ran a separate analysis for adults (over 18) and children (18 and under). We consider adults first.

The sample comprised 7,520 respondents who said they had tried cocaine and were between 19 and 50 at the time they were questioned. About 77 percent said they had not used cocaine in the last year, another 19 percent said they had used it less frequently than weekly, and 4 percent said weekly. Table 21 provides descriptive statistics; Table 22 provides regression results.

**Table 21**

**Continuation of Cocaine Use: Descriptive Statistics**

| Variable | Mean | Std Dev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|
| COCEPS | -0.0960 | 0.9306 | 0.8659 | -6.0000 | 3.1406 |
| COCYRFRQ | 1.2716 | 0.5315 | 0.2825 | 1.0000 | 3.0000 |
| NTL_MARF | 14.4018 | 2.7350 | 7.4803 | 9.9409 | 21.0294 |
| ALC_PRCF | 1.3861 | 0.2823 | 0.0797 | 0.0000 | 1.7749 |
| COCPRCF1 | 1.9816 | 0.4379 | 0.1918 | 1.3634 | 4.1740 |
| COCAGE | 0.2081 | 0.0466 | 0.0022 | 0.0315 | 0.5052 |
| COCAGE2 | 0.0455 | 0.0228 | 0.0005 | 0.0010 | 0.2552 |
| EDUC | 0.7650 | 0.1447 | 0.0209 | 0.0000 | 1.0000 |
| EDUC2 | 0.6061 | 0.2149 | 0.0462 | 0.0000 | 1.0000 |
| MARRIED | 0.3709 | 0.4810 | 0.2314 | 0.0000 | 1.0000 |
| EMPSTAT2 | 0.7618 | 0.4260 | 0.1815 | 0.0000 | 1.0000 |
| FAM_INC | 8.7777 | 3.0922 | 9.5614 | 1.0000 | 13.0000 |
| MALE | 0.5489 | 0.4976 | 0.2476 | 0.0000 | 1.0000 |
| AGE | 0.3021 | 0.0650 | 0.0042 | 0.1900 | 0.5500 |
| AGE2 | 0.0955 | 0.0425 | 0.0018 | 0.0361 | 0.3025 |
| WHITE | 0.5373 | 0.4986 | 0.2486 | 0.0000 | 1.0000 |
| BLACK | 0.1758 | 0.3807 | 0.1449 | 0.0000 | 1.0000 |
| HISPAN | 0.2701 | 0.4440 | 0.1972 | 0.0000 | 1.0000 |

Table 22

**Continuation of Cocaine Use as a Function of Cocaine Price**

Number of cases 7797

| Parameters | Estimates | Std. err. | Est./s.e. | Estimate | Error | t-value |
|---|---|---|---|---|---|---|
| CONST | -0.6631 | 0.7722 | -0.859 | | | |
| MJ PRICE | 0.0134 | 0.0062 | 2.161 | -0.01462 | 0.0061 | -2.39 |
| ALCPRICE | 0.7504 | 0.2263 | 3.316 | -0.68156 | 0.2271 | -3.00 |
| COCPRICE | 0.0484 | 0.1079 | 0.449 | -0.07129 | 0.1098 | -0.65 |
| COCAGE | 7.6762 | 5.3935 | 1.423 | -1.44232 | 2.1856 | -0.66 |
| COCAGE2 | -13.9317 | 8.0258 | -1.736 | 5.53749 | 4.6215 | 1.20 |
| EDUC | -0.7902 | 0.6495 | -1.217 | 0.79083 | 0.6217 | 1.27 |
| EDUC2 | 1.4397 | 0.4530 | 3.178 | -1.44518 | 0.4389 | -3.29 |
| MARRIED | 0.3743 | 0.0375 | 9.970 | -0.37645 | 0.0373 | -10.10 |
| EMPSTAT2 | 0.2098 | 0.0406 | 5.161 | -0.21004 | 0.0412 | -5.10 |
| FAM_INC | 0.0221 | 0.0059 | 3.720 | -0.02232 | 0.0059 | -3.81 |
| MALE | -0.2790 | 0.0331 | -8.430 | 0.27745 | 0.0335 | 8.27 |
| AGE | 2.6199 | 1.9505 | 1.343 | -2.86807 | 1.9669 | -1.46 |
| AGE2 | -0.3962 | 3.1355 | -0.126 | -0.38847 | 3.1132 | -0.12 |
| WHITE | -0.0050 | 0.1317 | -0.038 | 0.04433 | 0.1402 | 0.32 |
| BLACK | -0.3192 | 0.1340 | -2.382 | 0.34363 | 0.1439 | 2.39 |
| HISPAN | -0.0785 | 0.1308 | -0.600 | 0.10133 | 0.1409 | 0.72 |
| TRIGGER | | | | | | |
| CORR | -0.1599 | 0.1292 | -1.237 | | | |
| Alpha | 0.0840 | 0.0256 | 3.277 | | | |
| Alpha_1 | | | | -1.02099 | 0.5064 | -2.02 |
| Alpha_2 | | | | 0.07207 | 0.5061 | 0.14 |

Table 22 provides no evidence that cocaine consumption is sensitive to the price of cocaine. We tried a variety of different model specifications, which included using a past-month indicator of cocaine use, and alternative ways of representing prices. The conclusion was not intrinsically changed. Curiously, cocaine use seems to decrease as marijuana prices increase and as the price of alcohol increases. We have no ready explanation for those findings.

Some additional findings deserve comment. COCAGE is the respondent's age when he or she first tried cocaine, and COCAGE2 is the square of that age. The older a person was before he or she tried cocaine, the less likely that he or she used cocaine in the last year. (This is true for values of COCAGE up to about 30; thereafter, the effect reverses, but practically nobody tried cocaine for the first time after age 30.) Use decreases with age (AGE) although at a decreasing rate (AGE2).

Men are more likely to use than are females. Cocaine use falls with higher education. It is less likely for those who are married, less likely for those who are employed, and cocaine use falls with higher income. African-Americans have the highest rates of use.

We replicated the above analysis (with fewer variables) for people who were 18 and under at the time of the survey. There were only 491 respondents who had tried cocaine by the time of the interview. Of them, 33 said they had not used cocaine in the last year. About 64 percent used it less frequently than weekly, and another 12 percent said they used it weekly. There was no evidence that cocaine use fell with and an increase in cocaine prices. We do not show results.

### Hardcore Cocaine Use

Across the DUF sites, 69 percent of arrestees said they had not used cocaine in the month before the survey. About 15 percent said they had used it on 10 or fewer days that month, and about 16 percent said they had used it more frequently. "Use" is the maximum of days using either powder or crack. Table 23 reports the results of the cumulative logit analysis.

**Table 23**

**Cocaine Use by Arrestees**

Number of Observations: 165859

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| INTERCP1 | 1 | -8.0597 | 0.2920 | 761.7230 | 0.0001 | . |
| INTERCP2 | 1 | -7.0053 | 0.2919 | 576.1247 | 0.0001 | . |
| COCPRCF1 | 1 | -0.5485 | 0.0672 | 66.5957 | 0.0001 | -0.222852 |
| HERPRCF1 | 1 | 0.0554 | 0.0364 | 2.3119 | 0.1284 | 0.034850 |
| MARPRCF1 | 1 | -0.0465 | 0.0383 | 1.4785 | 0.2240 | -0.007880 |
| ALCPRCF | 1 | 0.7770 | 0.1423 | 29.8135 | 0.0001 | 0.066674 |
| ILLEGCAT | 1 | 1.7133 | 0.0141 | 14689.9409 | 0.0001 | 0.360757 |
| INCOME | 1 | -0.0157 | 0.00243 | 41.3967 | 0.0001 | -0.019975 |
| AGE | 1 | 0.3377 | 0.00440 | 5894.7708 | 0.0001 | 1.681459 |
| AGE2 | 1 | -0.00432 | 0.000065 | 4484.9861 | 0.0001 | -1.511839 |
| HIGRADE | 1 | 0.1452 | 0.0114 | 160.8441 | 0.0001 | 0.183639 |
| HIGRADE2 | 1 | -0.00953 | 0.000544 | 307.2459 | 0.0001 | -0.253113 |
| TIME | 1 | -0.0434 | 0.00950 | 20.8286 | 0.0001 | -0.246520 |
| TIME_6 | 1 | 0.00973 | 0.0110 | 0.7767 | 0.3782 | 0.052940 |
| TIME_24 | 1 | 0.0176 | 0.00316 | 31.1161 | 0.0001 | 0.038533 |
| BLACK | 1 | 1.1251 | 0.0718 | 245.1891 | 0.0001 | 0.305462 |
| WHITE | 1 | 0.7442 | 0.0721 | 106.3960 | 0.0001 | 0.167808 |
| HISP | 1 | 0.7620 | 0.0726 | 110.0922 | 0.0001 | 0.164871 |
| MALE | 1 | -0.2393 | 0.0126 | 358.5950 | 0.0001 | -0.058927 |
| ATLANTA | 1 | -0.1466 | 0.0904 | 2.6298 | 0.1049 | -0.017885 |
| CHICAGO | 1 | -0.4589 | 0.1084 | 17.9050 | 0.0001 | -0.051497 |
| CLEVE | 1 | -0.2610 | 0.1379 | 3.5848 | 0.0583 | -0.032938 |
| DALLAS | 1 | -1.1055 | 0.1192 | 85.9550 | 0.0001 | -0.156326 |

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| DC | 1 | -0.9277 | 0.1192 | 60.5571 | 0.0001 | -0.127876 |
| DETROIT | 1 | -0.8419 | 0.0899 | 87.6075 | 0.0001 | -0.097743 |
| HOUSTON | 1 | -0.0276 | 0.0385 | 0.5150 | 0.4730 | -0.003798 |
| LA | 1 | -0.8057 | 0.1413 | 32.4881 | 0.0001 | -0.127240 |
| MIAMI | 1 | -0.7235 | 0.1354 | 28.5522 | 0.0001 | -0.074962 |
| NEWORL | 1 | -0.6711 | 0.1201 | 31.2240 | 0.0001 | -0.092497 |
| NEWYORK | 1 | -0.3987 | 0.1350 | 8.7211 | 0.0031 | -0.055364 |
| PHIL | 1 | -0.6939 | 0.1369 | 25.6741 | 0.0001 | -0.098507 |
| PHOENIX | 1 | -0.6782 | 0.0942 | 51.8481 | 0.0001 | -0.100261 |
| SANANTON | 1 | -0.5277 | 0.0535 | 97.1527 | 0.0001 | -0.070449 |
| SANDIEGO | 1 | -1.3384 | 0.1276 | 110.0615 | 0.0001 | -0.182665 |

coc. Reference site is STLOUIS . k1=6, k2=24

There was a reasonably strong negative relationship between the price of cocaine and its level of use. On the logit scale, and with prices in $100 units, the parameter estimate was –0.5485 (p <0.0001). The implied elasticity (evaluated at the 1998 price of $169) for hardcore users and moderate users was –0.70 and –0.26 respectively. Thus a one percent increase in the price of cocaine reduces the proportion of hardcore cocaine users by 0.70%.

The cross-price elasticity between heroin or marijuana prices and cocaine use appear to be small, but alcohol prices do have a strong effect on cocaine usage. The higher the price of alcohol, the higher the use of cocaine, reinforcing the inference that drug users search for the lowest priced intoxicant.

Regarding the effect of other variables, cocaine use increases and then decreases with age (maximum at 39) and education (maximum at grade 9). Females are heavier users than males. Use is higher for those with illegal income, but tends to decrease with amount of (legal or illegal) income. African-Americans have higher use rates than Whites and Hispanics, who in turn have higher usage rates than "other" races. Use is relatively high in St. Louis and low in San Diego.

## Demand for Heroin

### Initiation of Heroin Use

Following the same estimation procedures applied to marijuana and cocaine, we estimated the time until first use of heroin, separately for White/African Americans and for Hispanic/other. Table 24 provides descriptive statistics. Tables 25 and 26 provide results for White/African-Americans and Hispanic/Other respectively.

Table 24

**Age at First Use of Heroin: Descriptive Statistics**

| Variable | White and Black Mean | White and Black Std Dev | Hispanic and Other Mean | Hispanic and Other Std Dev |
|---|---|---|---|---|
| MALE | 0.4432 | 0.4968 | 0.4667 | 0.4989 |
| BLACK | 0.4366 | 0.4960 | | |
| HISPANIC | | | 0.9021 | 0.2972 |
| CASES | 36680 | | 28307 | |

Table 25

**Age at First Use of Heroin: White and Black Males and Females**

Number of cases 36680

| Parameters | Estimates | Std. err. | Est./s.e. |
|---|---|---|---|
| QCONST | 17.9247 | 4.2815 | 4.187 |
| AGE | -169.9971 | 33.7889 | -5.031 |
| AGE_2 | 468.5139 | 88.4853 | 5.295 |
| AGE_3 | -421.1580 | 76.6851 | -5.492 |
| MALE | 0.3003 | 0.0392 | 7.652 |
| BLACK | -0.0127 | 0.0444 | -0.285 |
| TCONST | 5.3858 | 0.6608 | 8.151 |
| AGE | -11.8134 | 3.2978 | -3.582 |
| AGE_2 | 14.6597 | 4.1173 | 3.561 |
| MALE | -0.0138 | 0.0248 | -0.556 |
| BLACK | 0.0181 | 0.0253 | 0.717 |
| SCONST | 0.1383 | 0.4589 | 0.301 |
| AGE | -7.5464 | 2.3940 | -3.152 |
| AGE_2 | 9.0122 | 3.3401 | 2.698 |
| MALE | 0.0300 | 0.0475 | 0.631 |
| BLACK | -0.0251 | 0.0524 | -0.479 |

## Table 26

**Age at First Use of Heroin: Hispanic and Other Males and Females**

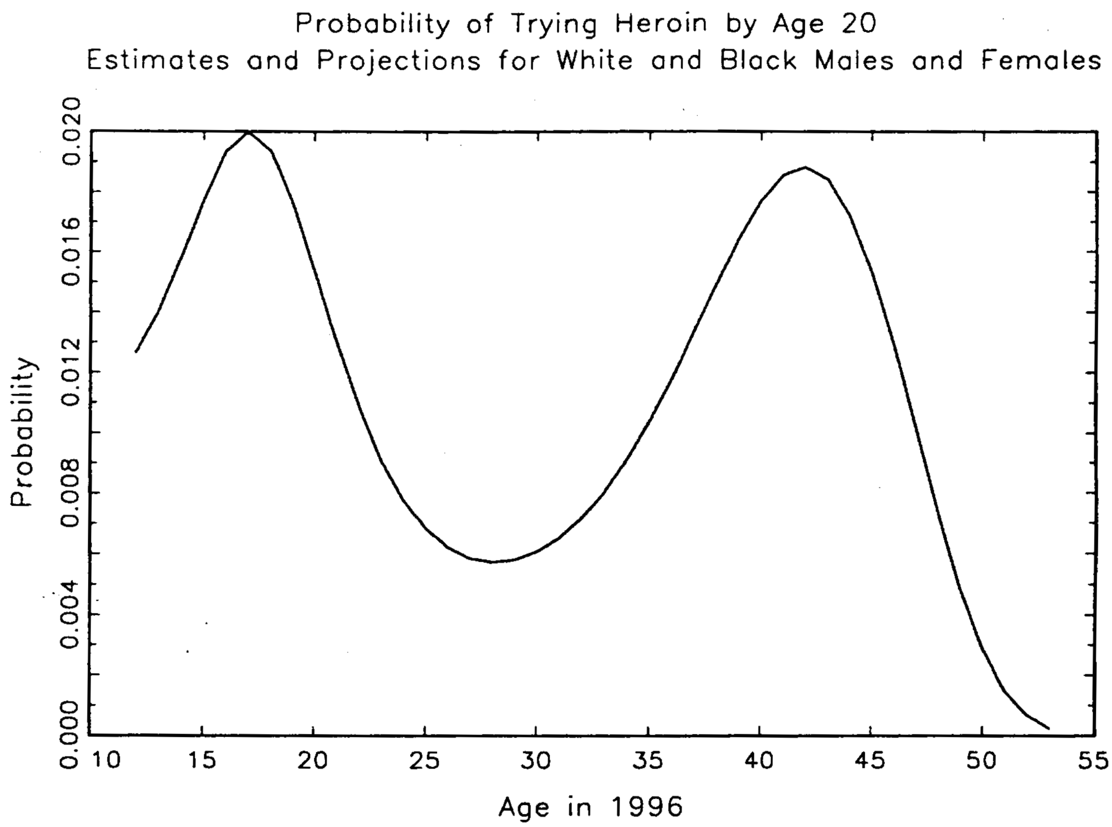
Number of cases 28307

| Parameters | Estimates | Std. err. | Est./s.e |
|---|---|---|---|
| QCONST | 1.9999 | 3.5118 | 0.569 |
| AGE | -41.8954 | 28.5481 | -1.468 |
| AGE_2 | 121.2022 | 77.1892 | 1.570 |
| AGE_3 | -113.6855 | 69.1448 | -1.644 |
| MALE | 0.3891 | 0.0603 | 6.450 |
| HISPANIC | 0.1615 | 0.1198 | 1.348 |
| TCONST | 3.1386 | 0.8122 | 3.864 |
| AGE | -0.3868 | 3.9813 | -0.097 |
| AGE_2 | 0.3666 | 5.1551 | 0.071 |
| MALE | 0.0294 | 0.0568 | 0.518 |
| HISPANIC | -0.0423 | 0.1023 | -0.413 |
| SCONST | -1.5219 | 1.0639 | -1.430 |
| AGE | 1.0094 | 5.4081 | 0.187 |
| AGE_2 | -0.1411 | 7.4656 | -0.019 |
| MALE | -0.1510 | 0.1318 | -1.146 |
| HISPANIC | -0.0827 | 0.2346 | -0.353 |

These regressions are difficult to interpret. For Whites and African-Americans, the risk of trying heroin varies from place to place. The risk is especially high in one place (0.5887), and it is relatively high in others (0.3983; 0.3166). It seems comparatively low in another (-0.7582). Men have a higher initiation rate than females. The cohort effects are difficult to interpret, because they appear at different places in this regression. Furthermore, the parameters associated with the cohort effects have extremely high parameter values, and we suspect they are not reliable. Figure 17 graphs these results.

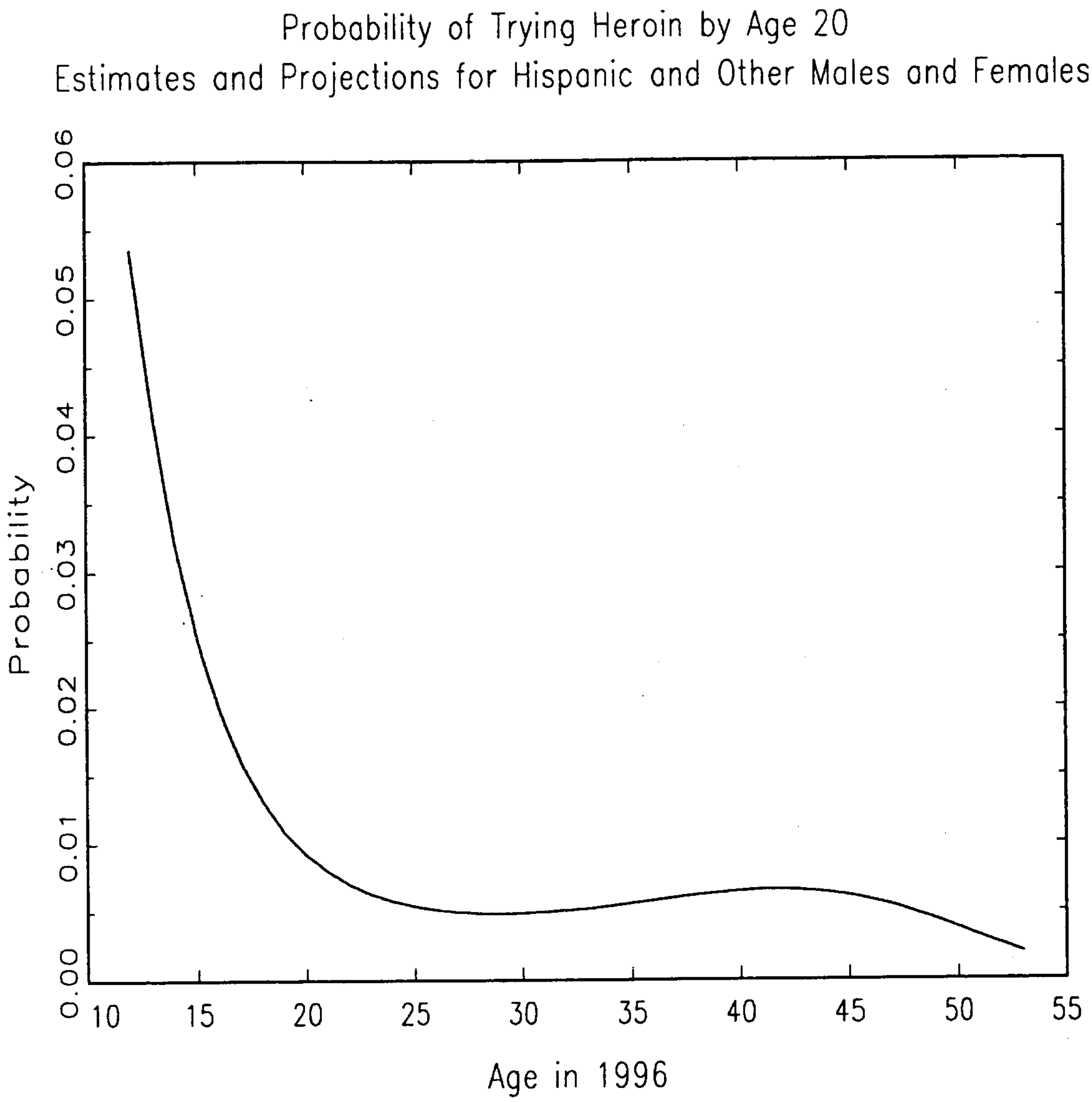
Figure 17 suggests that projected lifetime heroin use was especially high for cohort members who were between 40 and 45 in 1996. They would have been in their late teens and early twenties at the beginning of the 1970s, a time associated with elevated heroin use. The more interesting finding is the apparent elevated risk for more recent cohorts. The apparent reduction in risk for the very youngest cohorts should probably be ignored, because it is based on scant data. Figure 18 summarizes results for Hispanic and other Americans. As before, the youngest members of the Hispanic and other cohorts were at especially high risk of trying heroin. These findings are consistent with results from MTF (The University of Michigan, 1999), which show increased experimentation between 1991 and 1999 among 8th, 10th and 12th graders.

