A PLAN FOR ESTIMATING THE NUMBER OF "HARDCORE" DRUG USERS IN THE UNITED STATES

PRELIMINARY FINDINGS

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EXECUTIVE SUMMARY

Background. In October 1993, the Office of National Drug Control Policy contracted with Abt Associates to develop a method for monitoring the size and composition of the "hardcore" drug using population in the United States. Members of this population are by definition heavy users of heroin, powder cocaine, and crack cocaine.[1] The initiative stemmed largely from concerns that had been raised regarding the ability of the National Household Survey on Drug Abuse, and other Federally sponsored data collection systems, to reach and elicit accurate responses from these individuals.

People who are heavily involved in drug use often refuse to admit that they engage in such activity, and they are characteristically difficult to locate for an interview. These problems—of veracity and access, respectively—tend to produce negative bias in any estimates of size that are made with survey data gathered by conventional means. The resulting absence of reliable information on the number of hardcore drug users makes rigorous evaluation of our national supply and demand reduction initiatives virtually impossible.

The proposed solution. In response, we developed an approach that allows the size of the hardcore drug using population to be estimated by interviewing only admitted hardcore drug users at locations where they are likely to be found in substantial numbers. Such places include booking facilities, drug treatment programs, and residential homeless shelters. The method allows the probability of respondent selection to be determined *subsequent* to the interview.

We question people who are admitted hardcore drug users about the characteristics of their drug use careers, asking them to recount the frequency with which they made contact with various kinds of institutions during some preceding period of time. The information is used to estimate the rate at which such contacts occur. This is one component of the procedure.

We also collect information on the total number of contacts of each kind that are generated by hardcore drug users. These estimates are based upon a random sample of all individuals who appear at a representative sample of sites during some period of time. Bias inherent in self-reported responses to our questions about drug use is measured using hair radioimmunoassay results.

Having estimated both the rate at which hardcore drug users generate contacts, and the total number of contacts that are generated, we can in turn estimate the size of the hardcore drug using population—it is simply the total number of contacts divided by the estimated rate of contact. This is the essence of the approach.

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[1]We employ a consumption-based operationalization of hardcore drug use. It is this: The use of heroin, powder cocaine, or crack cocaine on eight or more days during at least one of the preceding two months.

The feasibility study. The proposed methodology was reviewed by a panel of national experts and determined to be scientifically sound. Our own simulation studies provided corroborating support for this conclusion. But there were some reservations about the operational viability of the technique, which would require gaining access to booking facilities, public and private drug treatment programs, and residential homeless shelters, and securing the cooperation of drug users who would be found there. The Office of Management and Budget therefore recommended that a feasibility study be conducted as a precursor to any large scale initiative that might be contemplated by the Office of National Drug Control Policy. We evaluated a number of alternative locations for the feasibility study, and eventually selected Cook County, Illinois. This location had the advantage of including a large city (Chicago) as well as diverse suburban areas, with state and local agencies that were supportive of the project. Overall, we found that the proposed approach is operationally feasible, although much was learned about the potential pitfalls of both implementation and estimation from the exercise.

Findings. Difficulty of site recruitment varied by site type. Booking facilities proved to be particularly problematic in this regard, and it was not possible to recruit a sample of precinct-level sites as originally planned. Members of the Chicago Police Department were quite concerned about interviewer safety, and thought that it would be better if we could conduct our operations in some more controlled setting. Arrangements were eventually made to collect data at Cook County Jail, and this had both positive and negative consequences. Event volume there was enormous, which made for efficient data collection. At the same time, some revisions in our instruments were made necessary by the change in our sampling plan, and special provisions had to be made in order to ensure that the data we collected were appropriately weighted. Data collection posed a number of challenges, but none were insurmountable, and the mean weighted response rate for screening interviews was about 64 percent.

We were able to gain access to both privately and publicly funded drug treatment programs in Cook County. The recruitment process for these sites was coordinated by the Illinois Department of Alcoholism and Substance Abuse. There were no particular problems associated with data collection in these settings, and the mean weighted response rate for screening interviews was about 74 percent.

Residential homeless shelters were perhaps most easily recruited into the sample. But data collection was made difficult by the dynamics of resident movement. Individuals tended to arrive *en masse* over a relatively short period of time, and were required to register anew each night. This meant that the development of case rosters (which provided the basis for respondent selection) often required a frantic level of activity on the part of interview staff. The physical characteristics of the facilities were sometimes not conducive to our work, and minor revisions in data collection procedures were required. The mean weighted response rate for screening interviews was about 67 percent.

Data collection began in March 1995, and ended in November 1995. The time at each site ranged from a few days to several months. While in the field, we recorded information on 28,539 arrest, treatment admission, and shelter stay events. More detailed information on drug use was collected for a sample of 2,752 of these events, and complete life histories were constructed for a subsample of 992 events.

Information gathered from people who had been arrested, from people who had been admitted to drug treatment, and from people who had spent the night at a residential homeless shelter was used to produce three separate estimates of the size of the (same) hardcore drug using population. These estimates should all be consistent, and indeed this consistency may be taken as a measure of the success of our modeling exercise.

The approach yields an estimate of about 333 thousand based upon arrests, an estimate of about 318 thousand based upon treatment admissions, and an estimate of about 53 thousand based upon shelter stays. We know that the last estimate is flawed, and we have strong reason to believe that it has to do with a question which asked respondents to distinguish between certain types of shelters that they saw as the same.

The range 318 thousand - 333 thousand is much higher than conventional surveys would suggest, but it is certainly not implausible. Recent survey-based estimates provided by the Substance Abuse and Mental Health Services Administration suggest that there are 117 thousand recent (and not necessarily hardcore) users of illicit drugs other than marijuana in the Chicago Metropolitan Statistical Area. Our estimate of the number of hardcore drug users in Cook County is about three times higher. As discussed in the main text, undercounts of this magnitude are quite consistent with previous research.

At the same time, our estimates should be treated with some caution. We have not determined the error of estimate, nor have we explored the sensitivity of our results to alternative specifications of the models that were used to estimate event rates and to make various radioimmunoassay-based adjustments. Further, and as expected, the feasibility study did indicate a number of improvements that might be made in sampling design, data collection and model specification. These caveats do not challenge the basic finding of this study: that the approach is feasible and appears to address the known limitations of conventional survey research.

A PLAN FOR ESTIMATING THE NUMBER OF "HARDCORE" DRUG USERS IN THE UNITED STATES

PRELIMINARY FINDINGS

OVERVIEW

The Federal government has pursued a host of major policy initiatives in an effort to reduce the number of drug users in the United States. These have involved ambitious programs focusing on both supply and demand reduction. While the efforts are believed to have been effective, it is difficult to measure their success empirically due to the absence of reliable information on the number of hardcore drug users.

Existing surveys tend to underestimate the size of this population. Drug use is both illegal and socially disapproved, so people are understandably hesitant to answer questions about their behavior in this area. The *veracity* of self-reported information is therefore suspect. In addition, many drug users are not easily reached by conventional sampling methods, since they do not have telephones or permanent homes. *Access* therefore becomes an issue.

In response to these apparent weaknesses in conventional survey methods, a number of researchers have used data from other sources to derive estimates of the number of hardcore drug users. Reduced to their common form, these efforts rely upon models of the rate at which people who use drugs make contact with various elements of the criminal justice, drug treatment, and health care systems. The models are predicated on the belief that *observed* numbers of "institutional contacts"—and by this we mean numbers of arrests, drug treatment admissions, and stays at homeless shelters—can tell us something about *unobserved* drug use activity.

In October of 1993, the Office of National Drug Control Policy (ONDCP) contracted with Abt Associates to develop and test a model-based technique for estimating the number of hardcore drug users in the United States. Our progress is summarized in this report. Section 1 describes the problems that are inherent in estimating the size and characteristics of the hardcore drug using population, and explains how these problems are addressed by the approach taken here. Section 2 offers a more formal mathematical description of the estimation procedure (which is continued in Appendix A). Section 3 discusses sampling and data collection, and Section 4 presents the results of our analysis.