**Figure 17**



Probability of Trying Heroin by Age 20
Estimates and Projections for White and Black Males and Females
Probability
0.000
0.004
0.008
0.012
0.016
0.020
10
15
20
25
30
35
40
45
50
55
Age in 1996

**Figure 18**



Probability of Trying Heroin by Age 20
Estimates and Projections for Hispanic and Other Males and Females
Probability
0.00
0.01
0.02
0.03
0.04
0.05
0.06
10
15
20
25
30
35
40
45
50
55
Age in 1996

So few survey respondents had tried heroin that we decided to combine all respondents to test for whether or not price had an effect on experimentation. Table 27 reports results.

**Table 27**

**First Time Heroin Use as a Function of Heroin Price**

| | | | |
|---|---|---|---|
| Mean log-likelihood | | -0.0744739 | |
| Number of cases | | 50270 | |

| Parameters | Estimates | Std. err. | Est./s.e. |
|---|---|---|---|
| QCONST | -2.6054 | 0.8919 | -2.921 |
| HERPRICE | 0.0501 | 0.0451 | 1.113 |
| MALE | 0.3170 | 0.0453 | 6.994 |
| BLACK | 0.0584 | 0.1166 | 0.501 |
| HISPANIC | -0.2073 | 0.0515 | -4.029 |
| OTHER | -0.3208 | 0.1782 | -1.801 |
| COHORT | 0.6767 | 6.0636 | 0.112 |
| COHORT 2 | 0.7766 | 10.3058 | 0.075 |
| TCONST | 2.5786 | 0.4861 | 5.304 |
| HERPRICE | 0.0590 | 0.0215 | 2.738 |
| MALE | 0.0804 | 0.0297 | 2.701 |
| BLACK | 0.1671 | 0.1078 | 1.550 |

| Parameters | Estimates | Std. err. | Est./s.e. |
|---|---|---|---|
| HISPANIC | -0.0462 | 0.0279 | -1.655 |
| OTHER | 0.0787 | 0.1664 | 0.473 |
| COHORT | 0.8068 | 3.3328 | 0.242 |
| COHORT 2 | -0.1305 | 5.7830 | -0.023 |
| SCONST | -2.2761 | 1.2018 | -1.894 |
| HERPRICE | 0.2265 | 0.0968 | 2.341 |
| MALE | 0.1779 | 0.0991 | 1.796 |
| BLACK | 0.4405 | 0.1780 | 2.475 |
| HISPANIC | -0.0420 | 0.0963 | -0.436 |
| OTHER | 0.3453 | 0.3369 | 1.025 |
| COHORT | -0.1973 | 8.5271 | -0.023 |
| COHORT 2 | 0.1551 | 15.1680 | 0.010 |

As before, price enters this regression in three places. The first time it enters the regression, it affects the probability of ever trying heroin. We expect the parameter estimate to be negative. In fact, it is positive, but not statistically significant. The second time that heroin price enters this regression, it affects the median time until trying heroin. We expect a positive sign, and the result is both consistent (parameter = 0.059) and statistically significant (t = 2.74). The third time that price enters the regression, it affects the variance, increasing it apparently (parameter = 0.44 and t-score = 2.48). This latter effect is difficult to interpret, but overall, these results suggest that experimentation with heroin is lower when heroin prices are higher.

### Continuation of Heroin Use

The NHSDA is not a suitable source for studying current heroin use, because so few people report any heroin use. For example, over 18,000 people answered the NHSDA during 1996. Of those, only 57 said they used heroin during the last year, and 9 percent of those responses were imputed. Consequently, we did not analyze the price elasticity for heroin.

### Hardcore Heroin Use

Across 15 DUF sites, 64 percent of arrestees said they had not used heroin during the month before the interview. Another 24 percent said they had used heroin on 10 or fewer days during that month, and the other 12 percent admitted to using heroin on more than 10 days. Table 28 reports regression results.

Table 28

**Heroin Use by Arrestees**

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| INTERCP1 | 1 | -9.9010 | 0.4927 | 403.8949 | 0.0001 | . |
| INTERCP2 | 1 | -9.4175 | 0.4926 | 365.5633 | 0.0001 | |
| HERPRCF1 | 1 | -0.1148 | 0.0674 | 2.8969 | 0.0887 | -0.072262 |
| COCPRCF1 | 1 | -0.1695 | 0.0955 | 3.1487 | 0.0760 | -0.068879 |
| MARPRCF1 | 1 | -0.0241 | 0.0826 | 0.0848 | 0.7709 | -0.004069 |
| ALCPRCF | 1 | 0.9432 | 0.2618 | 12.9763 | 0.0003 | 0.081152 |
| ILLEGCAT | 1 | 1.6499 | 0.0203 | 6577.1004 | 0.0001 | 0.347946 |
| INCOME | 1 | 0.0194 | 0.00291 | 44.6107 | 0.0001 | 0.024770 |
| AGE | 1 | 0.2928 | 0.00669 | 1916.9503 | 0.0001 | 1.455204 |
| AGE2 | 1 | -0.00325 | 0.000093 | 1215.9925 | 0.0001 | -1.134620 |
| HIGRADE | 1 | 0.2400 | 0.0189 | 161.8334 | 0.0001 | 0.303138 |
| HIGRADE2 | 1 | -0.0136 | 0.000904 | 225.2500 | 0.0001 | -0.360065 |
| TIME | 1 | -0.0587 | 0.00863 | 46.2922 | 0.0001 | -0.333941 |
| TIME_12 | 1 | 0.0500 | 0.0162 | 9.5528 | 0.0020 | 0.231552 |
| TIME_18 | 1 | -0.0141 | 0.00971 | 2.1172 | 0.1457 | -0.048927 |
| BLACK | 1 | 0.0783 | 0.1132 | 0.4783 | 0.4892 | 0.021250 |
| WHITE | 1 | 0.8296 | 0.1130 | 53.9045 | 0.0001 | 0.187132 |
| HISP | 1 | 1.0511 | 0.1135 | 85.7387 | 0.0001 | 0.226999 |
| MALE | 1 | -0.0477 | 0.0206 | 5.3448 | 0.0208 | -0.011748 |
| ATLANTA | 1 | -1.6483 | 0.1502 | 120.4346 | 0.0001 | -0.202075 |
| CHICAGO | 1 | 0.7983 | 0.1465 | 29.6911 | 0.0001 | 0.089380 |
| CLEVE | 1 | -0.6951 | 0.2447 | 8.0720 | 0.0045 | -0.087566 |
| DALLAS | 1 | -1.3007 | 0.1670 | 60.6486 | 0.0001 | -0.184367 |
| DC | 1 | 0.0857 | 0.1631 | 0.2761 | 0.5993 | 0.011824 |
| DETROIT | 1 | -0.2576 | 0.1338 | 3.7079 | 0.0542 | -0.029930 |
| HOUSTON | 1 | -1.0531 | 0.0736 | 204.8596 | 0.0001 | -0.144906 |
| LA | 1 | -0.8826 | 0.1924 | 21.0505 | 0.0001 | -0.139069 |
| MIAMI | 1 | -2.0885 | 0.2003 | 108.7074 | 0.0001 | -0.216259 |
| NEWORL | 1 | -0.2271 | 0.1997 | 1.2926 | 0.2556 | -0.031369 |
| NEWYORK | 1 | 0.0161 | 0.1868 | 0.0074 | 0.9314 | 0.002223 |
| PHIL | 1 | -0.6990 | 0.1926 | 13.1682 | 0.0003 | -0.099070 |
| PHOENIX | 1 | -0.5551 | 0.1320 | 17.6927 | 0.0001 | -0.082593 |
| SANANTON | 1 | -0.1804 | 0.0878 | 4.2267 | 0.0398 | -0.024091 |
| SANDIEGO | 1 | -0.7829 | 0.1727 | 20.5432 | 0.0001 | -0.106370 |

Reference site is STLOUIS . k1=12, k2=18

Although there was a negative relationship between the price of heroin and its level of use, the relationship was relatively weak and not statistically significant. On the logit scale, and with prices in \$1000 units, the parameter estimate was –0.1148 ($p < 0.089$). The implied elasticity (evaluated at the 1998 price of \$1,757) for hardcore users and moderate users was –0.19 and –0.17 respectively. Thus a one percent increase in the price of heroin reduces the proportion of hardcore heroin users by 0.19%.

Heroin use increases and then decreases with age (maximum at 45) and education (maximum at grade 9). Males are heavier users than females. Use is higher for those with illegal income, and tends to increase with amount of (legal or illegal) income. Hispanics and Whites have higher use rates than African-Americans and "other" races. Use is relatively high in Chicago and relatively low in Miami and Atlanta.

## Demand for Methamphetamine

### Hardcore Methamphetamine Use

Across the five DUF sites that entered this analysis, 91 percent of arrestees said they had not used methamphetamines during the months before the interview. (They were actually asked about amphetamines. Those who tested positive for amphetamines on a urine test had confirmation tests for methamphetamines. Most of these were positive for methamphetamines, so treating answers to questions about amphetamines as answers to questions about methamphetamines seems justified.) About 5 percent said they used methamphetamine 10 or fewer times during the month before the interview, and another 4 percent said they used methamphetamines more frequently. Table 29 reports regression results.

**Table 29**

**Methamphetamine Use by Arrestees**

Number of Observations: 55261

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| INTERCP1 | 1 | -5.3349 | 0.7887 | 45.7509 | 0.0001 | . |
| INTERCP2 | 1 | -4.1405 | 0.7884 | 27.5797 | 0.0001 | . |
| MTHPRCF1 | 1 | -1.0741 | 0.1488 | 52.0747 | 0.0001 | -0.237357 |
| COCPRCF1 | 1 | -0.4311 | 0.2868 | 2.2598 | 0.1328 | -0.155980 |
| HERPRCF1 | 1 | 0.1316 | 0.1790 | 0.5404 | 0.4623 | 0.036043 |
| MARPRCF1 | 1 | 0.2069 | 0.2023 | 1.0465 | 0.3063 | 0.034366 |
| ALCPRCF | 1 | 1.1484 | 0.4285 | 7.1830 | 0.0074 | 0.099806 |
| ILLEGCAT | 1 | 1.1879 | 0.0388 | 935.9048 | 0.0001 | 0.255498 |
| INCOME | 1 | -0.00367 | 0.00585 | 0.3937 | 0.5304 | -0.004849 |
| AGE | 1 | 0.1151 | 0.0139 | 68.6459 | 0.0001 | 0.566565 |
| AGE2 | 1 | -0.00200 | 0.000212 | 88.6917 | 0.0001 | -0.693519 |
| HIGRADE | 1 | 0.3189 | 0.0384 | 68.9189 | 0.0001 | 0.412622 |

| Variable | DF | Parameter Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Square | Standardized Estimate |
|---|---|---|---|---|---|---|
| HIGRADE2 | 1 | -0.0159 | 0.00176 | 82.3971 | 0.0001 | -0.435557 |
| TIME | 1 | -0.1148 | 0.0198 | 33.4936 | 0.0001 | -0.674829 |
| TIME_12 | 1 | 0.2682 | 0.0437 | 37.6387 | 0.0001 | 1.245017 |
| TIME_18 | 1 | -0.1752 | 0.0250 | 49.2536 | 0.0001 | -0.604632 |
| BLACK | 1 | -1.3199 | 0.1073 | 151.2339 | 0.0001 | -0.352940 |
| WHITE | 1 | 0.8815 | 0.0953 | 85.6260 | 0.0001 | 0.229919 |
| HISP | 1 | -0.3693 | 0.1000 | 13.6401 | 0.0002 | -0.089901 |
| MALE | 1 | 0.2498 | 0.0363 | 47.3908 | 0.0001 | 0.063952 |
| DALLAS | 1 | -2.3576 | 0.1739 | 183.8451 | 0.0001 | -0.524104 |
| PHIL | 1 | -3.8931 | 0.2684 | 210.4675 | 0.0001 | -0.863042 |
| PHOENIX | 1 | -0.7038 | 0.1698 | 17.1805 | 0.0001 | -0.162108 |
| SANANTON | 1 | -2.4651 | 0.4813 | 26.2299 | 0.0001 | -0.523424 |

Reference site is SANDIEGO. k1=12, k2=18

There was a strong negative relationship between the price of methamphetamine and its level of use. On the logit scale, and with prices in $100 units, the parameter estimate was –1.0741 ($p < 0.0001$). The implied elasticity (evaluated at the 1998 price of $140) for hardcore users and moderate users was –1.48 and –1.42 respectively. Thus a one percent increase in the price of methamphetamine reduces the proportion of hardcore methamphetamine users by 1.48%.

Methamphetamine use increases and then decreases with age (maximum at 29) and education (maximum at grade 10). Males are heavier users than females. Use is higher for those with illegal income, but is unrelated to amount of (legal or illegal) income. Whites have the highest use rates and African-Americans have the lowest rates. Use is relatively high in San Diego and relatively low in Dallas and San Antonio.

# Chapter 5 Projecting Future Drug Use

## Marijuana

### The Household Population

Earlier, this paper discussed targets set by the Office of National Drug Control Policy for reducing drug use by the year 2002 and 2007. One objective of this study is to assess whether or not those targets are obtainable, or put more narrowly, whether or not they could be obtained by increasing the price of illicit drugs.

To answer that question, we simulated drug use in the years 2002 and 2007 using two scenarios. In the first scenario, drug prices remained at their 1996 levels through 2007. In the second, drug prices doubled linearly through 2007. Presuming people are responsive to increasing drug prices, this doubling should result in fewer users and a lower level of use for those who persist. The size of those reductions is based on the statistical analysis reported earlier. Specifically, projections of future drug use take into account the following:

- current trends based on different initiation rates across cohorts;
- the aging of the drug using populations, notably the fact that people use drugs at a lower frequency as they age, and;
- simulated increases in drug prices.

To determine the composition of the population in 2002 and 2007, the analysis started with all respondents who answered the 1994, 1995 and 1996 NHSDA. The simulation assigned each respondent to a cohort. For example, respondents who were twenty in 1996, nineteen in 1995 and eighteen in 1994 were assigned to the twenty-year-old cohort. In general, all respondents who were age T in 1996, T-1 in 1995 and T-2 in 1994 were assigned to the age T cohort. Call the data combined across these three years the "baseline data."

Then, to simulate future cohorts, we "aged" the baseline data. For example, respondents who were members of the age T cohort in 1996 were considered to be members of the age T-1 cohort in 1997, the age T-2 cohort in 1998, and so on until 2007 when they were considered to be members of the age T-11 cohort. In essence, we changed three important variables in the baseline data – cohort membership, the respondent's age, and drug prices – to mimic how drug use would change as trends (reflected in the cohort effect and aging) and drug prices changed.

For example, consider the cohort that was age twenty in 1996. We let members of that cohort represent people who were twenty in 1997 as well, but in 1997 we treated them as members of the nineteen-year-old cohort. (Remember that a cohort was always identified by its members' age in 1996.) Then in 1998, we again let them be twenty, but we treated them as members of the eighteen-year-old cohort.

This approach has important limitations. It treats the race/ethnicity and geographic distribution of the population as fixed at the distribution observed in 1996. This seems like a minor limitation, however, given the objective of simulating the effect that future prices might have on drug use. A further limitation is that the estimates are limited to people who were between twelve and fifty. This, too, seems like a minor limitation because illicit drug use is infrequent among household members older than fifty.

Figure 19 reports the actual (until 1996) and projected (after 1996) drug use in three categories: ever used marijuana, used marijuana less than weekly during the last year, and used marijuana at least weekly during the last year. These are reported as logarithms so they would fit on the same scale. Up to 1996, the curves are based on tabulations of NHSDA data. After 1996, each of the three curves branches into two parts. The heavier part is a projection that assumes that drug prices will stay at their 1996 levels. The price-sensitive projections, shown as fine dots, assume that marijuana prices will double between 1996 and 2007. Price change less than a double are proportional and not shown here.

The first thing to note is that the proportion of people who say they have tried marijuana will not change much between 1996 and 2007. This is not surprising, because most people have already passed the age at which they are at risk of trying marijuana; new users are just replacing old ones in the database. The more interesting finding is that marijuana use will fall over time even if marijuana prices remain constant. This seems reasonable. Cohorts who were around the age of 30 in 1996 have the highest lifetime risk of trying marijuana. But this is an aging group and marijuana use decreases with age, so the prevalence of marijuana use is expected to fall.

The next figure shows projections for weekly users and occasional users. These projections are the same as were shown in Figure 20, but the scale is a natural unit instead of a logarithm. The proportion of the population projected to use marijuana falls even when marijuana prices remain constant. The principal reason is that the population who were at the highest risk of using marijuana at any level – the age thirty cohort – have aged. Many of them will have stopped using drugs and others will have restricted their use to levels that are lower than their use levels when they were younger.

Increasing the price of marijuana reduces the use level still further, for two reasons. The first is that higher prices cause lower initiation rates, and the second is that higher prices result in less use. Of course, the real question is whether or not the Government has the means to double marijuana prices. Earlier we speculated that peak marijuana prices were achieved in the early 1990s because the Government was successful at restricting foreign marijuana from entering the United States. The high prices engendered by that success seems to have promoted a resurgence of domestic production, especially hydroponic growing, and other comparatively expensive means of producing marijuana. It remains to be seem whether or not the Government can reduce domestic cultivation to a level that would once again result in historically high marijuana prices. Almost certainly, if this is to be achieved, it will require advances in detection technology, because expansion of traditional law enforcement has yet to show that it can reverse this price decline.

## Figure 19

Actual and Predicted Trends in Ever Use, Moderate Use and Heavy Use Marijuana with Future Prices Doubling over Time

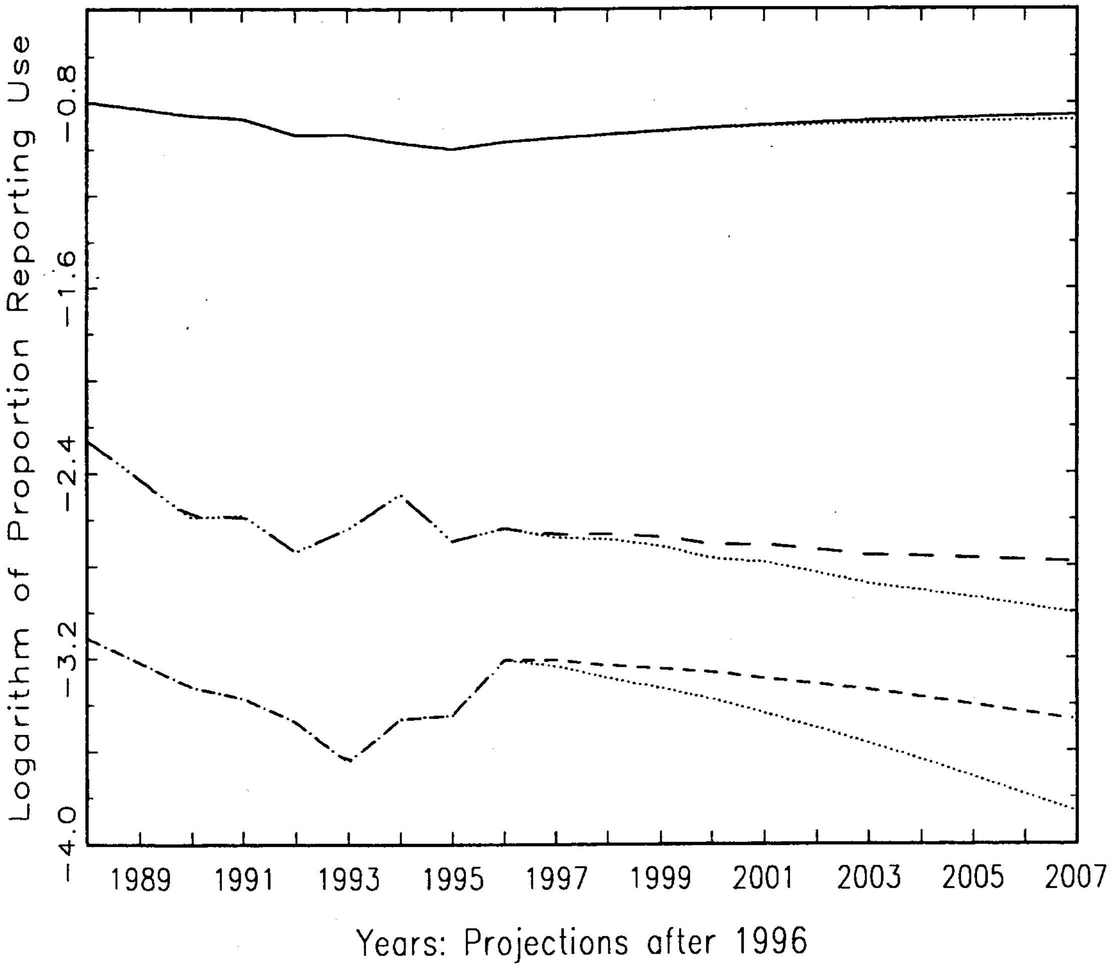
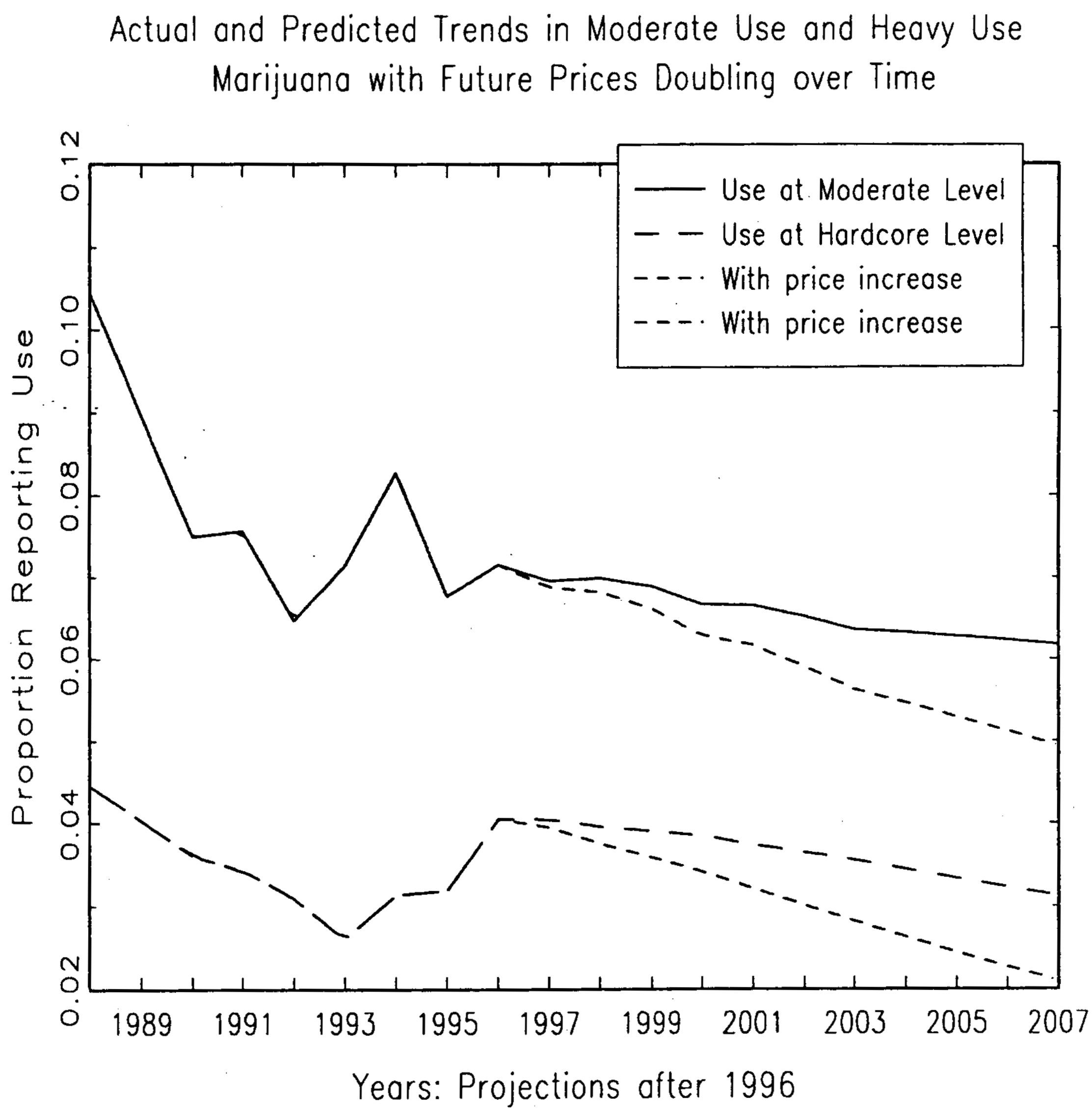


**Figure 20**



Actual and Predicted Trends in Moderate Use and Heavy Use
Marijuana with Future Prices Doubling over Time
Use at Moderate Level
Use at Hardcore Level
With price increase
With price increase
Proportion Reporting Use
0.02
0.04
0.06
0.08
0.10
0.12
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Years: Projections after 1996

## The Arrestee Population

We also simulated the proportion of arrestees who would be heavy (more than 10 days per month) and occasional (10 or fewer days per month) users of marijuana in the years 2002 and 2007. Figures 21, 22 and 23 summarize the projections.

Figure 21 shows the actual, estimated, and projected percentage of arrestees who say they used marijuana in the month before the survey. Hardcore users are those arrestees who used marijuana on more than ten days during the month before their arrests. The category "moderate or hardcore" comprises arrestees who said they used marijuana any time during the month before the month before their arrests. The small circles represent the percentage of arrestees who said they used marijuana.

The solid lines represent the estimated percentage who said they used marijuana before 1998 and the projected percentage who would say they used marijuana after 1998. In both cases, the estimates and projections set all variables except time, drug prices and age to their mean levels, so the estimates were somewhat better than implied by this figure. Still, the trend shown by these estimates is a good reflection of marijuana use among arrestees. These projections assume that future prices would be the same as current prices.

The second figure shows the same estimates as predictions for hardcore marijuana users along with some additional information. Figure 22 has a left-hand axis that reports the percentage of arrestees who admitted to heavy marijuana use and a right-hand axis that reports the price of marijuana in 1996 dollars. The curve toward the top of the figure is the estimated national price of marijuana. It increase slightly, shows a large increase in the early 1990s, and then decreases. The price projection is just the estimated 1996 price.

As before, the circles are the weighted observed percentage of arrestees who said they used marijuana on more than 10 days during the month before their interview. The weights are the number of arrests in the county. The curve that approximates the circles is the estimated percentage of arrestees who said they used on 10 or more days. That prediction comes from setting all variables except prices, age, and time to their mean values. These latter variables were set to the values estimated and predicted (price and age) or observed (time) during the quarter. Of course, the estimates and predictions were based on the regression results reported earlier.

The figure shows that the use of marijuana generally increases as marijuana prices fall and decreases as marijuana prices increase. The relationship between prices and predicted use is not exact, partly because factors other than the price of marijuana are changing (other drug prices and age). Nevertheless, the relationship between marijuana prices and use is apparent.

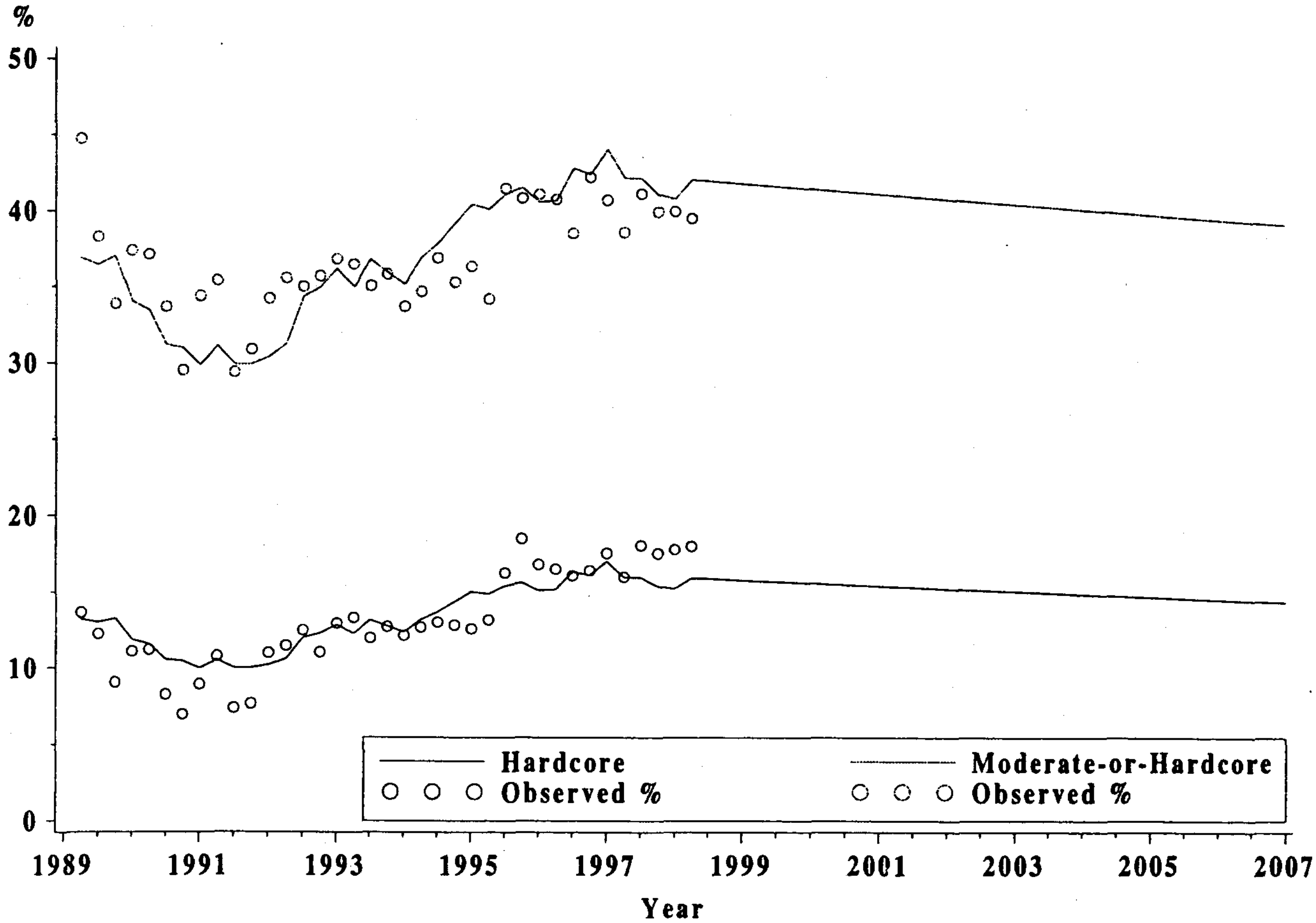
The three lines that diverge after 1996 are projections. One projection, based on "modeled price," purports to show what would happen to marijuana use if all price variables follow recent trends. We discount this representation heavily, because projecting recent trends for any extended period is tenuous. More believable is the second projection, which is based on an assumption that all drug prices would stay at their 1998 level. The third projection results from doubling all illicit drug prices – marijuana, cocaine and heroin prices. The resulting reduction in marijuana use is dramatic.

Figure 23 is similar to the previous figure except this new figure does not show prices and the projections are based on three scenarios. In the first, all drug prices are fixed at their 1998 levels, and marijuana use decreases modestly. In the second scenario, marijuana prices are doubled while all other prices are held constant. Heavy marijuana use falls from near 15 percent to somewhat over 10 percent of arrestees. The third scenario doubles all prices, and as a result, marijuana use falls to under 5 percent of all arrestees.

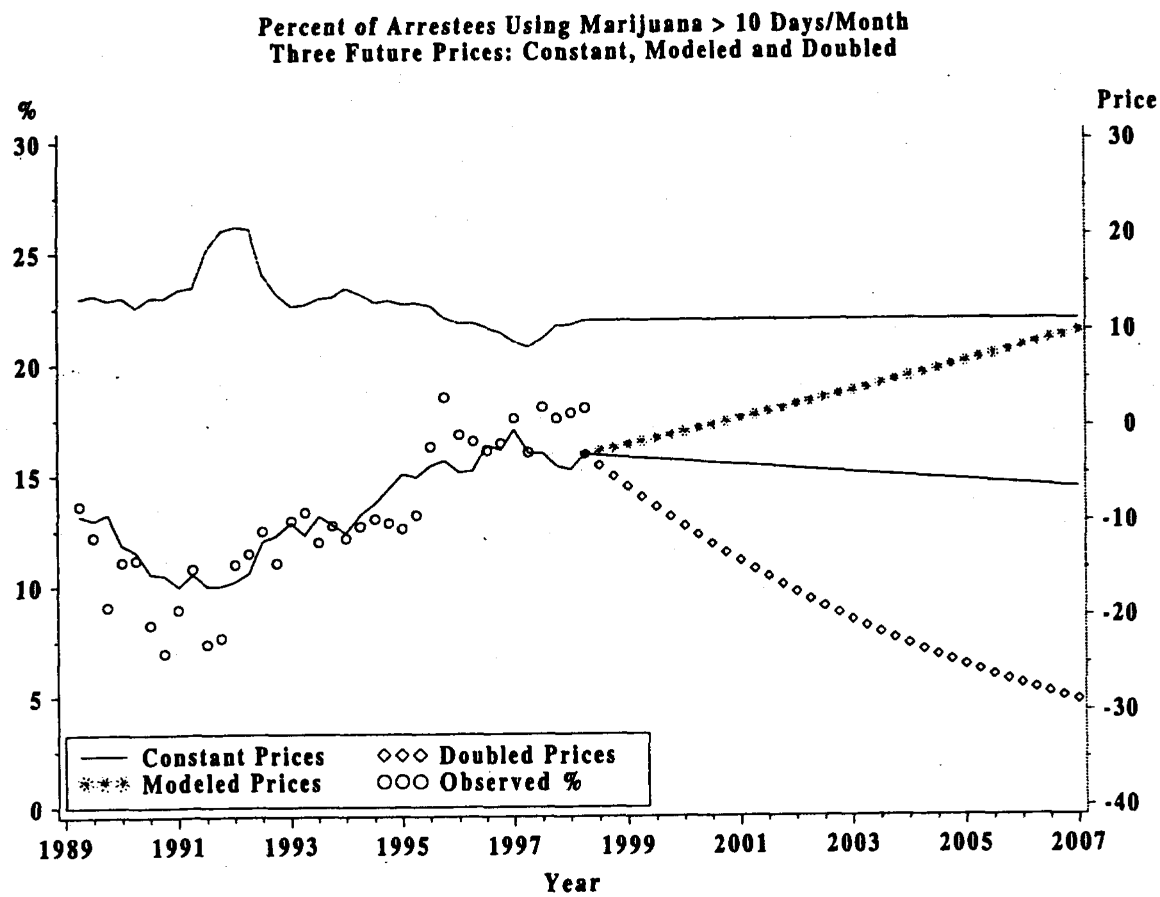
These results imply that a successful supply-side program that increases all illicit drug prices could have an appreciably effect on reducing marijuana use among arrestees. That is good new and reinforces findings about drug use among household members. The bad news is that prices would have to be changed by amounts that go well beyond what supply-size policy has been able to achieve recently.

**Figure 21**

**Percent of Arrestees Using Marijuana**
**Hardcore and Moderate-or-Hardcore Users**

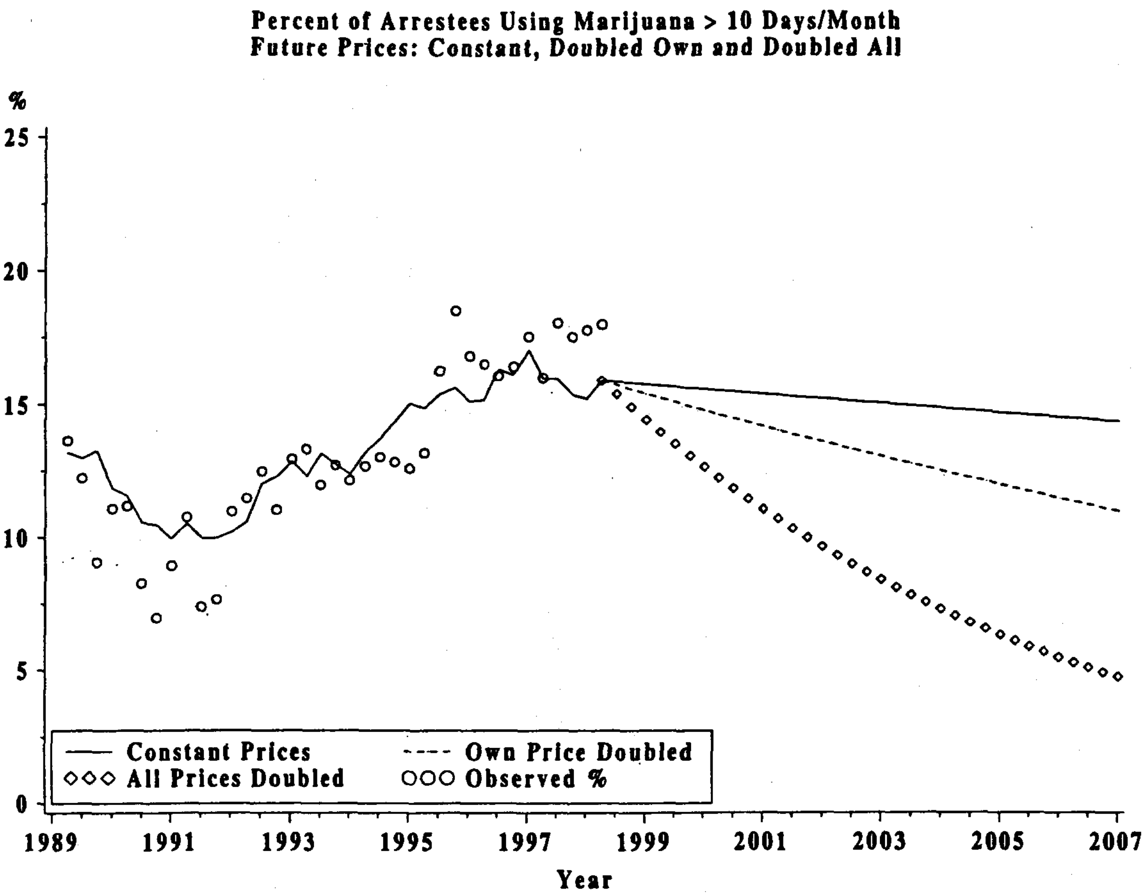


## Figure 22



Percent of Arrestees Using Marijuana > 10 Days/Month
Three Future Prices: Constant, Modeled and Doubled
%
Price
30
25
20
15
10
5
0
30
20
10
0
-10
-20
-30
-40
Constant Prices
Modeled Prices
Doubled Prices
Observed %
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year

## Figure 23



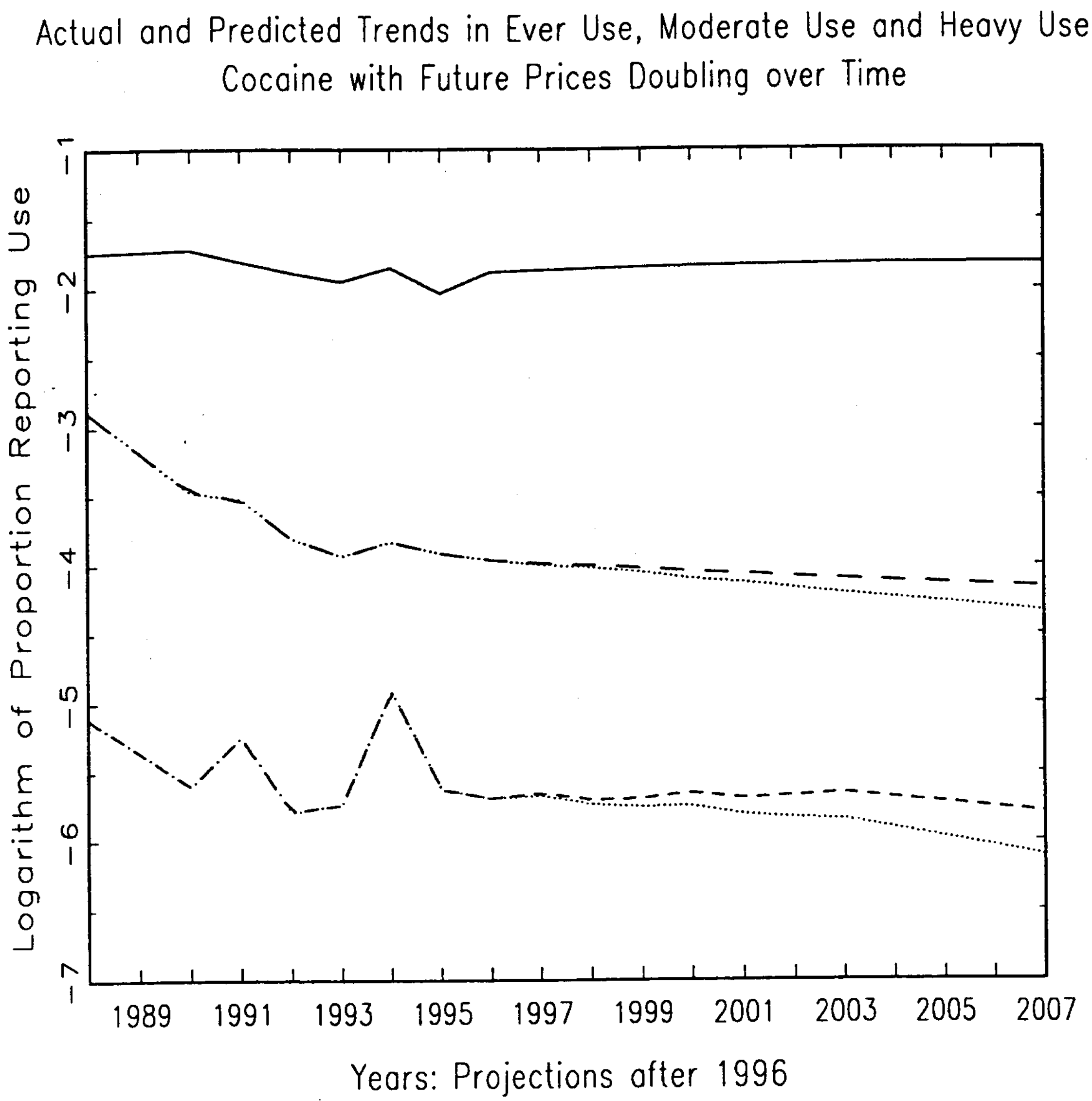

# Cocaine

### The Household Population

Figures 19 and 20 provided projections of future marijuana use by household members. Figures 24 and 25 are counterparts for cocaine. The curve toward the top of Figure 24 is the projection for lifetime use. As was true of its marijuana counterparts, the trend is projected to stay relatively flat through 2007. The reason is that people cannot reverse earlier experimentation with cocaine, so this statistic changes very slowly over time, despite any recent increase in initiation rates.