1. LIMITATIONS OF EXISTING SURVEY RESEARCH

Each year, the Federal government conducts several large scale population surveys intended to measure the prevalence of drug use in the United States. One of these is the National Household Survey on Drug Abuse (NHSDA). The survey provides coverage of the household population using confidential in-person interviews. In 1994 it included more than 17,800 respondents. Another is the Monitoring the Future Study (commonly known as the High School Senior Survey), which has been conducted annually for 21 consecutive years. Taken together, the results of these two surveys provide a description of the prevalence of drug use in the general population of the United States. While the information from these studies has been of some value in assessing the impact of Federal initiatives, experts agree that their utility is limited. This is because no conventional survey can successfully measure the size of the most recalcitrant and heavily involved population of drug users. There are two basic reasons for this.

First, people engaged in drug use—particularly of heroin, powder cocaine and crack cocaine—may be reluctant to acknowledge this activity within the context of the research interview. Drug use is illegal, and in addition, some level of stigma is attached to certain forms of drug using behavior, such as injection. It is therefore not surprising that a substantial body of literature has demonstrated that a wide discrepancy exists between self-reports of drug use and laboratory test results for the same individuals (Wish, et al., 1986; Hubbard, et al., 1989; Toborg, et al., 1989; Harrison, 1990; Wish, O'Neil, and Baldau, 1990; Mieczkowski, 1992). We call this *the problem of veracity*.

Second, when conducting general population surveys it is often difficult to find individuals who are heavily involved in drug use. Our analysis of NHSDA data indicates that many drug users are hidden to this survey because they have no stable residence. We applied the criterion used for inclusion in the NHSDA to the almost 50,000 drug users interviewed in the National AIDS Demonstration Research (NADR) projects (Brown and Beschner, 1993), and found that between one-third and two-thirds of these individuals would not have been eligible to be interviewed in the NHSDA because they were homeless or living in transient situations at the time of the interview. We call this *the problem of access.*

1.1 Addressing The Problems Of Veracity And Access

In designing an analysis plan and data collection strategy, it was necessary to address the two problems discussed above—that people tend to underreport drug use and that people involved in drug use tend to be difficult to locate. The approach taken here solves these problems by *allowing us to interview admitted drug users in places where they are most likely to be found*. These include booking facilities, public and private drug treatment programs, and homeless shelters.

First, we address the problem of veracity. One component of the model is the rate at which drug users generate events of each kind. We assume that people who are willing to admit that they are drug users will be candid in answering other questions about their pasts. We therefore go to a random sample of sites where respondents are likely to be found, and select at each site a random sample of individuals who are willing to self-disclose. We ask these individuals to tell us about the number of times that they had contact with selected institutions during some period of time. This information allows us to determine the rate at which such contacts are made.

The other component of the model is the total number of events of each kind that are generated by drug users. We know that not all drug users who make contact with these institutions will be forthcoming about their behavior. We therefore test the hair of a random sample of people who appear at selected sites to estimate the proportion of events of each kind that are attributable to members of the target population. Then we multiply each proportion times the corresponding total number of events to estimate the number of events of each kind that are generated by drug users. *This means that the components of the model are relatively unaffected by self-report bias.*

Second, we address the problem of access. The two sources of information identified above (rates and numbers of institutional contacts) allow us to infer the total number of drug users who were active during the primary data collection period. It is simply the sum over the number of events of a given kind divided by the corresponding rate at which such events are generated. In practice, the estimation procedure gets quite a bit more complicated than this, because the events under study are not really independent. But the point is that our method allows us to make inferences about the size of the drug using population *in toto* by interviewing people found at a few carefully chosen places.