Cocaine use is projected to decrease slightly over time, but those trends are easier to see in Figure 25, which reports trends in natural rather than logarithmic units. The trend toward lower cocaine use is modest. It is accelerated by doubling cocaine prices, but even then, the projected decrease in cocaine use does not come close to the National targets. Furthermore, cocaine prices have fallen, with some short-term perturbations, since 1988. It is difficult to find evidence that the Nation could achieve a doubling of cocaine prices by the year 2007 absent some favorable technological developments in eradication and interdiction. We do not see how supply-based programs alone could help the Nation meet its 2002 and 2007 targets.

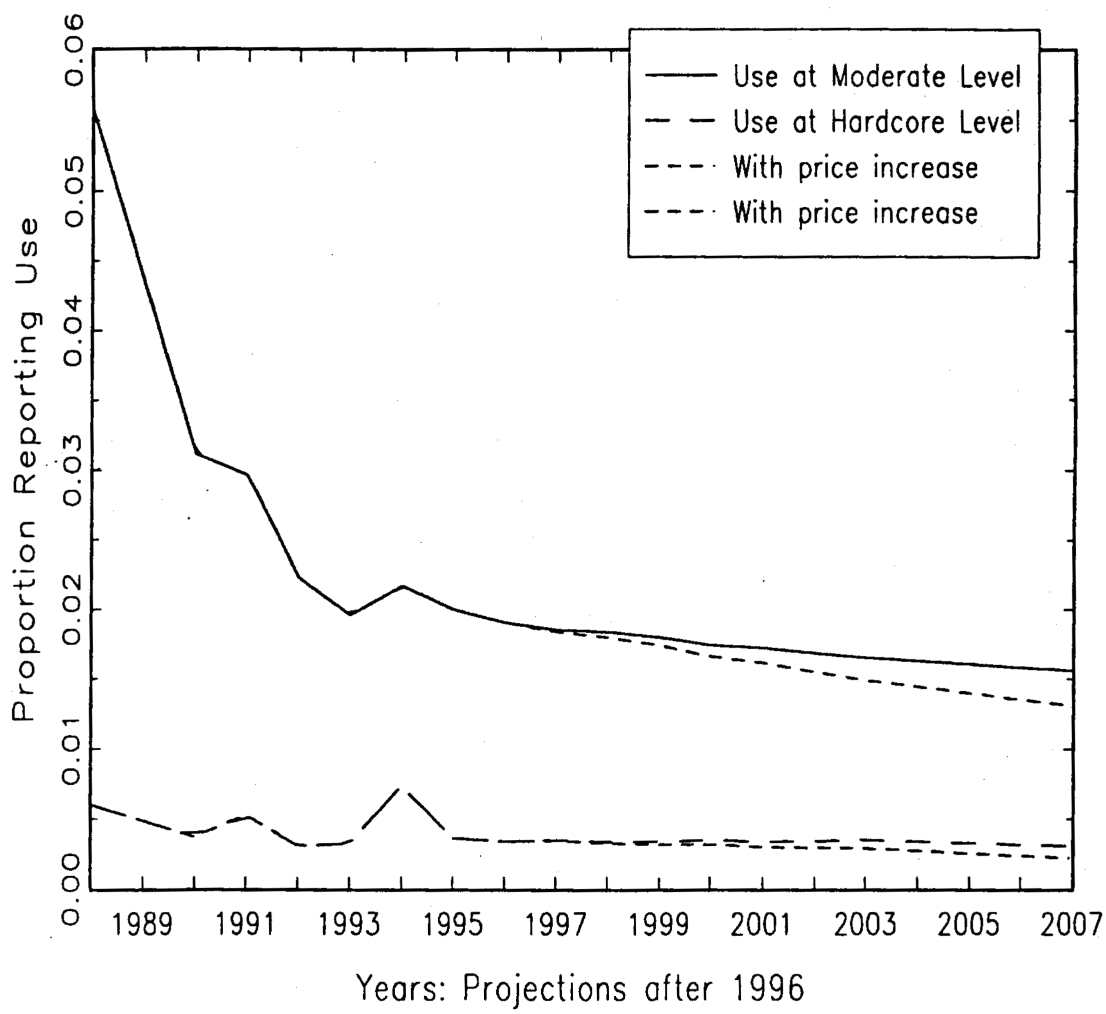
**Figure 24**



Actual and Predicted Trends in Ever Use, Moderate Use and Heavy Use
Cocaine with Future Prices Doubling over Time
Logarithm of Proportion Reporting Use
-1
-2
-3
-4
-5
-6
-7
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Years: Projections after 1996

**Figure 25**

Actual and Predicted Trends in Moderate Use and Heavy Use Cocaine with Future Prices Doubling over Time




**The Arrestee Population**

Results of simulated future cocaine use by arrestees are reported in Figures 26 through 28. These figures have the same structure as their cocaine counterparts, so we will focus on the substance of those figures.

Figure 26 shows trends in the proportion of arrestees who said they used cocaine during the month before the survey. The higher curve reports any cocaine use; the lower curve reports hardcore cocaine use. As before, the regressions seem to do a tolerably good job of fitting the observed data. These estimates and projections suggest that cocaine use has been falling over time and, if those trends persist, will continue to fall into the future. Apparently this will happen because fewer and fewer Americans are becoming cocaine users and those who are heavy users are aging out of their addictions. The target for reduced hardcore drug use would be achieved partly without changing cocaine prices.

## Figure 26

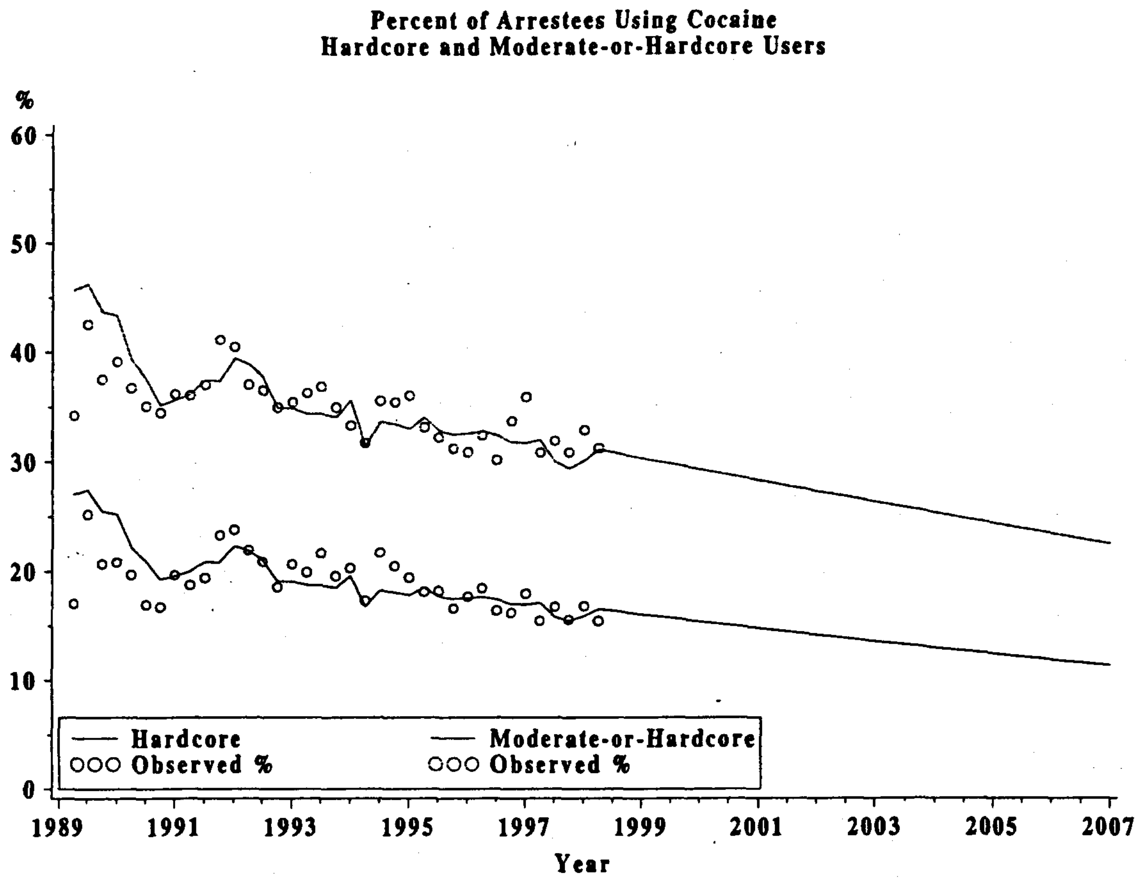
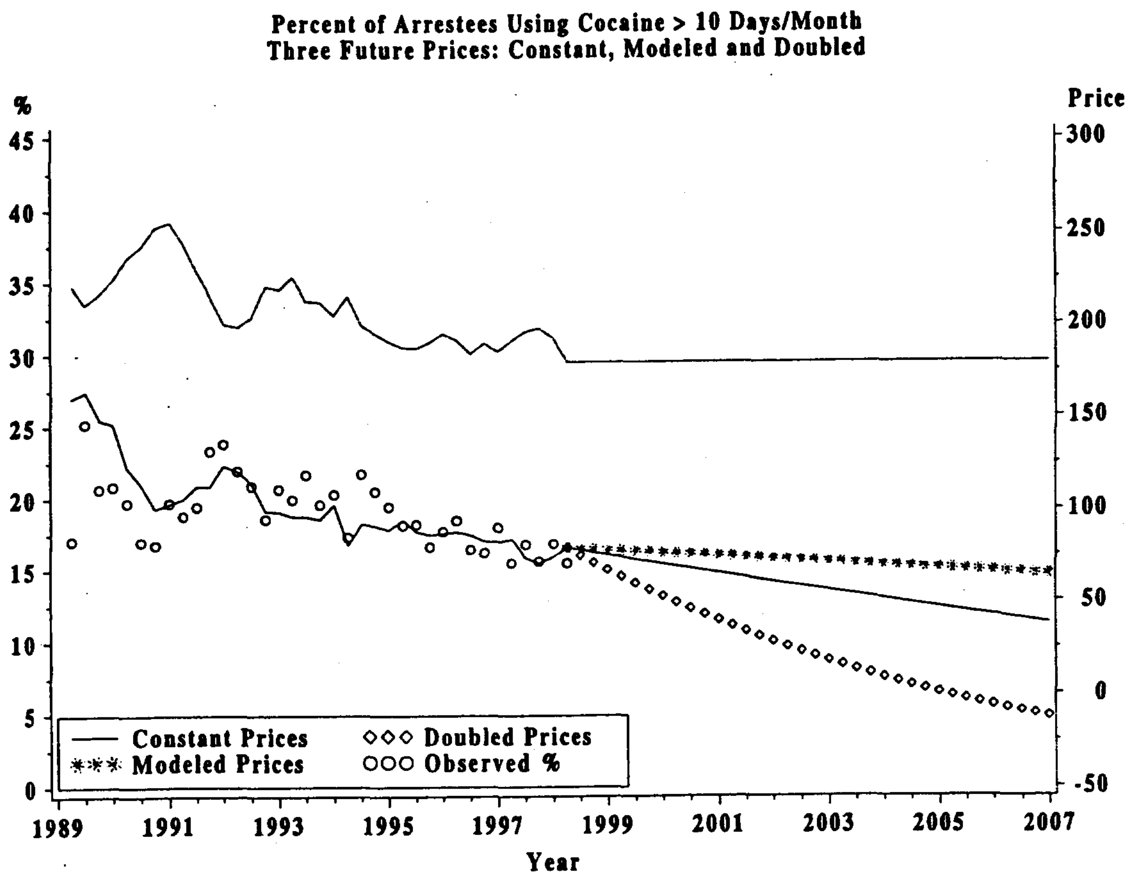



Figure 27 projects what would happen if drug prices were increased. The first curve, labeled modeled prices, projects what would happen if current trends in drug prices persisted into the future. As before, we discount this curve, because drug prices are so difficult to predict. The second curve – already shown in the previous figures – projects what would happen if prices remained at their 1998 levels. The final curve projects what would happen if all drug prices were doubled.

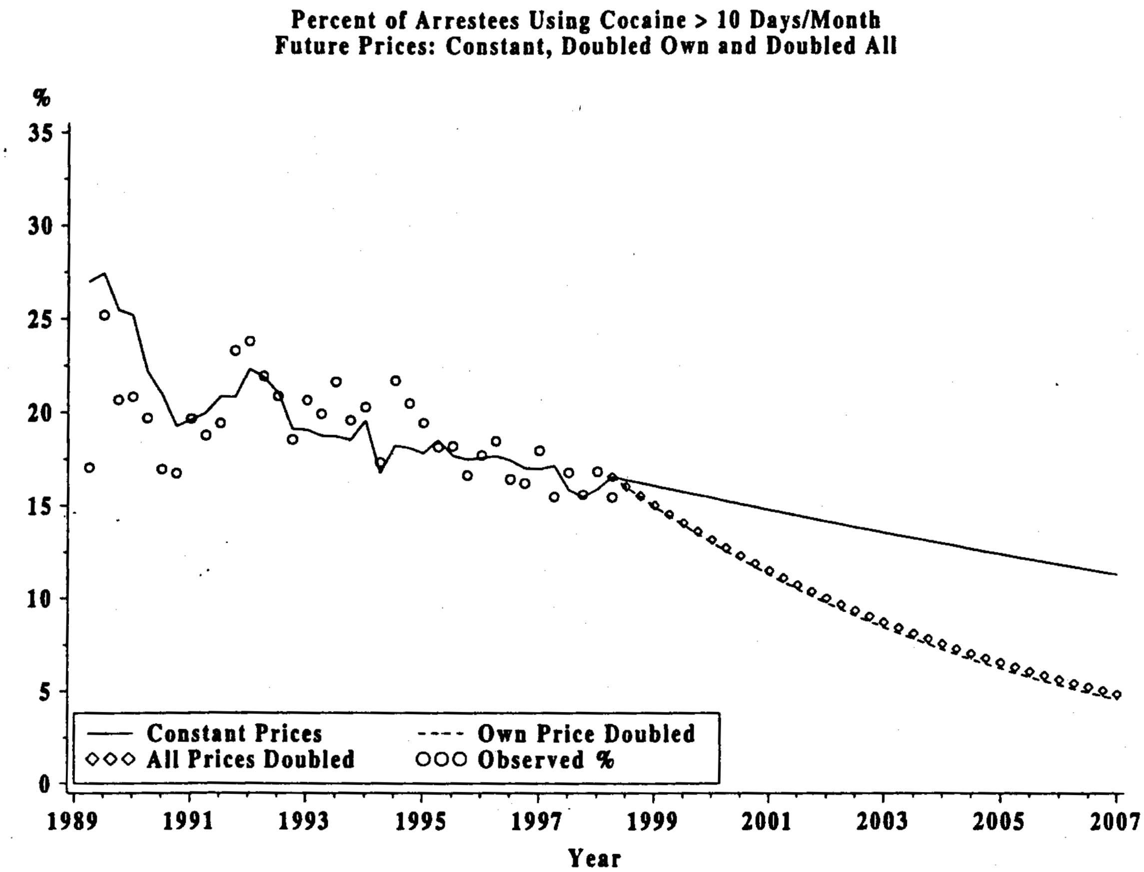
There is good news here. If drug prices were to be doubled, then hardcore drug use would fall considerably. Figure 28 breaks that fall into two parts. One curve projects what would happen if just cocaine prices doubled, and the other curve projects what would happen if all drug prices doubled. Apparently, the price of cocaine is the principal factor that drives future drug use. Given that the Nation has exercised so little control over cocaine prices, we are skeptical that trends in hardcore cocaine use among arrestees would fall by much more than is projected based on the assumption that cocaine prices will remain about the same as they are now.

## Figure 27



Percent of Arrestees Using Cocaine > 10 Days/Month
Three Future Prices: Constant, Modeled and Doubled
%
Price
45
40
35
30
25
20
15
10
5
0
300
250
200
150
100
50
0
-50
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year
Constant Prices
Modeled Prices
Doubled Prices
Observed %

## Figure 28




# Heroin

### The Arrestee Population

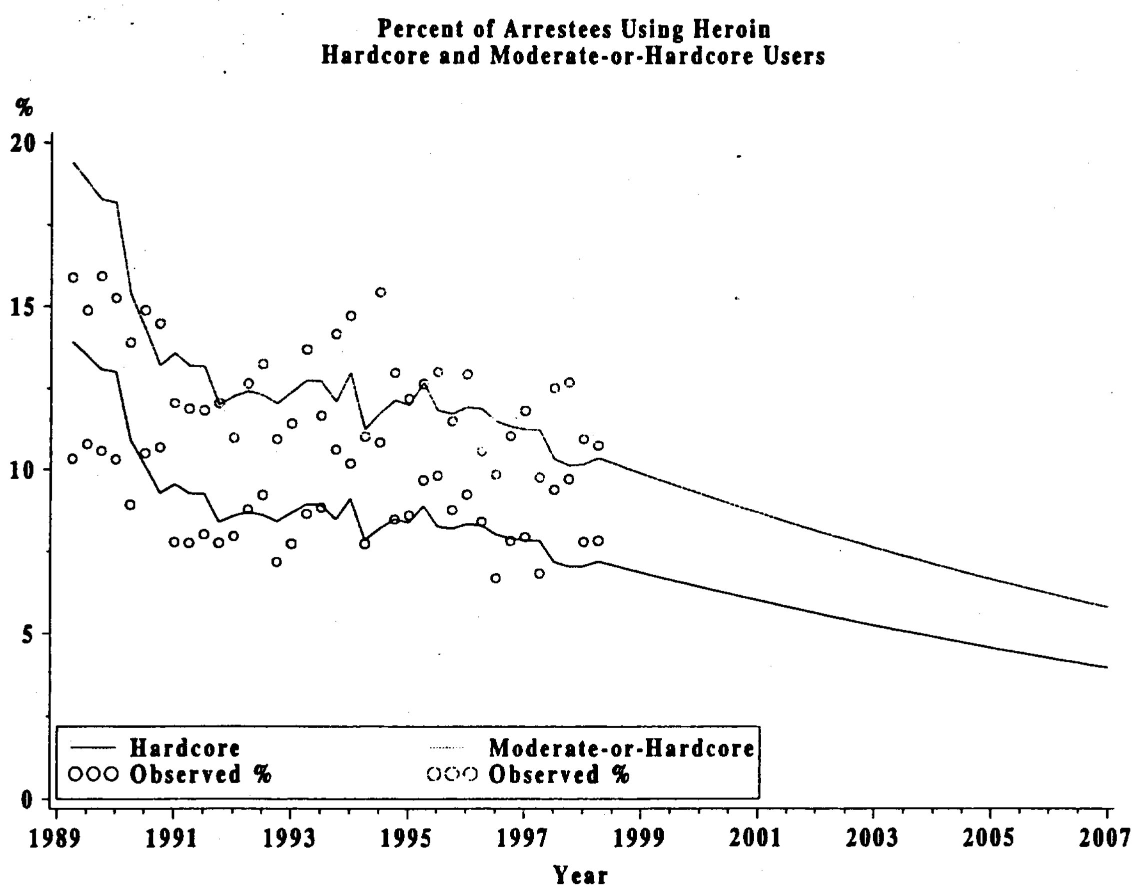
Estimated and projected trends in heroin use appear in Figures 29 through 31. As before, the small circles represent observed percentages and the lines represent estimates and projections. The trends imply reduced heroin use among arrestees in the future. This may not be an unreasonable inference because many heroin users, who became addicted during epidemics that predate the cocaine epidemic, are aging out of addictions.

Nevertheless, there is reason for caution. For example, the DUF data may not yet show the effect of increased heroin use during the late 1990s that resulted from less expensive, higher purity heroin. A cohort of new users, not represented in these trends, may be among future arrestees.

Figure 30 shows the price of heroin as well as trends and projections in the percentage of arrestees who are hardcore users. It is difficult to see a strong pattern between heroin prices and heroin usage. This may be because heroin prices did not seem to have even the episodic, transient price spikes that are characteristics of cocaine prices. Whatever price perturbations happened in the heroin prices series may have been too brief or too small to have had an appreciable effect on the use of heroin. That reasoning is consistent with the findings that the parameter associated with heroin prices was only marginally significant (p = .089) in the heroin regressions.

Figure 31shows that doubling the price of heroin would reduce heroin use. Still, the size of the effect is considerably smaller than was observed for the demand for cocaine and the demand for marijuana. Given that heroin prices have generally decreased throughout the 1990s, it is difficult to see how public policy could possibly achieve the projected results that assume a doubling of heroin prices.