2. ANALYTIC APPROACH

The approach that we take may be summarized in the following manner. Say that we have an estimate of n_A, the rate at which hardcore drug users generate arrest events over some period of time. Assume that we also have an estimate of N_A, the total number of arrests that are generated by hardcore drug users over this same period of time. Then we can estimate H, the size of the hardcore drug using population, as:

$$\hat{H} = \frac{\hat{N}_A}{\hat{n}_A} \tag{1}$$

We estimate the number of hardcore drug users by dividing the estimated total number of qualifying events by the estimated rate at which hardcore drug users generate such events. This is the essence of our approach. Among sampling statisticians, the general technique is called ratio estimation (see Cochran, 1977). The closed-system capture-recapture model that has been broadly applied in the field of drug use prevalence estimation is a special case of ratio estimation.

2.1 Estimating *n*, The Rate At Which Events Are Generated

Developing an estimate of n requires that we specify a model of the process by which events are generated. Our model builds upon theoretical work that characterizes the careers of individuals heavily involved in drug use (see Dai, 1937; Becker, 1963; Waldorf, 1973; Anglin and Speckart, 1986; Maddux and Desmond, 1986; Simpson and Marsh, 1986; Nurco, et al., 1988; Hanlon, et al., 1990). As defined here, a drug use career begins the first time that an individual uses drugs at or above some operational threshold. The drug user experiences various kinds of *events* during the course of his career. Events are for our purposes considered to be instantaneous. Thus, the moment that an individual first passes the threshold may be thought of as an event, as may the moment of each succeeding pass below and above this threshold. Other events include arrests, admissions to drug treatment, and stays at homeless shelters. Events may engender states that have duration. Some of these include being "in use," in jail, in drug treatment, and in a shelter. The occurrence of certain events is made more or less probable by the existence of certain states. It is not likely, for example, that someone will be arrested while he is in the hospital.

To illustrate this approach, we consider a very simple career model that includes only arrest events. We assume that the j^{th} drug user generates arrest events at a rate determined by the function $Ar_j(t)$. Our objective is to estimate n_A, the mean number of events generated by each of H active hardcore drug users over the period t_1 to t_2.[2] That is:

$$n_A = \frac{\sum_{j=1}^{H} \int_{t_1}^{t_2} \hat{A}r_j(t)\ dt}{H} \tag{2}$$

If we had a simple random sample of hardcore drug users, and were able to determine the total number of times that each person had been arrested during the period t_1 to t_2, this would be easy. We could just determine the average number of arrests per drug user, per unit of time, and this would be our estimate. That is:

$$\hat{n}_A = \frac{\sum_{j=1}^{J} n_{Aj}}{J} \tag{3}$$

where J is the sample size, and n_{Aj} is the number of times that the j^{th} sampled hardcore drug user was arrested during the period t_1 to t_2. Even if we had a random sample with unequal sampling weights, the problem would not be much harder. We would merely adjust the average number of arrests per drug user, per unit of time, by the sample selection probabilities. In fact, our method involves precisely this procedure, except that we do not know the sample selection probabilities in advance of data collection. These probabilities are instead estimated after the fact. To demonstrate this, imagine that we draw a simple random sample of hardcore drug users arrested during the period t_1 to t_2. Since this is a sample of arrested individuals, we can no longer use the arrest rate for an individual to estimate the expected number of arrests. Instead:

$$E(n_{Aj} \mid n_{Aj} \geq 1) = \frac{E(n_{Aj})}{1 - p_{0j}} \tag{4}$$

where $(1\text{-}p_{0j})$ is the probability that the j^{th} hardcore drug user is arrested one or more times during the period t_1 to t_2. Thus our estimate of $E(n_A)$ is:

[2] A person is said to have an active career is he is using drugs at or above threshold level.

$$\hat{E}(n_{Aj}) = (1 - p_{0j})\, n_{Aj} \tag{5}$$

where n_{Aj} is the observed number of arrests for the j^{th} sampled hardcore drug user arrested during the period t_1 to t_2.

If we want to project the results for this sample to the entire population of hardcore drug users, then we must weight the sample estimates of $E(n_A)$ by the inverse of the probability that the user was sampled. Thus:

$$w_j = \frac{1}{f(1 - p_{0j})} \tag{6}$$

where w is the weight, and f is the sampling rate for arrested hardcore drug users. Our estimate of n_A is therefore:[3]

$$\hat{n}_A = \frac{\sum_j w_j \hat{E}(n_{Aj})}{\sum_j w_j} = \frac{\sum_j \frac{1}{(f(1 - p_{0j})}(1 - p_{0j}) n_{Aj}}{\sum_j \frac{1}{f(1 - p_{0j})}} = \frac{\sum_j n_{Aj}}{\sum_j \frac{1}{1 - p_{0j}}} \tag{7}$$

In order to estimate n_A, however, we need to determine p_{0j} (the probability that the j^{th} hardcore drug user is not arrested during the period t_1 to t_2). This is accomplished by estimating the parameters of a model of the process that generates arrest events. By way of example, consider a relatively simple specification for $Ar(t)$, that it is constant at λ_j for the j^{th} drug user. Further, assume that $\lambda_j = f(X_j, \beta)$. That is, λ is a function of a vector of variables (X) that distinguish drug users from each other, and a vector of parameters (β). This formulation is for exposition only, because in real applications we would assume that $Ar(t)$ follows a more general form. Given the assumptions above, we can write the expected rate of arrest for the j^{th} drug user as:

$$E(n_{Aj} | X_j, \beta, n_{Aj} \geq 1) = \frac{\lambda_j (t_2 - t_1)}{e^{\lambda_j t_2 \; t_1}} \tag{8}$$

[3] In this case, $\hat{n}_A$ reduces to $\hat{N}_A / \hat{H}_A$ where $\hat{H}_A = \sum w_j$ and $\hat{N}_A$ is the estimate of the total number of arrests involving hardcore drug users. Thus our estimate of H reduces to $\hat{H} = \hat{H}_A$. This is not true of our actual estimates of n_A, which are based on samples generated by other events in addition to arrests.

Appendix A describes our actual estimation procedure in some detail, and it differs from the example given above in several ways. First, we use a much more flexible specification for *Ar(t)*, allowing both for changes in *Ar(t)* from one arrest to the next, and for a range of functional forms.

Second, we do not assume that the population of hardcore drug users is fixed over the sampling period. Rather, we adopt a steady state assumption—meaning that the size and composition (in terms of *X*) of the population are constant, whereas the individuals themselves may change over time.[4]

Third, we do not sample individuals and collect information on their arrests during the period t_1 to t_2. Instead, we sample arrests throughout the period. This changes—and simplifies—both the likelihood function used to estimate β, and the development of weights for sampled individuals.

Fourth, and perhaps of greatest substantive importance, our estimate of any one event rate is based upon information from all three event samples (arrests, drug treatment admissions, and shelter stays). This addresses an important limitation of the procedure described above. If some hardcore drug users have a near-zero probability of being arrested, then they are unlikely to appear in the arrest sample. The existence of such individuals means that we could never estimate the total population of drug users if we sampled only on arrests. But if we incorporate information on the rate of arrest gathered from individuals who appear at drug treatment programs and homeless shelters as well, then we will fail only to represent individuals with a near-zero probability of appearing at *any* of these places during the data collection period. To the extent that there are such people, we will tend to overestimate the event rates, and thus underestimate the size of the population.

2.2 Estimating *N*, The Number Of Events Generated

Information on the total number of arrests, treatment admissions, and shelter stays may be available as a product of the management information systems maintained by local and state criminal justice agencies, drug treatment agencies, and in some cases homeless shelters. Unfortunately, this information cannot provide us with measures of the number of events generated by drug users. This is because many arrest, drug treatment admission, and shelter stay events are generated by individuals who are *not* hardcore drug users.

[4]This steady state assumption could be relaxed if we sampled all sites and events for the same period.

This means that a sample of individuals must be drawn as they generate institutional contact events, and that their drug use must be assessed—thereby allowing us to estimate the proportion of all events that are produced by members of the drug using population.

But we remain concerned about the accuracy of self-reported drug use. While it may be reasonable to believe that people who are interviewed at drug treatment programs will be candid in their reporting, the same may not be said for people who are interviewed in booking facilities and homeless shelters.