**Figure 29**



## Figure 30

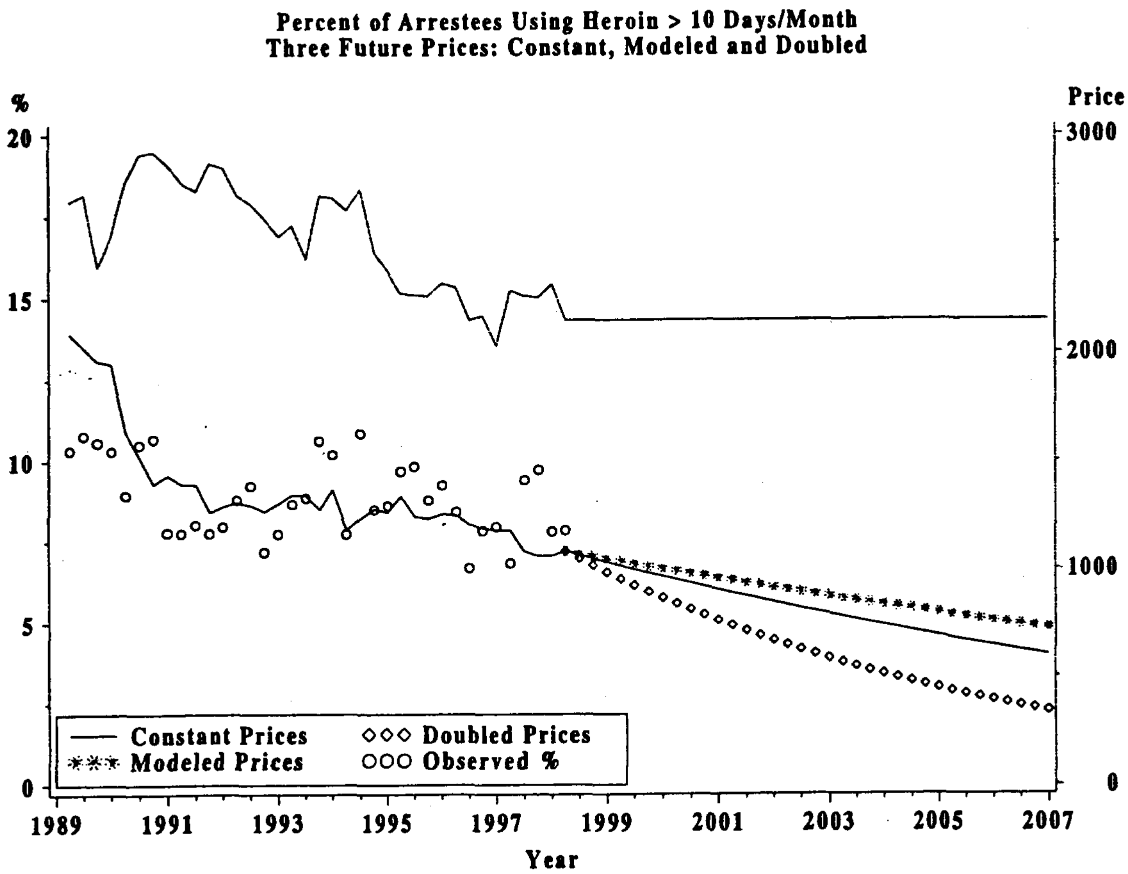
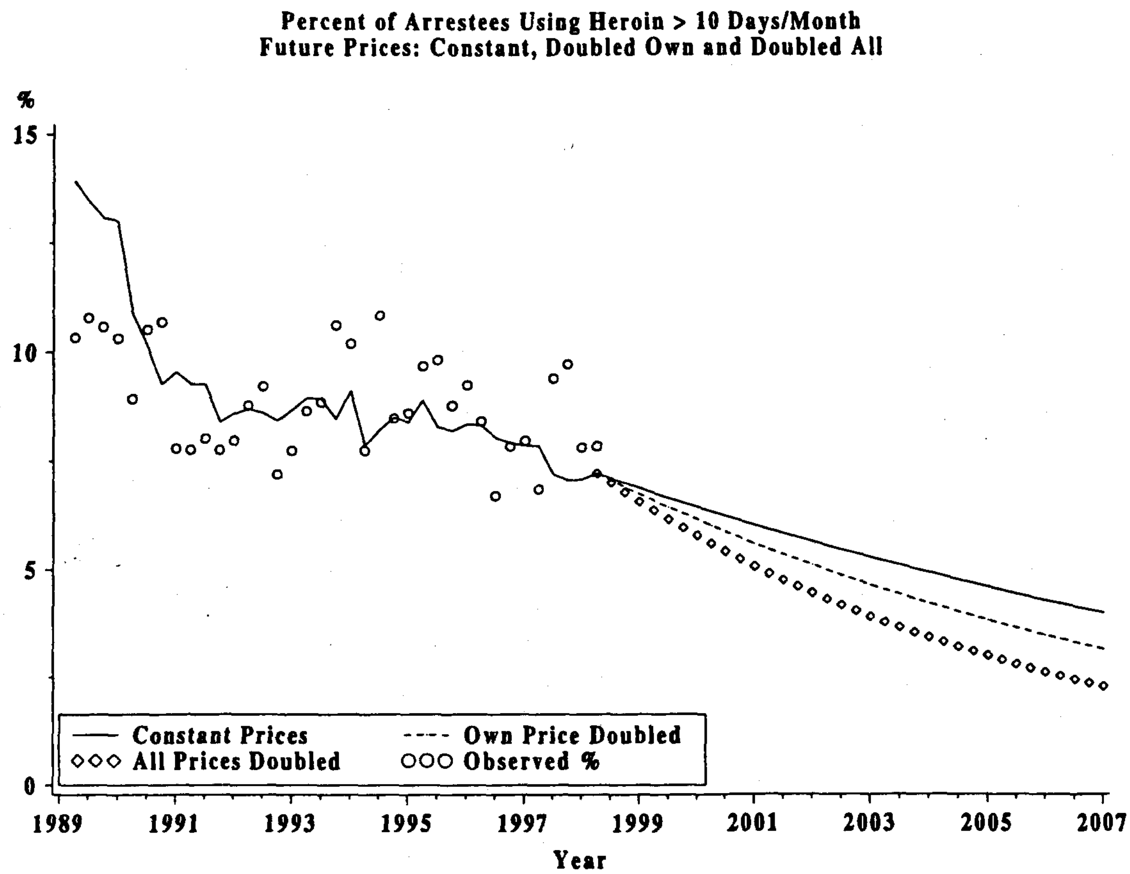

Percent of Arrestees Using Heroin > 10 Days/Month
Three Future Prices: Constant, Modeled and Doubled
%
Price
20
15
10
5
0
3000
2000
1000
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year
Constant Prices
Modeled Prices
Doubled Prices
Observed %

**Figure 31**




## Methamphetamine

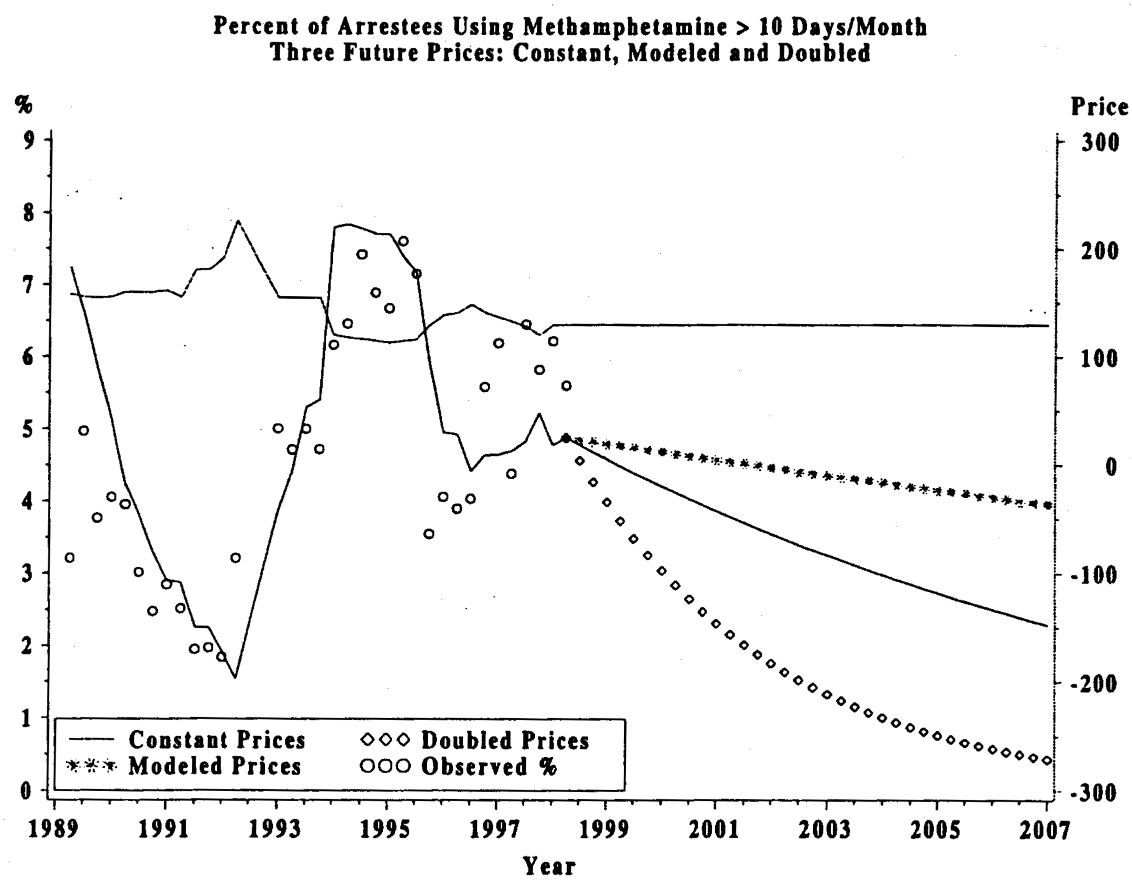
### The Arrestee Population

Figure 32 shows observed and modeled trends in reported methamphetamine use. The proportion of arrestees saying they used methamphetamine decreased from 1989 to the middle of 1991, increase from the middle of 1991 until the beginning of 1995, and thereafter decreased. Deriving trends from such cyclical data is precarious and uncertain, so we probably should not put too much weight on projections of decreased methamphetamine use based on recent projections.

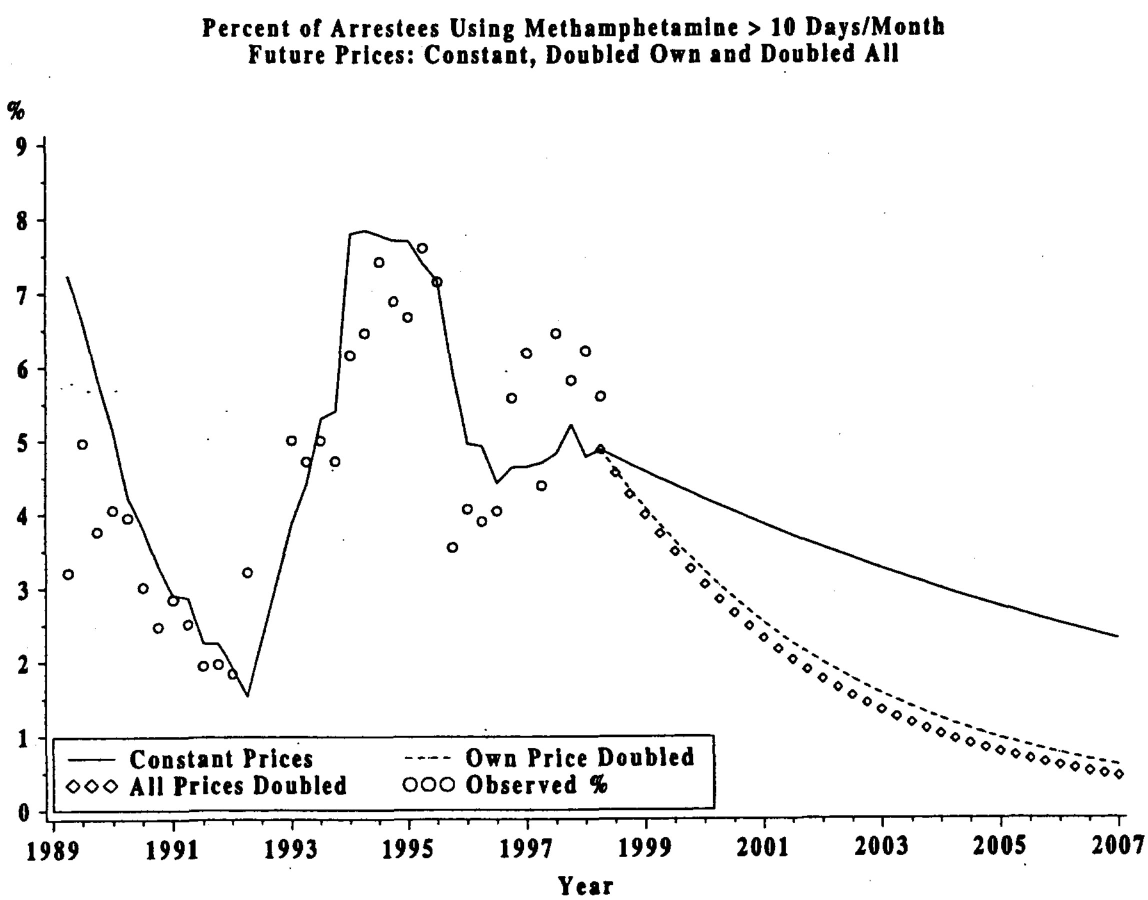
Figure 34 shows that changes in the level of self-reports of methamphetamine use have run parallel to changes in methamphetamine prices. The relatively low level of self-reports during the early 1990s corresponded to a temporal peak in methamphetamine prices. Then when prices started to fall in 1992, self-reports of methamphetamine use increased. That increase abated and reversed as methamphetamine prices leveled and increased. Except for the late 1990s, the regressions do a tolerable job of fitting these data. Unfortunately, our inability to fit the last few quarters of data cast additional doubt on the projections which, of course, depend heavily on those last few observations.

Although we are uncertain about the projections when prices remain the same, the findings suggest strongly that methamphetamine use is sensitive to prices, so we think it is reasonable to project that methamphetamine use would be much lower if prices could be increased than if they remained at current levels. This is reflected in Figure 32 and Figure 33. Note especially that methamphetamine use is sensitive to the price of methamphetamine and not to the price of other drugs.

## Figure 32

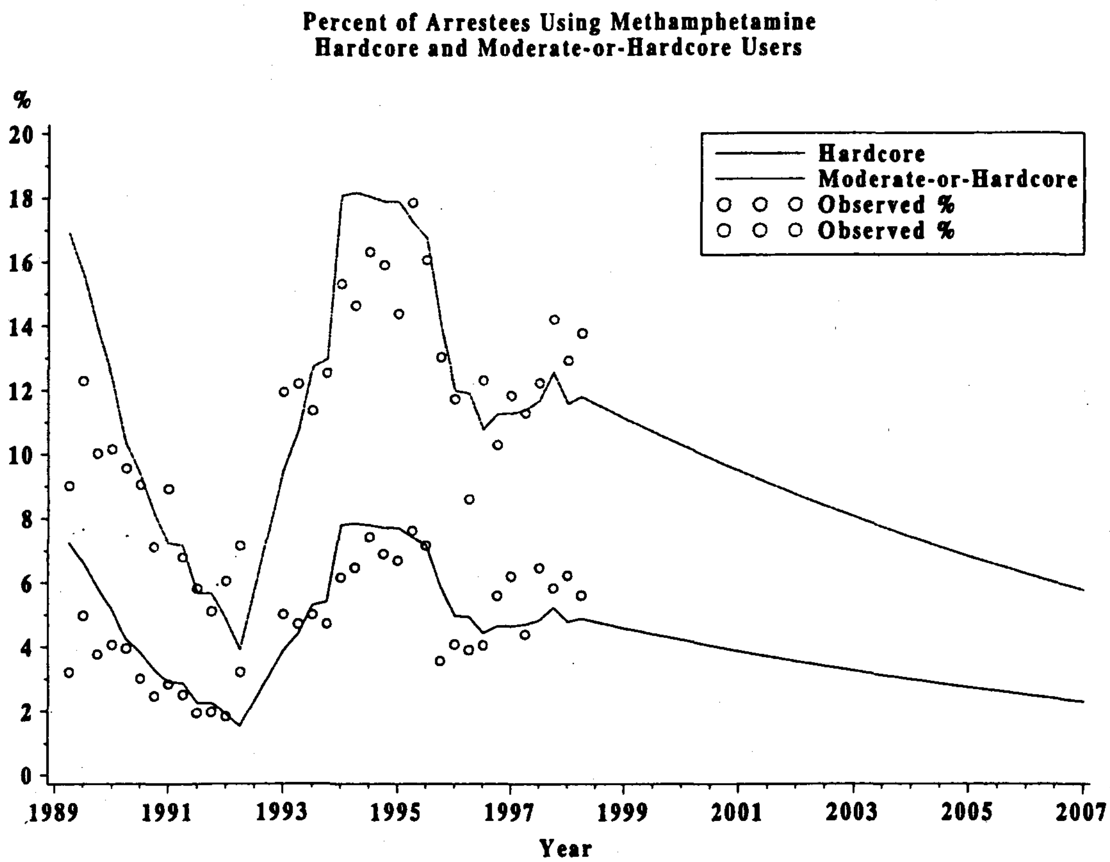


## Figure 33



Percent of Arrestees Using Methamphetamine > 10 Days/Month
Future Prices: Constant, Doubled Own and Doubled All
%
9
8
7
6
5
4
3
2
1
0
Constant Prices
Own Price Doubled
All Prices Doubled
Observed %
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year

**Figure 34**




# Summary and Conclusions

The 1998 National Drug Control Strategy established an ambitious national agenda for reducing illicit drug use by 25 percent as of 2002 and by 50 percent as of 2007. When it established those targets, the Office of National Drug Control Policy recognized that achieving its goals would require a multifaceted mixture of supply-based and demand-based programs. The nature of that mix was unknown, however, because there was no solid quantitative evidence of how supply-based and demand-based programs would interact to reduce substance abuse. Indeed, there was no compelling evidence that available technology targets – treatment, prevention, or law enforcement – provided the means to achieve those.

Are those targets achievable with the tools at the Nation's disposal? This study did not attempt to answer that general question, but it did address a more narrow one: How can supply-based programs, which restrict drug availability and consequently increase drug prices, reduce the initiation and continuation of drug abuse in the United States?

This is an empirical study. Estimates of trends in drug prices come from an earlier study done by Abt Associates Inc. for the Office of National Drug Control Policy. That earlier study used data from two

Drug Enforcement Administration data sources: the System to Retrieve Information from Drug Evidence and the Domestic Monitor Program. Data about the initiation and continuation of drug use come from multiple administrations of the National Household Survey on Drug Abuse, mostly from the years 1988 through 1996. Data about drug use by hardcore users come from multiple administrations of the Drug Use Forecasting data, mostly from 1989 through 1998.

We used a survival model, developed especially for this study, to analyze whether or not drug prices affect the eventual probability that a youth would experiment with drugs and the age of experimentation if he or she did try an illicit substance. We used an ordered probit model, also developed especially for this study, to study how drug prices influenced decisions to use illicit substances by those who, at some time, had tried drugs at an experimental level. Finally, we used an ordered logistic model to analyze the relationship between illicit drug prices and the level of substance abuse among arrestees.

Based on the statistical findings, we projected drug use into the years 2002 and 2007 based on different scenarios about how future drug prices will change from their present levels. The purpose of this simulation was to estimate how closely a supply-based program that successfully increased drug prices could approach the national target of reducing drug use by 50 percent as of 2007.

## Findings

### Drug Prices

There seems little doubt that the combination of source area programs, interdiction and domestic law enforcement have successfully increased the price of illicit drug products to levels that are many times higher than would otherwise prevail. Cocaine, heroin and marijuana are basically agricultural products that require minimal inexpensive chemical processing. If it were not for law enforcement, they might sell for prices that are comparable to aspirin. Instead, users pay many times the price of aspirin for typical doses.

Still, the Nation's ability to reduce drug availability and to increase drug prices appears to be limited. Since about 1988, the prices of cocaine, heroin and methamphetamine have all fallen or remained about the same, despite what was inaugurated in the late 1980s as a war on drugs. The price of marijuana increased into the early 1990s, apparently because of a successful program of interdiction, but prices have declined since then as domestic production has supplanted foreign production. Thus, while law enforcement efforts have maintained high domestic prices for illicit substances, an expansion of law enforcement resources in the 1990s has not had a commensurate effect on drug prices.

### Elasticity of Demand

*Marijuana*

When marijuana has been relatively unavailable, as reflected in high marijuana prices during the late 1980s and early 1990s, young Americans have been less likely to experiment with marijuana. Thus, Americans who came of age during the early 1980s, when marijuana was relatively inexpensive, were more likely to try marijuana than were Americans who came of age in the early 1990s, when marijuana cost more. Marijuana prices have fallen toward the end of the 1990s, while the best evidence, available from several sources, indicates that youth have increasingly returned to marijuana use. There seems to be strong evidence that price and availability influence the decisions of children and young adults to experiment with marijuana.

The evidence is also strong that adults are sensitive to the price of marijuana. The higher the price, the smaller the number of people who use marijuana at both weekly and occasional levels. This is true for members of households, who tend to use on an occasional basis, as well as for arrestees, who often use at a weekly level or higher.

*Cocaine*
There is some evidence that experimentation with cocaine is less frequent when cocaine prices are high, but the evidence is weak. It would be a mistake to conclude that cocaine prices do not matter, however, because these data are not well suited to answering the question. Because cocaine prices have decreased fairly steadily since 1981, with just a few short-term perturbations, we could not readily distinguish the effect of changes in cocaine prices from other secular trends.

We did not find household members to be sensitive to cocaine prices. However, arrestees reacted strongly to cocaine prices, decreasing their consumption when prices were high and increasing their consumption when prices were low.

*Heroin*
Heroin prices seemed to affect experimentation with heroin. However, the effect was difficult to quantify because prices decreased fairly steadily from 1981 through 1998. We may not have been able to distinguish price responsiveness from other trends.

It was not practical to study the demand for heroin using NHSDA data because so few respondents admitted heroin use. Arrestees seemed to be mildly responsive to heroin prices. When prices were high, they reduced their consumption, and they did the opposite when prices were low, but this relationship was statistically significant only at the 10 percent level.

*Methamphetamines*
The NHSDA did not ask the requisite questions about methamphetamine use, so the NHSDA data did not enter this analysis. Data from five places that had an appreciable amount of methamphetamine use indicated that methamphetamine users were very responsive to prices. The prevalence of methamphetamine use, both by heavy and occasional users, was greatest when prices were low and least when prices were high.

**Projections**

*Marijuana*
The key question was whether or not the targets set by the National Strategy are obtainable. The good news is that the prevalence of marijuana use is likely to fall toward the national goal even if marijuana prices remain about the same as they were during the latter 1990s. This follows because cohorts who came of age during the late 1970s and early 1980s were at the highest risk of experimenting with marijuana, but continued marijuana use is age sensitive. As those high-risk cohorts grow older, fewer of their members will be active marijuana users. Because initiation rates have been lower in the late 1980s and early 1990s, the disappearance of marijuana use by high-risk cohort members will not be offset by an equal increase in new marijuana users. Higher marijuana prices would reinforce this change, of course; as of yet there is no evidence of domestic programs that

would substantially increase marijuana prices by increasing the production and distribution costs of domestic producers.