We address the veracity problem by estimating the bias that exists in self-reports of drug use. This involves calibrating drug use as recorded on our respondent screening instrument against the results of hair radioimmunoassays. The procedure that we follow is described in greater detail in Section 4.2.

This part of the exercise uses a more conventional sample selection and weighting procedure than that used in estimating n_A, in that the selection probabilities (for sites and for individuals within sites) are known at the outset. It assumes only that we make use of a probability sample of sites, and that we are able to gather information from a randomly selected sample of individuals within these sites.

As with all surveys, some assumptions must be made about non-respondents. We assume that non-respondents are a random subsample, and therefore that respondents can be used to estimate parameters for the entire sample. In using the hair radioimmunoassay results, we assume that individuals who are asked to provide a hair specimen and who refuse are no more prone to drug use (or to data reporting) than individuals who are asked to provide a hair specimen and who agree.

3. SITE SELECTION, RESPONDENT SELECTION, AND WEIGHTING

The following sections outline the approach that we take to sampling. A summary of operational details is provided in a separate technical report. Generally, we make use of a two stage procedure, which involves:

Stage 1: *Selecting sites* to serve as data collection points. Again, these data collection points include booking facilities, drug treatment programs (both public and private), and homeless shelters.

Stage 2: *Selecting respondents* who appear at data collection points. An individual may appear more than once in our sample, and that this is accommodated by our modeling procedures.

3.1 Site Selection

As noted earlier, we sampled at three site types—booking facilities, drug treatment programs, and homeless shelters. Each site type sample was stratified as described below. Sites were drawn within strata with probability proportional to size, using information on prior year event volume as our measure. Thus, the probability of selection for any site is given by zw, where:

z = the proportion formed by dividing the number of events generated at a particular site by the total number of events generated by all sites in the stratum; and

w = the number of sites that are drawn within the stratum.

Booking facilities. Chicago authorities prohibited our interviewing people anywhere but in the Cook County Jail, where (for all intents and purposes) felons but not misdemeanants are processed. This had several consequences for the analysis, one of which must be discussed here: self-reports and hair assays were available only for people who were booked as felons, while we need to know the percentage of all arrestees (felons and misdemeanants) who are hardcore drug users. There seemed to be no alternative to assuming that the percentage of hardcore drug users among felons was the same as the percentage of hardcore drug users among misdemeanants. This assumption is not testable directly, but available evidence suggests that it is reasonable.

Cook County authorities provided a breakdown of arrests by arrest charge for adults in Cook County. We compared this breakdown with the distribution of charges from past arrests as reported in our data collection instruments. In making this comparison we discarded the arrest that got the respondent into the jail sample (because this had to be a felony) and then we weighted the distribution for the remaining offenses to reflect sampling probabilities. The resulting distribution was very similar to the distribution provided by Cook County authorities, and we therefore concluded that for our purposes the sample of felony arrestees was representative of all arrestees in Cook County.

Drug treatment programs. Sites were first stratified by type (ambulatory programs, detoxification programs, and residential programs). The ambulatory programs and detoxification programs were each further stratified by geographic area (using two areas for ambulatory programs and four for detoxification programs). In addition, we organized the sampling over all treatment programs to ensure that the sample included both publicly and privately funded programs. Samples were drawn of five ambulatory programs, five detoxification programs, and one residential program.

Homeless shelters. Eight sites were included in the sample. Three were drawn with certainty and are self-representing. The remaining five were drawn with probability proportional to size within each of three strata, including overnight shelters and warming centers in Chicago, and all suburban sites.

3.2 Respondent Selection

Individuals were sampled within each site as depicted in Figure 1, and described in the associated box. We project our sample estimates to a common reference interval (one year), treating the specific sampling period at any site as representative of all such periods that might exist within the reference interval. Accordingly, the sample weights for observations at a site are inversely proportional to the duration of the period over which the site operations were conducted, as well as the site selection probability, the respondent selection rates, and the response rates.

Our plan for respondent selection was designed to allow enough LHIs to be gathered to support estimation of *n* for each of the three event types. In developing this plan, certain assumptions were made about the duration of data collection, and about the event volume and response rates that would obtain at each site.

As might be expected, there were some discrepancies between these assumptions and reality. To expedite completion of the feasibility study, we did not select replacement sites after data collection began, nor did we return to a site after data collection had been completed there. Instead, we extended the duration of data collection and adjusted initial selection intervals in order to ensure an adequate yield. While this was deemed appropriate for a feasibility study, it is not a procedure that we would normally follow, since accommodations of this kind can result in increased errors of estimate.[5]

[5]Extending data collection in some sites with unexpectedly low volumes (or response rates) reduces the individual weights in those sites, and increases the variation in these weights. In fact, variation in weights was potentially troublesome only for the homeless shelters, where two sites with roughly five percent of the Screener sample and eight percent of the LHI sample accounted for about 41 percent of the Screener weights and about 58 percent of the LHI weights.

We explored the effects of variation in weights by re-estimating with equal weights within each event type. Using equal weights increased each of the three estimates of the number of hardcore durg users by 48 percent. This suggests that there is substantial inter-site variation, and that the extreme variation in weights within the shelter sample is probably associated with a materially increased error of estimate. Accordingly, sampling designs for this sort of study should attempt to develop accurate measures of size and avoid procedures that exacerbate variation in weights.

Figure 1: The Data Collection Process

(1) A case roster identifies a set of individuals who are eligible to be included in the study by virtue of the fact that they appeared during a selected shift. Individuals are in turn selected from this list at some interval. We denote the reciprocal of this interval as r^1.

A selected individual is approached, and the purpose of the study is explained. The individual is told that as part of the interview process, it may be necessary to take a small sample of his hair. Where appropriate, we also offer token remuneration.

Not everyone who is approached agrees to participate in the study, and the rate at which people opt to continue beyond this point is denoted r^2. An individual who chooses to continue is administered a self-report Screener.

(2) The Screener first asks a number of questions that allow us to determine whether the respondent has used any of the drugs that are of interest to us (at any level) during the past two months.

If the response is yes, it then asks a number of questions that allow us to determine whether the individual has used any of the drugs that are of interest to us at or above the hardcore threshold. A copy of the Screener is provided as Appendix B of this report.

In order to qualify for further consideration, the individual must have used *heroin, powder cocaine, or crack cocaine on eight or more days during at least one of the preceding two months*. The rate at which individuals screen positive at this point is denoted r^3.

All individuals who admit to above threshold use are asked to complete the LHI, and therefore the reciprocal of this selection interval, denoted r^4, is 1.00. Not everyone who is approached agrees to participate, and the rate at which people opt to continue beyond this point is denoted r^5.

(3) Individuals are selected as candidates to provide a hair specimen at some fixed interval. Information on this interval is not used directly in our estimation procedure. It is important to note that the hair specimens are drawn from a random sample of individuals who appear at the facility, and that the collection of a hair specimen is not contingent upon screening positive for hardcore drug use. Testing of hair specimens occurs at a later date and does not affect the data collection process.

(4) Hair specimens are received by a laboratory and analyzed. Test results are returned to project staff.

(5) An individual who chooses to continue is administered the LHI. This is a calendar instrument that collects retrospective information on spells of drug use and their intersection with institutional contact events. The LHI has a maximum retrospective range of six years. Information on spells of drug use and on institutional contacts occurring prior to that time is stored as a series of summary measures. A copy of the LHI is provided as Appendix C of this report.

3.3 Weighting

Data were collected over different intervals of time at each site. In order to estimate the annual number of events involving individuals who would be classified as hardcore drug users, we treat these intervals as a random sample of all such intervals in a year. We also assume that completed Screeners are a random sample of all attempted interviews. The estimated number of type *k* events generated by hardcore drug users is given by:

$$\hat{N}_k = c_k \sum_{j \in S_k} a_j \tag{9}$$

for the site at which the individual was selected, and where:

$\hat{N}_k$ = the estimated annual number of type *k* events attributable to hardcore drug users;

c_k = the proportion of type *k* events attributable to hardcore drug users;

S_k = the set of individuals sampled in association with the k^{th} event type; and

a_j = the weight for the j^{th} Screener completed in association with the k^{th} event type.