The uncertainty regarding this otherwise positive conclusion stems from recent increases in marijuana use by eighth, tenth and twelfth graders who reported substance use to the Monitoring the Future Survey. Although the analysis reported here identified the beginning of that upturn in experimentation with marijuana use, our data ended in 1996, so we may have understated this resurgence in marijuana use. The future may not be as bright as is painted here.

***Cocaine***

Similar patterns apply to cocaine, although for cocaine, the pattern is not so strong. We project a very gradual downward trend in cocaine use among household members. Higher cocaine prices would reinforce that trend, but the analysis showed little if any consumer responsiveness by household members to increased cocaine prices. On the other hand, the analysis showed very strong price responsiveness by arrestees, whose prevalence of cocaine use was diminishing anyway. Higher cocaine prices would reinforce that trend among heavy users, helping the Nation move toward its targets.

***Heroin***

We are less certain about projections for future heroin use. The NHSDA is not especially informative about heroin use, so we relied exclusively on the DUF data. Results suggested that the prevalence of heroin use would decline even without price increase, apparently because heroin users are an aging population whose use would decrease naturally. The problem with this interpretation is that the number of heroin users could increase as lower prices and higher purity induce more users into the market.

***Methamphetamine***

We are also less certain about future levels of methamphetamine use. Trends imply lower levels of future use among arrestees, and those trends would be reinforced by higher prices. A problem with that inference is that it is based on past reports, which are very cyclical and do not point clearly toward less use. Furthermore, methamphetamine use is currently limited to the West and (to a lesser extent) the Midwest. It is difficult to anticipate whether or not methamphetamine use will spread to the rest of the country. If it does, projections are probably in error.

## Conclusions

Prospective and confirmed drug users are sensitive to the price of drugs, so if the Nation can increase the effectiveness of source country programs, interdiction and domestic law enforcement, then drug abuse can be reduced appreciably. Given experiences since the beginning of the war on drugs, which initiated major expansions in expenditures on supply-based programs, it seems more reasonable to conclude that the Nation will not be able to have any large future influence on decreasing the availability and increasing the price of illicit drugs. Of course, this conclusions rests on observations of past trends, and it could be reversed by the introduction of technological advances, such as improved ways of detecting cocaine, better informed decisions about the placement of interdiction resources, and improved means of detecting domestic marijuana cultivation. But until those improvements happen, it is difficult to be sanguine that supply-based programs can be the major means by which the Nation reaches its 2002 and 2007 targets.

On the other hand, there are reasons to believe that those targets can be obtained. Excluding the use of alcohol and tobacco by youth, marijuana is by far the most widely abused illicit substance. Evidence presented in this report finds that marijuana use will decrease in the future even if marijuana prices remain the same. If marijuana prices could be returned to near the levels they attained in the early 1990s, then drug use in the household population would decrease even more. Thus, targets that pertain to the drug use by household members are within the Nation's grasp, although supply-side programs alone cannot guarantee they will be reached.

Trends by hardcore drug users are also encouraging. If the Nation can hold the line on the initiation of illicit drug use, preventing it from returning to the epidemic proportions experienced during earlier decades, then as more hardcore drug users age out of their addictions, there will be fewer replacements to take their place. These trends, by themselves, do not appear adequate to reach the Nation's targets for reducing hardcore drug use. But with the reinforcement of supply-based and expanded demand-based programs (especially treatment), the Nation can be hopeful, if not expectant, that drug abuse and its sequela will abate.

The fly in this prediction ointment is that our data stopped in 1996 and, of course, predictions had to be based on data as of that date. In fact, the Monitoring the Future Survey (University of Michigan, 1999) shows that lifetime prevalence of any illicit drug use by seniors reached a peak (since 1975) with the class of 1981 and decreased more or less steadily until the class of 1993. Thereafter, experimentation has increased more or less steadily through the class of 1999. Our analysis may not fully account for this recent resurgence of use, although nothing in our findings contradict the recent trend reported by the MTF.

The final conclusion, then, is the inevitable call for further research. If it is important to monitor and explain trends, in order to predict the future, it seems imperative to do this with the most recently available data. This study provides a template for how data obtained through annual surveys might be analyzed, to gain a better understanding of drug abuse.

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## APPENDIX A

### NHSDA DATA ASSEMBLY

One of the data sets used in the elasticity study consists of alcohol and drug prices merged onto data from the National Household Survey on Drug Abuse (NHSDA). The following documents the assembly of this data set. Tables follow that show the values of the variables before and after recoding for both drug related variables and non-drug related variables.

### Step 1. Assemble NHSDA Data

For each year of NHSDA data, only those variables pertinent to the elasticity study were extracted from the public use files which were downloaded from the ICPSR (University of Michigan's Inter-University Consortium for Political and Social Research) website. Variables selected covered information such as demographics (race, gender, age), financial status, employment status, education level, marital status, health insurance coverage and frequency of drug use (alcohol, cocaine, crack, heroin, marijuana) in the past month and past year.

Since geographic information is encrypted in the NHSDA public use files, the downloaded data was merged with a file received from Research Triangle Institute which identifies the place for each observation. The public use file was merged with its respective identifier file for the years 1982, 1988, 1990-1996. [Note: The NHSDA survey was changed in the middle of 1994 so there are two versions for this year. The 1994-A survey is comparable to the surveys from years preceding while the second survey 1994-B is comparable to surveys from years following. The observations from the beginning of 1994-A were dropped; 4,272 observations were dropped which is about 20% of the observations from 1994. ]

The National Household Survey was also conducted in the years 1979, 1985, and 1997. However, these years of data are not incorporated into the data set. Since the drug and alcohol prices series do not date back to 1979 this year of NHSDA data is not used. The 1985 NHSDA public use file is available, however, we do not have the identifier file for this year. Conversely, we have the identifier file for 1997 but this year of NHSDA data is not yet publicly available.

Ultimately, the data set has observations from the 1982, 1988, 1990-1996 National Household Surveys.

### Step 2. Recode NHSDA Data

Once merged with the geographic information, the separate years of selected NHSDA data are set together. The agency that conducts NHSDA, SAMHSA (Substance Abuse and Mental Health Services Administration), has made changes to the survey since the first survey conducted in 1979. Therefore, variables and their values are not necessarily identical year to year. By researching the variables in the codebooks and tracking changes in their names and definitions, it is possible to recode many of the variables so that they have a uniform value across the years. The recoding process included renaming variables, collapsing values of a variable so that they were consistent with other years, setting certain responses to missing, and collapsing variables with multiple responses into a 0/1 variables (variables with only two responses).

Step 3. Select NHSDA Sites for the Elasticity Study

Since the elasticity study is longitudinal, places that would be valuable to the elasticity study are those that were interviewed with substantial frequency spanning the years 1979-1996. This resulted in 28 places for the analysis.

Step 4. Merge Drug Prices onto NHSDA Data

At this point, the data set for the elasticity study consists only of selected variables from the NHSDA surveys for the 28 selected places. The next step is to merge on the quarterly and fiscal prices of cocaine, heroin, marijuana and methamphetamine for each place. Then the national quarterly and fiscal price of marijuana in each year is merged on. There are two versions of both the place and national quarterly and fiscal drug prices. Version 1 prices correspond to the main effects model and version 2 prices correspond to the interactions model. A fiscal price is defined as the average of the current quarter drug price and the past three quarters' drug price. (For the very first quarter of data, use that quarter's price as the fiscal price. For the second and third quarters, use the average of the current quarter and the previous quarter(s) drug price.) The drug prices were prepared using the Drug Enforcement Administration's STRIDE (System To Retrieve Information from Drug Evidence) data.

There are a few places not matched up to drug price data and proxies were used for several places.

There is no variable for interview month in the 1988 NHSDA data. As documented in the codebook, some of the interviews in the 1988 data set were actually conducted in 1989 which introduces some error (which cannot be rectified without a month variable). Another implication is that the data cannot be broken down into quarters which means drug price data cannot be merged on by quarter. Instead, the average price in 1988 for each drug for each place is taken and is merged onto the NHSDA observations by year by place.

Step 5. Merge Alcohol Prices onto NHSDA Data

After merging drug prices onto the NHSDA data set, alcohol prices are merged on. The alcohol prices come from the current Consumer Price Index (CPI) which is the most widely used measure of inflation of consumer goods and services including alcohol.

[The CPI simplifies the measurement of changes in prices over time by selecting an appropriate base time period and setting that price index equal to 100, and measuring prices changes in relation to that figure. This allows for comparison between price levels at different points in time. ] This bi-annual CPI data for alcohol prices is publicly available through the Bureau of Labor Statistics web site. In order for this data to coincide with drug price data, linear interpolation was used to produce quarterly alcohol prices. The alcohol price data used is collected across 26 metropolitan areas so the place data is mapped into areas geographically closest to them without crossing state borders (as state alcohol prices are a factor). Observations from 1981 and 1982 do not have alcohol prices since the CPI data is not available before 1984. There are several places that do not have alcohol prices for any year.

Since there is no variable for quarters in the 1988 data, average prices for each place for that year are used. Also, the Washington DC-Virginia- Maryland- West Virginia CPI area alcohol price data does not commence until 1997. Since there are so few data available for this area, at each quarter the average of all available alcohol prices at the different CPI areas is taken and used in place of the DC data. Several places are affected by this mapping.

## NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
### (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MARIJUANA** | | | | | | | | | | | | |
| age when first used marijuana/ hashish | **mjage** | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 981= never used mj/hash- logically assigned | n/a | n/a | 181 | 181 | | | | | | |
| | | 985= bad data= logically assigned | n/a | 95 | 185 | 185 | | | | | | |
| | | 991= never used marijuana | 91 | 91 | 191 | 191 | | | | | | |
| | | illegible | n/a | n/a | 192 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 994= don't know | 94 | n/a | 194 | 194 | | | | | | |
| | | 995= bad data | n/a | n/a | 195 | n/a | n/a | n/a | | | n/a | n/a |
| | | refused | n/a | n/a | n/a | 197 | n/a | n/a | n/a | | n/a | n/a |
| | | 998= blank (no answer) | n/a | 98 | 198 | 198 | | | | | | |
| # days used mj/ hashish past 12 months | **mjyrfreq** | 1= more than 300 days | N/A ↓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1= several times a day in the past 12 months | ✓ | ✓ | ✓ |
| | | 2= 201 to 300 days | | | | | | | 2= daily in the past 12 months | | | |
| | | 3= 101 to 200 days | | | | | | | 3= almost daily or 3 to 6 days a week | | | |
| | | 4= 51 to 100 days | | | | | | | 4= 1 or 2 days a week | | | |
| | | 5= 25 to 50 days | | | | | | | 5= several times a month (about 25 to 51 days a year) | | | |
| | | 6= 12 to 24 days | | | | | | | 6= 1 or 2 times a month (12 to 24 days a year) | | | |
| | | 7= 6 to 11 days (less than one day a month) | | | | | | | 7= every other month or so (6 to 11 days a year) | | | |
| | | 8= 3 to 5 days in the past 12 months | | | | | | | 8= 3 to 5 days in the past 12 months | | | |
| | | 9= 1 to 2 days in the past 12 months | | | | | | | 9= 1 or 2 days in the past 12 months | | | |
| | | 81= never used mj (logically assigned) | | | | | | | | | | |
| | | 83= did not use mj past 12 months (logically assigned) | | | | | | | | | | |
| | | 85= bad data (logically assigned) | | | | | | | | | | |
| | | 91= never used mj | | | | | | | | | | |
| | | 93= did not use mj in past 12 months | | | | | | | | | | |
| | | 95= bad data | | | | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| # days used mj/hashish in past 30 days | **mjday30a** | *number* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 35= date specified within the past 30 days | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 81= never used mj (logically assigned) | n/a | n/a | | | | | | | | |
| | | 83= did not use mj past 12 months (logically assigned) | n/a | n/a | n/a | | | | | | | |
| | | 85= bad data (logically assigned) | n/a | n/a | | | | | | | | |
| | | 91= never used mj | | | | | | | | | | |
| | | 93= did not use mj in past 12 months | | n/a | n/a | | | | | | | |
| | | 94= don't know | | n/a | n/a | n/a | | n/a | | | n/a | n/a |
| | | 95= bad data | n/a | | n/a | | | n/a | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| **COCAINE** age when first used cocaine | **cocage** | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 981= never used cocaine- logically assigned | n/a | n/a | 181 | 181 | | | | | | |
| | | 985= bad data- logically assigned | n/a | n/a | 185 | 185 | | | | | | |
| | | 991= never used cocaine | 91 | 91 | 191 | 191 | | | | | | |
| | | 994= don't know | n/a | n/a | n/a | n/a | | | n/a | | n/a | n/a |
| | | 995= bad data | 94 | 95 | 195 | 197= refused | n/a | n/a | | n/a | | |
| | | 998= blank (no answer) | n/a | 98 | n/a | 198 | | | | | | |

## NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
### (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # days used cocaine past 12 months | cocyrfreq | 1= more than 300 days | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= 201 to 300 days | | | | | | | | | | |
| | | 3= 101 to 200 days | | | | | | | | | | |
| | | 4= 51 to 100 days | | | | | | | | | | |
| | | 5= 25 to 50 days | | | | | | | | | | |
| | | 6= 12 to 24 days | | | | | | | | | | |
| | | 7= 6 to 11 days (less than one day a month) | | | | | | | | | | |
| | | 8= 3 to 5 days in the past 12 months | | | | | | | | | | |
| | | 9= 1 to 2 days in the past 12 months | | | | | | | | | | |
| | | 81= never used cocaine (logically assigned) | | | | | | | | | | |
| | | 83= did not use cocaine past 12 months (logically assigned) | | | | | | | | | | |
| | | 85= bad data (logically assigned) | | | | | | | | | | |
| | | 91= never used cocaine | | | | | | | | | | |
| | | 93= did not use cocaine in past 12 months | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| # days used cocaine in past 30 days | cocus30a | *number* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 35= date specified within past 30 days | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 81= never used mj (logically assigned) | n/a | n/a | | | | | | | | |
| | | 83= did not use mj past 12 months (logically assigned) | n/a | n/a | n/a | | | | | | | |
| | | 85= bad data (logically assigned) | n/a | n/a | | | | | | | | |
| | | 91= never used cocaine | | | | | | | | | | |
| | | 93= did not use cocaine in past 12 months | | n/a | n/a | | | | | | | |
| | | 94= don't know | | n/a | n/a | n/a | | n/a | n/a | n/a | n/a | n/a |
| | | 95= bad data | n/a | | n/a | | | n/a | n/a | | | |
| | | 98= blank (no answer) | | | n/a | | | n/a | | | | |
| **CRACK** | | | | | | | | | | | | |
| age when first used crack | crkage | *age* | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 981= never used crack- logically assigned | | | | | | | | | | |
| | | 985= bad data- logically assigned | | | | | | | | | | |
| | | 991= never used crack | | | | | | | | | | |
| | | 995= bad data | | | | | | | | n/a | | |
| | | 998= blank (no answer) | | | | | | | | | | |
| # days used crack in past 12 months | crkyrfrq | 1= more than 300 days (every day or almost every day) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= 201 to 300 days (5 to 6 days a week) | | | | | | | | | | |
| | | 3= 101 to 200 days (3 to 4 days a week) | | | | | | | | | | |
| | | 4= 51 to 100 days (1 to 2 days a week) | | | | | | | | | | |
| | | 5= 25 to 50 days (3 to 4 days a week) | | | | | | | | | | |
| | | 6= 12 to 24 days (1 to 2 days a month) | | | | | | | | | | |
| | | 7= 6 to 11 days (less than one day a month) | | | | | | | | | | |
| | | 8= used 3-5 days in past 12 months | | | | | | | | | | |
| | | 9= used 1-2 days in the past 12 months | | | | | | | | | | |
| | | 81= never used crack- logically assigned | | | | | | | | | | |
| | | 83= did not use crack past 12 months- logically assigned | | | | | | | | | | |
| | | 85= bad data- logically assigned | | | | | | | | | | |
| | | 91= never used crack | | | | | | | | | | |
| | | 93= did not use crack in the past 12 months | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # days used crack past 30 days | crkus30a | *days* | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 35= date specified within the past 30 days | | | | | | | | | n/a | n/a |
| | | 81= never used crack- logically assigned | | | | | | | | | | |
| | | 83= did not use crack past 12 months- logically assigned | | | | | | | | | | |
| | | 85= bad data- logically assigned | | | | | | | | | | |
| | | 91= never used crack | | | | | | | | | | |
| | | 93= did not use crack in the past 12 months | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | n/a | n/a |
| | | 95= bad data | | | | | | | | n/a | n/a | |
| | | 98= blank (no answer) | | | | | | | | | | |
| most recent time used crack | crakrec | 1= within the past week (7 days) | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1 from 1996 | 1 from 1996 | 1= within the past 30 days<br>2= more than 30 days ago but within the past 12 months<br>3= more than 12 months ago but within the past 3 years<br>4= more than 3 years ago |
| | | 2= more than 1 week ago but less than 1 month ago | | | | | | | | 2 from 1996 | 2 from 1996 | |
| | | 3= 1 or more months ago but less than 6 months ago | | | | | | | | 3 from 1996 | 3 from 1996 | |
| | | 4= 6 or more months ago but less than 1 year ago | | | | | | | | 4 from 1996 | 4 from 1996 | |
| | | 5= 1 or more years ago but less than 3 years ago | | | | | | | | n/a | n/a | n/a |
| | | 6= 3 or more years ago | | | | | | | | n/a | n/a | n/a |
| | | 7= use in past 30 days- logically imputed | | | | | | | | | | |
| | | 8= use in past year- logically imputed | | n/a | n/a | | n/a | | n/a | | | |
| | | 9= use in lifetime- logically imputed | | n/a | | | | | | | | |
| | | 81= never used crack- logically assigned | | n/a | n/a | | | | | | | |
| | | 91= never used crack | | | | | | | | n/a | n/a | n/a |
| | | 97= refused | | n/a | | n/a | | | n/a | n/a | n/a | n/a |
| | | 98= blank (no answer) | | | n/a | | n/a | | | | | |
| # vials of crack used in past 30 days | crkam30a | *range* | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 981= never used crack- logically assigned | | n/a | | | | | | | | |
| | | 983= did not use crack in past 30 days- logically assigned | | n/a | | | | | | | | |
| | | 985= bad data- logically assigned | | n/a | | | | | | | | |
| | | 991= never used crack | | n/a | | | | | | | | |
| | | 993= did not use crack in past 30 days | | | | | | | | | | |
| | | 994= don't know | | n/a | n/a | n/a | | | n/a | | | |
| | | 995= bad data | | | n/a | n/a | n/a | n/a | n/a | | | |
| | | 997= refused | | n/a | | | | n/a | n/a | | | |
| | | 998= blank (no answer) | | | | | | | | | | |
| did not use crack in past 30 days | ckobtnon | 2= response not circled | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 81= never used crack- logically assigned | | | | | | | | | | |
| | | 83= did not use crack in past 30 days- logically assigned | | | | | | | | | | |
| | | 85= bad data- logically assigned | | | | | | | | | | |
| | | 91= never used crack | | | | | | | | | | |
| | | 93= did not use crack in past 30 days | | | | | | | | | | |
| | | 97= refused | | | | | | n/a | n/a | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ever used crack daily for 2 or more weeks | ckfdaly | 1= yes | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 2= no | | | | | | | | | | |
| | | 81= never used crack- logically assigned | | | | | | | | | | |
| | | 91= never used crack | | | | | | | | | | |
| | | 93= did not use crack in past 30 days | | | | | | | | | | |
| | | 95= bad data | | | | | | n/a | n/a | | | |
| | | 97= refused | | | | | | n/a | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| **HEROIN** | | | | | | | | | | | | |
| age when first used heroin | herage | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 981= never used heroin- logically assigned | n/a | n/a | 181 from 1991 | 181= never had a chance to try heroin- logically assigned | | | | | | |
| | | 985= bad data= logically assigned | n/a | n/a | 185 | 185 | | | | | | |
| | | 991= never used heroin | 91 | 91 | 191 from 1991 | 191= never had a chance to try heroin | | | | | | |
| | | 994= don't know | 94 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | |
| | | 995= bad data | n/a | 95 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 997= refused | n/a | n/a | n/a | 197 | | | n/a | n/a | | |
| | | 998= blank (no answer) | n/a | 98 | 198 | 198 | | | | | | |
| # days used heroin in past 30 days | her30use | *number* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 81= never used heroin (logically assigned) | n/a | | | | | | | | | |
| | | 83= did not use heroin past 12 months (logically assigned) | n/a | | n/a | | | | | | | |
| | | 85= bad data (logically assigned) | n/a | | n/a | | n/a | | | | | |
| | | 91= never used heroin | | | | | | | | | | |
| | | 93= did not use heroin in past 12 months | | | n/a | | | | | | | |
| | | 94= don't know | n/a | | n/a | n/a | n/a | n/a | n/a | n/a | | |
| | | 95= bad data | n/a | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 97= refused | n/a | | n/a | | | | n/a | n/a | | |
| | | 98= blank (no answer) | | | | | | | n/a | | | |
| **ALCOHOL** | | | | | | | | | | | | |
| age when had first drink of alcoholic beverage | alctry | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 981= never used alcohol- logically assigned | 81 | n/a | 181 | 181 | | | | | | |
| | | 985= bad data= logically assigned | n/a | n/a | 185 | 185 | | | | | | |
| | | 991= never used alcohol | 91 | 91 | 191 | 191 | | | | | | |
| | | illegible | n/a | n/a | 192 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 994= don't know | 94 | 94 | 194 | 194 | | | | | | |
| | | 995= bad data | n/a | 95 | 195 | 197= refused | n/a | n/a | | | | |
| | | 996= multiple response | n/a | 96 | n/a | | | | n/a | | | |
| | | 997= refused | n/a | 97 | 197 | | | | n/a | | | |
| | | 998= blank (no answer) | n/a | 98 | 198 | 198 | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| frequency of alcohol consumption in past 12 months | alcpat | 1= daily | N/A | ✓ | ✓ | ✓ | 1= daily in the past 12 months | 1= daily in the past 12 months | ✓ | 1= more than 300 days (every day or almost every day) 2= 201 to 300 day | ✓ | ✓ |
| | | 2= almost daily or 3 to 6 days a week | | | | | | | | 3= 101 to 200 days (3 to 4 days a week) | | |
| | | 3= about 1 or 2 days a week | | | | | | | | 4= 51 to 100 days (1 or 2 days a week) | | |
| | | 4= several times a month (about 25-51 days a year) | | | | | | | | 5= 25 to 50 days (3 to 4 days a month) | | |
| | | 5= 1 or 2 times a month (12 to 24 days a year) | | | | | | | | 6= 12 to 24 days (1 to 2 days a month) | | |
| | | 6= every other month or so (6 to 11 days a year) | | | | | | | | 7= 6 to 11 days (less than one day a month) | | |
| | | 7= 3 to 5 days in the past 12 months | | | | | | | | 8= 3 to 5 days in the past 12 months | | |
| | | 8= 1 or 2 days in the past 12 months | | | | | | | | 9= 1 to 2 days in the past 12 months | | |
| | | 81= never used alcohol (logically assigned) | | n/a | | | | | | | | |
| | | 83= did not use alcohol past 12 months (logically assigned) | | n/a | | | | | | | | |
| | | 85= bad data (logically assigned) | | n/a | | | | | | | | |
| | | 91= never used alcohol | | | | | | | | | | |
| | | 93= did not use alcohol in the past 12 months | | | | | | | | | | |
| | | 94= don't know | | | n/a | | | | n/a | | | |
| | | 95= bad data | | | n/a | n/a | n/a | n/a | n/a | n/a | | |
| | | 96= multiple responses | | | | | n/a | n/a | n/a | n/a | | |
| | | 97= refused | | | | n/a | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| # days had one or more drinks past 30 days | alcdays | *# days* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 35= date specified within the past 30 days | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | | n/a |
| | | 81= never used alcohol (logically assigned) | | n/a | | | | | | | | |
| | | 83= did not use alcohol in past 30 days (logically assigned) | n/a | n/a | n/a | | n/a | | | | | |
| | | 85= bad data (logically assigned) | n/a | n/a | | | | | | | | |
| | | 91= never used alcohol | | | | | | | | | | |
| | | 93= did not use alcohol in past 30 days | | n/a | n/a | | | | | | | |
| | | 94= don't know | | | n/a | | | | | | | |
| | | 95= bad data | n/a | | | | | | | | | |
| | | 96= multiple response | n/a | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 97= refused | n/a | n/a | | n/a | | n/a | n/a | n/a | n/a | |
| | | 98= blank (no answer) | | | | | n/a | | | | | |
| **CIGARETTES** | | | | | | | | | | | | |
| age when first smoked a cigarette | cigtry | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 981= never used cigarettes- logically assigned | n/a | n/a | n/a | n/a | | | n/a | | | |
| | | 985= bad data- logically assigned | n/a | n/a | 185 | 185 | | | | | | |
| | | 991= never used cigarettes | 91 | 91 | 191 | n/a | | | | | | |
| | | 994= don't know | 94 | 94 | 194 | 194 | | | | | | |
| | | 995= bad data | n/a | 95 | 195 | n/a | | | n/a | | | |
| | | 996= multiple response | n/a | 96 | 196 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 997= refused | n/a | 97 | n/a | 197 | | | n/a | n/a | n/a | |
| | | 998= blank (no answer) | n/a | 98 | 198 | 198 | | | | | | |
| ever smoked a cigarette | cigever | 1= yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 3= yes- logically assigned | | | | | | | | | | |
| | | 4= no- logically assigned | | | | | | | | | | |
| | | 97= refused | | | | | | | | n/a | n/a | |
| | | 98= blank (no answer) | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1962 | 1968 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| number days smoked cigarettes in life | cigtot | 1= more than 300 days | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= at least 101 but not more than 300 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 3= at least 12 but not more than 100 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 4= at least 3 but not more than 11 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 5= at least 1 but not more than 2 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 81= never used cigarettes- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 85= bad data- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 91= never used cigarettes | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 94= don't know | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 97= refused | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | n/a | n/a | |
| | | 98= blank (no answer) | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| number days smoked past 30 days | cig30use | range (1-30) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 35= date specified within the past 30 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 81= never used cigarettes- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 83= did not use cigarettes in past 30 days- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 85= bad data- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 91= never used cigarettes | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 93= did not use cigarettes in past 30 days | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 94= don't know | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 95= bad data | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 97= refused | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | n/a | n/a | |
| | | 98= blank (no answer) | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| number cigarettes smoked per day past 30 days | avcig | 1= at least a puff but less than one cig each day | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= 1 to 5 cigarettes each day | | | | | | | | | | |
| | | 3= 6 to 15 cigarettes (about 1/2 pack) each day | | | | | | | | | | |
| | | 4= 16 to 25 cigarettes (about 1 pack) each day | | | | | | | | | | |
| | | 5= 26 to 35 cigarettes (about 1 1/2 packs) each day | | | | | | | | | | |
| | | 6= 35 or more cigarettes (about 2 packs) each day | | | | | | | | | | |
| | | 81= never used cigarettes- logically assigned | n/a | n/a | | n/a | n/a | n/a | n/a | | | |
| | | 83= did not use cigarettes pasts 30 days- logically assigned | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 85= bad data- logically assigned | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 89= legitimate skip- logically assigned | n/a | n/a | | | | | | n/a | n/a | n/a |
| | | 91= never used cigarettes | | | | | | | | | | |
| | | 93= did not use cigarettes in the past 30 days | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 94= don't know | | | n/a | | | | n/a | n/a | n/a | n/a |
| | | 97= refused | n/a | n/a | n/a | | n/a | | | n/a | n/a | |
| | | 98= blank (no answer) | n/a | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | n/a | n/a | n/a |
| ever smoked daily | cigevyda | 1= yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= no | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 3= yes- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 4= no- logically assigned | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |
| | | 97= refused | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | n/a | n/a | |
| | | 98= blank (no answer) | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| number years smoked cigarettes every day | cigyrs | range (1-66) | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 0= I smoked cigarettes every day but only for less than 1 yr | | | | | | 0= no years | 0= no years | | 0= no years | |
| | | 981= never used cigarettes- logically assigned | | n/a | 181 | 181 | n/a | n/a | | | | |
| | | 983= never used cigarettes everyday- logically assigned | | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 985= bad data- logically assigned | | n/a | 185 | 185 | | | n/a | | | |
| | | 989= legitimate skip- logically assigned | | n/a | n/a | n/a | | n/a | n/a | n/a | n/a | n/a |
| | | 991= never used cigarettes | | 91 | 191 | 191 | | | | | | |
| | | 993= never used cigarettes every day | | n/a | 193 | n/a | n/a | n/a | n/a | | | |
| | | 994= don't know | | 94 | 194 | 194 | | | | | | |
| | | 995= bad data | | 95 | n/a | n/a | n/a | n/a | | | | |
| | | 997= refused | | n/a | n/a | 197 | | n/a | n/a | n/a | n/a | |
| | | 998= blank (no answer) | | 98 | 198 | 198 | | | | | | |
| | | 999= legitimate skip | | 99 | 199 | 199 | | | | n/a | n/a | n/a |
| smoked 5 or more packs of cigarettes in lifetime | cig5pk | 1= yes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 2= no | | | | | | | | | | |
| | | 3= yes- logically assigned | n/a | n/a | | | | | | | | |
| | | 81= never used cigarettes- logically assigned | | n/a | | | | | | | | |
| | | 91= never used cigarettes | | | | | | | | | | |
| | | 94= don't know | n/a | | n/a | | n/a | n/a | n/a | | | |
| | | 95= bad data | n/a | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 97= refused | n/a | n/a | n/a | | n/a | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| number cigarettes smoked daily | packs | 1= one to five cigarettes a day | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 2= about 1/2 pack a day (6-15 cigarettes) | | | | | | | | | | |
| | | 3= about a pack a day (16-25 cigarettes) | | | | | | | | | | |
| | | 4= about 1 1/2 packs a day (26-35 cigarettes) | | | | | | | | | | |
| | | 5= about 2 packs or more a day (over 35 cigarettes) | | | | | | | | | | |
| | | 6= smoked cigars only | | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 89= legitimate skip- logically assigned | | n/a | n/a | n/a | | n/a | n/a | | | |
| | | 91= never used cigarettes | | | | | | | | | | |
| | | 94= don't know | | | n/a | | n/a | | n/a | | | |
| | | 95= bad data | | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 97= refused | | n/a | n/a | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| number months smoked number cigarettes /day in avcig | cigtime | range (1-720) | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 0= no months | | | | | | | | | | |
| | | 9981= never used cigarettes- logically assigned | | n/a | | | | | | | | |
| | | 9985= bad data- logically assigned | | n/a | | | n/a | n/a | | | | |
| | | 9989= legitimate skip- logically assigned | | n/a | | | | | | | | |
| | | 9991= never used cigarettes | | 91 | | | | | | | | |
| | | 9993= has not smoked cigarettes in past 30 days | | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| | | 9994= don't know | | 94 | | | | | | | | |
| | | 9995= bad data | | 95 | | n/a | n/a | n/a | n/a | | | |
| | | 9997= refused | | n/a | n/a | | n/a | n/a | | | | |
| | | 9998= blank (no answer) | | 98 | | | | | | | | |
| | | 9999= legitimate skip | | 99 | | | | | | | | |

## NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
### (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| respondent identification number | **respid** | *id number* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| primary sampling unit (encrypted) | **encpsu** | *code* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| segment identification number (encrypted) | **encseg** | *code* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| household level identification number (encrypted) | **enccase** | *code* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| interview month | **intmonth** | *number* | **intmo**<br>1= November 1981 | N/A | ✓ | ✓ | 1= January<br>2= February | ✓ | ✓ | ✓ | ✓ | ✓ |
| birth month | **birmonth** | *number of month in year* | N/A | N/A | **birthmon** | **birmon** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| birth year | **biryear** | *year* | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| analysis weight | **analwt** | *number* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| risk if smoke marijuana once a month | **rskmjocc** | 1= no risk | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | ✓ |
| | | 2= slight risk | | | | | | | | | | |
| | | 3= moderate risk | | | | | | | | | | |
| | | 4= great risk | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | n/a | | | | | | |
| | | 97= refused | | | | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| risk if smoke marijuana once or twice a week | **rskmjreg** | 1= no risk | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | ✓ |
| | | 2= slight risk | | | | | | | | | | |
| | | 3= moderate risk | | | | | | | | | | |
| | | 4= great risk | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | n/a | | n/a | | | | | | |
| | | 97= refused | | | | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| risk if use cocaine once a month | **rskcococc** | 1= no risk | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | ✓ |
| | | 2= slight risk | | | | | | | | | | |
| | | 3= moderate risk | | | | | | | | | | |
| | | 4= great risk | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 95= bad data | | | n/a | n/a | n/a | n/a | n/a | n/a | | n/a |
| | | 96= multiple response | | | | n/a | | | | | | |
| | | 97= refused | | | | | n/a | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| risk if use cocaine once or twice a week | rskcocreg | 1= no risk | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | N/A | ✓ |
| | | 2= slight risk | | | | | | | | | | |
| | | 3= moderate risk | | | | | | | | | | |
| | | 4= great risk | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | n/a | | | n/a | | | |
| | | 97= refused | | | | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| annual total personal income received | indinc | *amount* | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| total personal income-imputation indicator | iindinc | 1= all personal income sources from questionnaire | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | N/A | N/A | N/A |
| | | 3= at least one of sources were stat or logic imputed | | | | | | | | | | |
| total personal income recode (13 categories) | indcat | 1= $0 | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= $1- $4,999 | | | | | | | | | | |
| | | 3=$5,000- $6,999 | | | | | | | | | | |
| | | 4= $7,000- $8,999 | | | | | | | | | | |
| | | 5= $9,000-$11,999 | | | | | | | | | | |
| | | 6=$12,000-$14,999 | | | | | | | | | | |
| | | 7=$15,000-$19,999 | | | | | | | | | | |
| | | 8=$20,000- $24,999 | | | | | | | | | | |
| | | 9=$25,000- $29,999 | | | | | | | | | | |
| | | 10= $30,000-$39,999 | | | | | | | | | | |
| | | 11=$40,000-$49,999 | | | | | | | | | | |
| | | 12=$50,000-$74,999 | | | | | | | | | | |
| | | 13=$75,000+ | | | | | | | | | | |
| personal earnings from employment for past year | income | 1= no personal earnings | N/A | ✓ | ✓ | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | 2= yearly.. Under $5000 | | | | | | | | | | |
| | | 3= yearly $5,000- $6,999 | | | | | | | | | | |
| | | 4=yearly $7,000- $8,999 | | | | | | | | | | |
| | | 5= yearly $9,000-$11,999 | | | | | | | | | | |
| | | 6= yearly $12,000-$14,999 | | | | | | | | | | |
| | | 7= yearly $15,000-$19,999 | | | | | | | | | | |
| | | 8= yearly $20,000- $24,999 | | | | | | | | | | |
| | | 9= yearly $25,000- $29,999 | | | | | | | | | | |
| | | 10= yearly $30,000-$39,999 | | | | | | | | | | |
| | | 11= yearly $40,000-$49,999 | | 11= yearly $40,000- $50,000 | | | | | | | | |
| | | 12= yearly $50,000-$74,999 | | 12= yearly more than $50,000 | | | | | | | | |
| | | 13= yearly... more than $ 75,000 | | n/a | | | | | | | | |
| | | 85= bad data (logically assigned) | | n/a | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 95= bad data | | | n/a | | | | | | | |
| | | 96= multiple response | | | n/a | | | | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank | | | | | | | | | | |
| | | 99= legitimate skip (irage<15) | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURVEY YEAR | | | | | | | | | |
| total family income recode (13 categories) | totcat | 1= 0 | 1= no income | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= $1- $4,999 | 2= under $10,000 | | | | | | | | | |
| | | 3=$5,000- $6,999 | 3= $10,000-19,999 | | | | | | | | | |
| | | 4= $7,000- $8,999 | 4= $20,000- 29,999 | | | | | | | | | |
| | | 5= $9,000-$11,999 | 5= $30,000-39,999 | | | | | | | | | |
| | | 6=$12,000-$14,999 | 6= $40,000-49,999 | | | | | | | | | |
| | | 7=$15,000-$19,999 | 7= $50,000 and above | | | | | | | | | |
| | | 8=$20,000- $24,999 | | | | | | | | | | |
| | | 9=$25,000- $29,999 | | | | | | | | | | |
| | | 10= $30,000-$39,999 | | | | | | | | | | |
| | | 11=$40,000-$49,999 | | | | | | | | | | |
| | | 12=$50,000-$74,999 | | | | | | | | | | |
| | | 13=$75,000+ | | | | | | | | | | |
| | | 94= don't know | | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 98= blank (no answer) | | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 99= legitimate skip | | | | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| health in general | health | 1= excellent | N/A | healthyr | healthyr | healthyr | healthyr | healthyr | N/A | ✓ | ✓ | ✓ |
| | | 2= very good | | | | | | | | | | |
| | | 3= good | | | | | | | | | | |
| | | 4= fair | | | | | | | | | | |
| | | 5= poor | | | | | | | | | | |
| | | 94= don't know | | | | | | | | n/a | | |
| | | 96= multiple response | | | | n/a | | | | | | |
| | | 97= refused | | | | | | | | n/a | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| felt depressed 2 weeks or more in past 12 months | depress | 1= yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 3= yes (logically assigned) | | | | | | | | | | |
| | | 4= no (logically assigned) | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| # weeks felt depressed in past 12 months | depwks1 | *# weeks* | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 85= bad data (logically assigned) | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 95= bad data | | | | | | | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURVEY YEAR | | | | | | | | | |
| period longer than 1 month felt anxious past year | worried | 1= yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 3= yes (logically assigned) | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| # months before anxiety ended- recode | wornomo1 | *# months* | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 9989= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 9994= don't know | | | | | | | | n/a | | |
| | | 9995= bad data | | | | | | | | n/a | | |
| | | 9997= refused | | | | | | | | | | |
| | | 9998= blank (no answer) | | | | | | | | | | |
| | | 9999= legitimate skip | | | | | | | | | | |
| is there usual place for health care | careusu | 1= yes | N/A | N/A | N/A | N/A | N/A | N/A | N/A | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 3= don't know | | | | | | | | | | |
| | | 4= there is more than one place | | | | | | | | | | |
| | | 94= don't know | | | | | | | | n/a | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| covered by medicare | medicare | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | | | | n/a | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| covered by medicaid | medicaid | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 95= bad data | | | | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 96= multiple response | | | | n/a | | | n/a | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| covered by champus, champva, va, military | champus | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | n/a | | n/a | n/a | n/a | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| covered by private insurance or hmo | prvhltin | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 3= yes (logically assigned) | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | | | n/a | n/a | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| private health insurata plan or hmo include coverage for treatment for alcohol abuse or alcoholism | hltinalc | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | | | | n/a | | n/a | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| private health insurate plan or hmo include coverage for treatment for drug abuse | hltindrg | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | | n/a | | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| private health insurate plan or hmo include coverage for treatment for mental or emotional difficulties | hltinmnt | 1= yes | N/A | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | | | | | | | | | |
| | | 94= don't know | | | | | | | | | | |
| | | 96= multiple response | | | | | n/a | n/a | | | | |
| | | 97= refused | | | | | | | | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| race/ hispanic-origin recode | race* | 1= white | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= black | | | | | | | | | | |
| | | 3= hispanic | | | | | | | | | | |
| | | 4= other | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sex- imputation revised | irsex | 1= male<br>2= female | ✓ | sex | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | | | orsex | | | | | | | | |
| irsex indicator | ilsex | 1= sex from questionnaire | 1= sex from source file | 1= sex from questionnaire | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= sex from relationship on roster | n/a | 2= sex taken from screener | 2= sex taken from screener | 2= sex from roster | 2= sex from roster | | | | | |
| | | 3= sex from roster | na | n/a | n/a | 3= sex statistically imputed | | | | | | |
| | | 4= sex statistically imputed | n/a | n/a | n/a | n/a | n/a | | n/a | n/a | n/a | n/a |
| imputation revised age of respondent | irage | *age* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| irage indicator | ilage | 1= age from birthdate | 1= age from source file | 1= age calculated from questionnaire | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= age from cover of questionnaire | n/a | 2= age taken from screener | | | | | | | | |
| | | 3= age from roster | n/a | 3= age imputed | 3= age taken from screener | | | | | | | |
| | | 4= age statistically imputed using ages gr from roste | n/a | n/a | 4= age imputed | | | | | | | |
| last grade completed in school | educ | 0=no schooling | 1= no schooling | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 1= first grade....12= twelfth grade | 2= elementary school- 8th grade or less | | | | | | | | | |
| | | 13= freshman/ 13th year | 3= some high school | | | | | | | | | |
| | | 14= sophomore/ 14th year | 4= high school graduate | | | | | | | | | |
| | | 15= junior/ 15th year | 5= vocational/ technical school | | | | | | | | | |
| | | 16= senior/ 16th year | 6= some college | | | | | | | | | |
| | | 17= graduate/ professional school (or higher) | 7= college graduate or beyond | | | | | | | | | |
| | | 85= bad data (logically assigned) | n/a | | | | | n/a | | | | |
| | | 94= don't know | n/a | | | | | n/a | n/a | | | |
| | | 97= refused | n/a | | | | | n/a | | n/a | | |
| | | 98= blank (no answer) | | | | | | | | n/a | | |
| | | 99= legitimate skip | | n/a | n/a | n/a | n/a | n/a | n/a | | n/a | n/a |
| evidence of high school completion (Have you received a hs diploma, or a GED certificate of hs completion?) | diploma | 1= high school diploma | N/A ↓ | N/A ↓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= GED Certificate | ↓ | ↓ | | | | | | | | |
| | | 3= Neither of the above | ↓ | ↓ | | | | | | | | |
| | | 89= legitmate skip (logically assigned) | ↓ | ↓ | | | | | | | | |
| | | 94= don't know | ↓ | ↓ | | | | n/a | | n/a | n/a | n/a |
| | | 96= multiple responses | ↓ | ↓ | n/a | | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 97= refused | ↓ | ↓ | | | | | | n/a | | |
| | | 98= blank (no answer) | ↓ | ↓ | | | | | | | | |
| | | 99= legitimate skip | ↓ | ↓ | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | SURVEY YEAR 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| current marital status | marital | 1= married | 1= married | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= widowed | 2= living as a couple | | | | | | | | | |
| | | 3= divorced or separated | 3= widowed | | | | | | | | | |
| | | 4= never been married | 4= divorced or separated | | | | | | | | | |
| | | 85= bad data (logically assigned) | 5= never married | | | | | | | | | |
| | | 89= legitimate skip (logically assigned) | n/a | | n/a | | | | | | | |
| | | 94= don't know | n/a | n/a | n/a | | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 96= multiple response | n/a | | | | | | n/a | | | |
| | | 97= refused | n/a | | | | | | n/a | | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |
| work status- imputation indicator | iiworkst | 1= questionnaire data | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= logically imputed data | | | | | | | | | | |
| | | 3= statistically imputed data | | | | | | | | | | |
| work status- imputation revised | irworkst | 1= working full-time, 35 hours or more a week | N/A | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= woking part-time, less than 35 hours a week | | | | | | | | | | |
| | | 3= have a job, but not at work, illness/maternity | | | 3 from 1994A | 3 from 1994A | 3 from 1994A | 3 from 1994A | 3= have job but out: illness/ leave/ furlough/ strike | | | |
| | | 4= have a job but not at work b/c it is seasonal | | | 4 from 1994A | 4 from 1994A | 4 from 1994A | 4 from 1994A | 4= unemployed or laid off and looking for work | | | |
| | | 5= unemployed or laid off and looking for work | | | 5 from 1994A | 5 from 1994A | 5 from 1994A | 5 from 1994A | 5= unemployed and not looking for work | | | |
| | | 6= unemployed or laid off and not looking for work | | | 6 from 1994A | 6 from 1994A | 6 from 1994A | 6 from 1994A | 6= full time homemaker only | | | |
| | | 7= full time homemaker | | | 7 from 1994A | 7 from 1994A | 7 from 1994A | 7 from 1994A | 7= in school only | | | |
| | | 8= in school only | | | 8 from 1994A | 8 from 1994A | 8 from 1994A | 8 from 1994A | 8= retired | | | |
| | | 9= retired | | | 9 from 1994A | 9 from 1994A | 9 from 1994A | 9 from 1994A | 9= diabled, not able to work | | | |
| | | 10= disabled for work | | | 10 from 1994A | 10 from 1994A | 10 from 1994A | 10 from 1994A | 10= other, in labor force | | | |
| | | 11= other, in labor force | | | 11 from 1994A | 11 from 1994A | 11 from 1994A | 11 from 1994A | 11= other, not in labor force | | | |
| | | 12= other, not in labor force | | | n/a | n/a | n/a | n/a | n/a | | | |
| employment status recode | empstat2* | 1= full time | N/A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= part time | | | | | | | | | | |
| | | 3= unemployed | | | | | | | | | | |
| | | 4= other | | | | | | | | | | |
| | | 5= 12-17 year olds | | .= unknown or 12-17 year olds | | | | | | | | |
| ever been in the US' Armed Forces | service | 1= yes | N/A | 1= on extended active duty in the armed forces | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 2= no | | 2= in a reserves component | | | | | | | | |
| | | 3= yes (logically assigned) | | 3= separated/ retire( | n/a | | | | | | | |
| | | 89= legitimate skip (logically assigned) | | n/a | n/a | | | | | | | |
| | | 95= bad data | | | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| | | 96= multiple responses | | | n/a | n/a | n/a | | | | | n/a |
| | | 97= refused | | | | | | | n/a | n/a | | |
| | | 98= blank (no answer) | | | | | | | | | | |
| | | 99= legitimate skip | | | | | | | | | | |

# NATIONAL HOUSEHOLD SURVEY RESPONSES BEFORE RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE | 1982 | 1988 | 1990 | 1991 | 1992 | 1993 | 1994A | 1994B | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SURVEY YEAR | | | | | | | | | |
| Are you a veteran or a current member of the armed forces? | veteran | 1= yes, a veteran (includes reserves)<br>2= yes, a current member on active duty<br>3= no, neither<br>4= yes, a non-US veteran<br>98= blank (no answer)<br>99= legitimate skip | ✓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ | N/A ↓ |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| **MARIJUANA** | | |
| age when first used marijuana/ hashish | mjage | *age*<br>999= never used marijuana/ never used mj (logically assigned)<br>. = missing |
| # days used mj/ hashish past 12 months | mjyrfreq | 1= more than 300 days (several times a day in past year/ daily in the past year)<br>2= 101 to 300 days (almost daily or 3 to 6 days a week)<br>3= 51 to 100 days (1 or 2 days a week)<br>4= 25 to 50 days (severa times a month- about 25 to 51 days a year)<br>5= 12 to 24 days (1 or 2 times a month)<br>6= 6 to 11 days (every other month or so)<br>7= 3 to 5 days in the past 12 months<br>8= 1 to 2 days in the past 12 months<br>9= did not use mj past 12 months (logically assigned)/ did not use mj in past 12 months<br>999= never used mj (logically assigned)/ never used mj<br>. = missing |
| # days used mj/hashish in past 30 days | mjday30a | *number*<br>999= never used mj (logically assigned)/ never used mj<br>. = missing |
| **COCAINE** | | |
| age when first used cocaine | cocage | *age*<br>999= never used cocaine/ never used cocaine (logically assigned)<br>. = missing |
| # days used cocaine past 12 months | cocyrfrq | 1= more than 300 days/ (daily in past year)<br>2= 101 to 300 days/ (almost daily or 3 to 6 days a week)<br>3= 51 to 100 days/ (1 or 2 days a week) .<br>4= 25 to 50 days/ (several times a month- about 25 to 51 days a year)<br>5= 12 to 24 days/ (1 or 2 times a month)<br>6= 6 to 11 days ( every other month or so)<br>7= 3 to 5 days in the past 12 months<br>8= 1 to 2 days in the past 12 months<br>9= did not use cocaine in past 12 months (logically assigned)/ did not use cocaine in past 12 montl<br>999= never used cocaine/ never used cocaine (logically assigned)<br>. = missing |
| # days used cocaine in past 30 days | cocus30a | *number*<br>999= never used cocaine (logically assigned)/ never used cocaine<br>. = missing |
| **CRACK** | | |
| age when first used crack | crkage | *age*<br>999= never used crack/ never used crack (logically assigned)<br>. = missing |
| # days used crack in past 12 months | crkyrfrq | 1= more than 300 days (every day or almost every day)<br>2= 101 to 300 days (3 to 6 days a week)<br>3= 51 to 100 days (1 to 2 days a week)<br>4= 25 to 50 days (3 to 4 days a week)<br>5= 12 to 24 days (1 to 2 days a month)<br>6= 6 to 11 days (less than one day a month)<br>7= used 3-5 days in past 12 months<br>8= used 1-2 days in the past 12 months<br>9= did not use crack in past 12 months/ did not use crack past 12 months (logically assigned)<br>999= never used crack/ never used crack (logically assigned)<br>. = missing |
| # days used crack past 30 days | crkus30a | *days*<br>999= never used crack/ never used crack (logically assigned)<br>. = missing |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| most recent time used crack | crakrec | 1= within the past 30 days/ use in past 30 days- logically imputed<br>2= more than 30 days ago but within the past 12 months<br>3= more than 12 months ago but within the past 3 years<br>4= more than 3 years ago<br>5= use in past year- logically imputed<br>6= use in lifetime- logically imputed<br>999= never used crack- logically assigned/ never used crack<br>. = missing |
| # vials of crack used in past 30 days | crkam30a | *range*<br>999= never used crack- logically assigned/ never used crack<br>. = missing |
| ever used crack daily for 2 or more weeks | ckdfdaly | 1= yes<br>2= no/ did not use crack in past 3 days<br>999= never used crack- logically assigned/ never used crack<br>. = missing |
| **HEROIN** | | |
| age when first used heroin | herage | *age*<br>999= never used heroin/ never used heroin (logically assigned)<br>. = missing |
| # days used heroin in past 30 days | her30use | *number*<br>999= never used heroin- logically assigned/ never used heroin<br>. = missing |
| **ALCOHOL** | | |
| age when had first drink of alcoholic beverage | alctry | *age*<br>999= never used alcohol/ never used alcohol (logically assigned)<br>. = missing |
| frequency of alcohol consumption in past 12 months | alcpat | 1= more than 300 days (every day or almost every day/ daily)<br>2= 101 to 300 days (3 to 6 days a week/ almost daily)<br>3= 51 to 100 days (1 or 2 days a week)<br>4= several times a month (about 25-51 days a year)<br>5= 12 to 24 days (1 to 2 days a month)<br>6= 6 to 11 days (less than one day a month/ every other month or so)<br>7= 3 to 5 days in the past 12 months<br>8= 1 to 2 days in the past 12 months<br>9= did not use alcohol in past 12 months/ did not use alcohol in past 12 months (logically assigned<br>999= never used alcohol/ never used alcohol (logically assigned)<br>. = missing |
| # days had one or more drinks past 30 | alcdays | *# days*<br>999= never used alcohol (logically assigned)/ never used alcohol<br>. = missing |
| **TOBACCO** | | |
| age when first smoked a cigarette | cigtry | *age*<br>999= never used cigarettes/ never used cigaretts (logically assigned)<br>. = missing |
| age when first started smoking cigarettes everyday | cigage | age<br>999= never used cigarettes/ never used cigarettes- (logically assigned); never used cigarettes every day/ never used cigarettes every day (logically assigned)<br>. = missing |
| number cigarettes smoked per day past 30 days | avcig | 0= did not use cigarettes in past 30 days/ did not use cigarettes in past 30 days (logically assigned<br>1= at least a puff but less than one cig each day<br>2= 1 to 5 cigarettes each day<br>3= 6 to 15 cigarettes (about 1/2 pack) each day<br>4= 16 to 25 cigarettes (about 1 pack) each day<br>5= 26 to 35 cigarettes (about 1 1/2 packs) each day<br>6= 35 or more cigarettes (about 2 packs) each day |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| | | 999= never used cigarettes/ never used cigarettes- logically assigned<br>. = missing |
| number years smoked cigarettes every day | cigyrs | *range*<br>0= smoked cigarettes every day but only for less than 1 yr/ never used cigarettes every day/ never used cigarettes every day- logically assigned<br>999= never used cigarettes/ never used cigarettes- logically assigned<br>. = missing |
| smoked 5 or more packs of cigarettes in lifetime | cig5pk | 1= yes/ yes- logically assigned<br>0= no<br>999= never used cigarettes/ never used cigarettes- logically assigned<br>. = missing |
| number cigarettes smoked daily | packs | 1= one to five cigarettes a day<br>2= about 1/2 pack a day (6-15 cigarettes)<br>3= about a pack a day (16-25 cigarettes)<br>4= about 1 1/2 packs a day (26-35 cigarettes)<br>5= about 2 packs or more a day (over 35 cigarettes)<br>999= never used cigarettes/ never used cigarettes- logically assigned<br>. = missing |
| number months smoked number cigarettes /day in avcig | cigtime | *range*<br>0= no months<br>999= never used cigarettes/ never used cigarettes- logically assigned<br>. = missing |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| primary sampling unit (encrypted) | encpsu | code |
| segment identification number (encrypted) | encseg | code |
| household level identification number (encrypted) | enccase | code |
| interview month | intmonth | 1-12 correspond to months |
| analysis weight | analwt | |
| risk if smoke marijuana once a month | rskmjocc | 1= no risk<br>2= slight risk<br>3= moderate risk<br>4= great risk<br>. = missing |
| risk if smoke marijuana once or twice a week | rskmjreg | 1= no risk<br>2= slight risk<br>3= moderate risk<br>4= great risk<br>. = missing |
| risk if use cocaine once a month | rskcococc | 1= no risk<br>2= slight risk<br>3= moderate risk<br>4= great risk<br>. = missing |
| risk if use cocaine once or twice a week | rskcocreg | 1= no risk<br>2= slight risk<br>3= moderate risk<br>4= great risk<br>. = missing |
| total personal income recode (13 categories) | per_inc | 1= $0<br>2= $1- $4,999<br>3=$5,000- $6,999<br>4= $7,000- $8,999<br>5= $9,000-$11,999<br>6=$12,000-$14,999<br>7=$15,000-$19,999<br>8=$20,000- $24,999<br>9=$25,000- $29,999<br>10= $30,000-$39,999<br>11=$40,000-$49,999<br>12=$50,000 and over<br>pinc_skp=1 if per_inc was 'legitimate skip'<br>. = missing |
| total family income recode (13 categories) | fam_inc | 1= $0<br>2= $1- $4,999<br>3=$5,000- $6,999<br>4= $7,000- $8,999<br>5= $9,000-$11,999<br>6=$12,000-$14,999<br>7=$15,000-$19,999<br>8=$20,000- $24,999<br>9=$25,000- $29,999<br>10= $30,000-$39,999<br>11=$40,000-$49,999<br>12=$50,000-$74,999<br>13=$75,000+<br>. = missing<br>finc_skp=1 if fam_inc was 'legitimate skip' |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| health in general | health | 1= excellent<br>2= very good<br>3= good<br>4= fair<br>5= poor<br>. = missing |
| felt depressed 2 weeks or more in past 12 months | depress | 1= yes/ yes (logically assigned)<br>0= no/ no (logically assigned)<br>. = missing<br>depskp=1 if depress was 'legitimate skip' |
| # weeks felt depressed in past 12 months | depwks1 | # weeks<br>. = missing<br>depwkskp=1 if depwks1 was 'legitimate skip' |
| period longer than 1 month felt anxious past year | worried | 1= yes/ yes (logically assigned)<br>0= no/ no (logically assigned)<br>. = missing<br>worrskp=1 if worried was 'legitimate skip' |
| # months before anxiety ended- recode | wornomo1 | # months<br>. = missing<br>anxskp=1 if wornomo1 was 'legitimate skip' |
| is there usual place for health care | careusu | 1= yes/ there is more than one place<br>0= no<br>. = missing |
| covered by medicare | medicare | 1= yes<br>0= no<br>. = missing |
| covered by medicaid | medicaid | 1= yes<br>0= no<br>. = missing |
| covered by champus, champva, va, military | champus | 1= yes<br>0= no<br>. = missing |
| covered by private insurance or hmo | prvhltin | 1= yes/ yes (logically assigned)<br>0= no<br>missing |
| private health insurate plan or hmo include coverage for treatment for alcohol abuse or alcoholism | hltinalc | 1= yes<br>0= no<br>. = missing<br>halcskp=1 if hltinalc is 'legitimate skip' |
| private health insurate plan or hmo include coverage for treatment for drug abuse | hltindrg | 1= yes<br>0= no<br>. = missing<br>hdrgskp=1 if hltindrg is 'legitimate skip' |
| private health insurate plan or hmo include coverage for treatment for mental or emotional difficulties | hltinmnt | 1= yes<br>0= no<br>. = missing<br>hmntskp=1 if hltinmnt is 'legitimate skip' |

## NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
### (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| race/ hispanic-origin recode | white | 1= yes, race-white<br>0= no |
| | black | 1= yes, race-black<br>0= no |
| | hispan | 1= yes, race- hispanic<br>0= no |
| | othrc | 1= yes, other race (not white, not black, not hispanic)<br>0= no |
| sex- imputation revised | irsex | 1= male<br>0= female |
| irsex indicator | iisex | 1= sex from questionnaire/ sex from source file<br>2= sex from relationship on roster<br>3= sex from roster<br>4= sex statistically imputed<br>5= sex from screener |
| imputation revised age of respondent | irage | *age* |
| irage indicator | iiage | 1= age from birthdate<br>2= age from cover of questionnaire/ age from source file/ age calculated from questionnaire<br>3= age from roster<br>4= age statistically imputed using ages gr from roster/ age imputed<br>5= age taken from screener |
| last grade completed in school | educ | 0=no schooling<br>1= first grade....12= twelfth grade<br>13= freshman/ 13th year<br>14= sophomore/ 14th year<br>15= junior/ 15th year<br>16= senior/ 16th year<br>17= graduate/ professional school (or higher)<br>. = missing<br>**educskp=1 if educ was 'legitimate skip'** |
| evidence of high school completion (Have you received a hs diploma, or a GED certificate of hs completion?) | diploma | 1= high school diploma/ GED certificate<br>0= Neither of the above<br>. = missing<br>**dplmskp=1 if diploma was 'legitimate skip'** |
| current marital status | married | 1= married<br>0= otherwise |
| | divorced | 1= divorced<br>0= otherwise<br><br>**marrskp=1 if marital was 'legitimate skip'** |
| work status- imputation indicator | iiworkst | 1= questionnaire data<br>2= logically imputed data<br>3= statistically imputed data |

# NATIONAL HOUSEHOLD SURVEY RESPONSES AFTER RECODING
## (NON-DRUG VARIABLES)

| LABEL | VARIABLE | RESPONSE |
|---|---|---|
| work status- imputation revised | **irworkst** | 1= working full-time, 35 hours or more a week<br>2= woking part-time, less than 35 hours a week<br>3= have a job, but not at work, illness/maternity<br>4= have a job but not at work b/c it is seasonal<br>5= unemployed or laid off and looking for work<br>6= unemployed or laid off and not looking for work<br>7= full time homemaker<br>8= in school only<br>9= retired<br>10= disabled for work<br>11= other, in labor force<br>12= other, not in labor force |
| employment status recode | **empstat2*** | 1= full time/ part time<br>0= unemployed/ other/ 12-17 year olds<br>**emp_teen=1 if empstat is a 12-17 year old** |
| ever been in the US' Armed Forces | **service** | 1= yes/ yes (logically assigned)<br>0= no<br>. = missing<br>**servskp=1 if service is legitimate skip** |
| Are you a veteran or a current member of the armed forces? | **veteran** | 1= yes, a veteran (includes reserves)/ yes, a current member on active duty/ yes, a non-U.S. veteran<br>0= no, neither<br>. = missing<br>**vetskp=1 if veteran is legitimate skip** |

APPENDIX B

# Loglikelihood Function

We want to estimate three equations

$$\begin{aligned} I &= Z\beta + u & (1)\\ \ln t &= X\alpha + \epsilon & (2)\\ d^* &= Y\gamma + \nu & (3) \end{aligned}$$

Probability of using drug when $t \to +\infty$ is determined by equation (1). The probability is

$$Q = G(Z\beta),$$

with density function $g(Z\beta)$.

The random variable $u$ is assumed to be independent of $\epsilon$ and $\nu$, while $\epsilon$ and $\nu$ are assumed to be bi-normal with standard deviations $\sigma_\epsilon$ and $\sigma_\nu$, and correlation coefficient $r$. Denote the CDF and PDF of standard normal distribution by $\Phi$ and $\phi$, respectively. Then the conditional distribution of $d^*$ given $\ln t$ is

$$d^* \,|\ln t \sim N\left(Y\gamma + \frac{r\sigma_\nu}{\sigma_\epsilon}(\ln t - X\alpha), \sigma_\nu^2(1 - r^2)\right).$$

Assume there are $n$ categories of drug use for the group of people who tried drug in the past. Including the interval of non-use, there are $n$ cut-off points.

$$\rho_{k-1} \le d^* < \rho_k, \quad k = 0, 1, \ldots, n.$$

Note that we set

$$\rho_{-1} = -\infty, \quad \rho_0 = 0, \quad \rho_n = +\infty.$$

Denote the current age by $age$ and the age of the first use of drug by $t_f$. Denote the set of persons who tried drug in the past by $E$ and the set of persons who never tried drug by $N$. The log-likelihood function is

$$L = \sum_{i \in N} L_i^N + \sum_{i \in E} L_i^E,$$

where

$$L_i^N = \ln\left[G(Z\beta)\left(1-\Phi\left(\frac{\ln age - X\alpha}{\sigma_\epsilon}\right)\right) + (1-G(Z\beta))\right] \tag{4}$$

and

$$\begin{aligned} L_i^E = {} & \ln G(Z\beta) + \ln\phi\left(\frac{\ln t_f - X\alpha}{\sigma_\epsilon}\right) - \ln\sigma_\epsilon - \ln t_f \\ & + \ln\sum_k I^i(k)\left[\Phi\left(\frac{\rho_k - \left(Y\gamma + \frac{r\sigma_\nu}{\sigma_\epsilon}(\ln t_f - X\alpha)\right)}{\sigma_\nu\sqrt{1-r^2}}\right)\right. \\ & \left. -\Phi\left(\frac{\rho_{k-1} - \left(Y\gamma + \frac{r\sigma_\nu}{\sigma_\epsilon}(\ln t_f - X\alpha)\right)}{\sigma_\nu\sqrt{1-r^2}}\right)\right] \end{aligned} \tag{5}$$

where $I^i(k) = 1$ if person $i$ is in $k$th category; $I^i(k) = 0$ otherwise.

Note that the parameters $\gamma$ can only be identified up to a fraction of $\sigma_\nu$. So we set

$$\sigma_\nu = 1.$$

Also we transform $r$ and $\sigma_\epsilon$ according to

$$\sigma_\epsilon = e^\eta, \quad r = \frac{2}{\pi}\arctan(\xi)$$

so that $\eta$ and $\xi$ can change freely on the real line while keeping $\sigma_\epsilon$ positive and $r$ in $(-1, 1)$. So the parameters to be estimated are

$$\alpha, \beta, \gamma, \eta, \xi, \rho_1, \cdots, \rho_{n-1}.$$

## Gradients

First we calculate the gradients of $L_i^N$ with respect to $\alpha, \beta$ and $\eta$. Define

$$\begin{aligned} B_a &\equiv \frac{\ln age - X\alpha}{e^\eta} \\ A &\equiv G(Z\beta)(1-\Phi(B_a)) + (1-G(Z\beta)) \end{aligned}$$

So we have

$$\begin{aligned}
\frac{\partial L_i^N}{\partial \alpha} &= \frac{G(Z\beta)}{Ae^{\eta}}\phi(B_a)X \\
\frac{\partial L_i^N}{\partial \beta} &= -\frac{g(Z\beta)}{A}\Phi(B_a)Z \\
\frac{\partial L_i^N}{\partial \eta} &= \frac{G(Z\beta)}{A}\phi(B_a)B_a
\end{aligned}$$

We define the following notations.

$$\begin{aligned}
B_f &\equiv \frac{\ln t_f - X\alpha}{e^{\eta}} \\
\tau_k &\equiv \frac{\rho_k - (Y\gamma + rB_f)}{\sqrt{1-r^2}} \\
C &\equiv \sum_k I^i(k)(\Phi(\tau_k) - \Phi(\tau_{k-1})) \\
D &\equiv \frac{1}{C\sqrt{1-r^2}}\sum_k I^i(k)(\phi(\tau_k) - \phi(\tau_{k-1})) \\
E &\equiv \sum_k I^i(k)(\phi(\tau_k)\tau_k - \phi(\tau_{k-1})\tau_{k-1})
\end{aligned}$$

Then $L_i^E$ changes to

$$L_i^E = \ln G(Z\beta) + \ln \phi(B_f) - \eta - \ln t_f + \ln C.$$

So we have

$$\begin{aligned}
\frac{\partial L_i^E}{\partial \alpha} &= (B_f + rD)\,X/\sigma_\epsilon \\
\frac{\partial L_i^E}{\partial \beta} &= \frac{g(Z\beta)}{G(Z\beta)}Z \\
\frac{\partial L_i^E}{\partial \gamma} &= -DY \\
\frac{\partial L_i^E}{\partial \eta} &= B_f^2 + rDB_f - 1 \\
\frac{\partial L_i^E}{\partial \xi} &= \frac{2/\pi}{(1+\xi^2)}\left(\frac{r}{C\sqrt{1-r^2}}E - B_fD\right) \\
\frac{\partial L_i^E}{\partial \rho_k} &= \frac{I^i(k) - I^i(k-1)}{C\sqrt{1-r^2}}\phi(\tau_k)
\end{aligned}$$