As described in Section 4.2, we use self-reported information from the Screener in conjunction with radioimmunoassay results to estimate c_k. The Screener weights are defined by the value of:

$$a = \frac{1}{(zw)(t/s)\bar{r}^1\bar{r}^2} \tag{10}$$

for the site at which the individual was sampled, where:

(zw) = the probability of selection for the site (where z is the size of the site relative to the total size of its stratum and w is the number of sites drawn from that stratum);

(t/s) = the number of shifts during which data collection occurred at the site (t), divided by the total number of such periods in a year (s);[6]

$\bar{r}^1$ = the reciprocal of the average selection interval used for the Screener; and

[6]For shelters, the value of *t* was also adjusted to correct for seasonality.

$\bar{r}^2$ = the average rate at which individuals who are selected for the Screener agree to complete that portion of the interview.

Information from the LHI was used to estimate the expected number of events that a hardcore drug user would experience at any point in time, given various user characteristics. We then used these rates to estimate the annual number of events that each hardcore user would generate, projecting the LHI sample in a way that corresponded to the projection of the Screener sample. For example, the estimated annual number of arrests per hardcore user is given by:

$$\hat{n}_A = \frac{\sum_{j \in S} \tilde{b}_j \hat{n}_A(X_j, t_j)}{\sum_{j \in S} \tilde{b}_j} \tag{11}$$

where:

$\hat{n}_A$ = the estimated annual number of arrests per hardcore drug user;

$\hat{n}_A(X_j, t_j)$ = an estimate of the number of times that a hardcore drug user with the characteristics (X) and length of spell (t) of the individual completing the j^{th} LHI would be arrested during a one year period;

S = the superset of individuals sampled, comprising all k event types; and

$\tilde{b}_j$ = the weight for the j^{th} LHI.

The weights reflect the expected number of times that hardcore drug users would have been sampled. The weight for the j^{th} LHI taken at a given site is the value for that LHI of:

$$\tilde{b} = \frac{b}{\hat{n}_k(X_j, t_j)} \tag{12a}$$

$$b = \frac{1}{(zw)(t/s)c_k \bar{r}^1 \bar{r}^2 \bar{r}^4 \bar{r}^5} \tag{12b}$$

where:

$\tilde{b}$ = the weight for the LHI;

$\hat{n}_k(X_j,t_j)$ = an estimate of the number of times that a hardcore drug user with characteristics (X) and length of spell (t) would have an event of type k at the time when the j^{th} LHI was completed;

b = the probability that such events were sampled;

$\bar{r}^4$ = the reciprocal of the average selection interval used for the LHI;

$\bar{r}^5$ = the average rate at which individuals selected for the LHI agree to complete that portion of the interview; and other terms are as defined in EQ(10).

Table 1 summarizes the response rates and selection probabilities for the various sites. We can also calculate weighted response rates for the Screener and the LHI for the k^{th} event type. These are given by:

$$\bar{r}_k^2 = \frac{\sum_{i \in k} w_{Si} \bar{r}_i^2}{\sum_{i \in k} w_{Si}} = \frac{\sum_{i \in k} a_i n_{Sc_i} \bar{r}_i^2}{\sum_{i \in k} a_i n_{Sc_i}} \tag{13}$$

where:

$\bar{r}_i^2$ = the mean Screener response rate for the i^{th} site;

a_i = the weight for completed Screeners for the i^{th} site;

n_{Sc_i} = the number of completed Screeners for the i^{th} site;

$\bar{r}_k^2$ = the weighted average Screener response rate for the k^{th} site type; and

w_{Si} = the total weight of Screeners for the i^{th} site ($w_i = a_i n_{Sc_i}$).

Similarly, the weighted LHI response rate is given by:

$$\bar{r}_k^5 = \frac{\sum_{i \in k} w_{(LHI,i)} \bar{r}_i^5}{\sum_{i \in k} w_{(LHI,i)}} = \frac{\sum_{i \in k} b_i n_{LHI_i} \bar{r}_i^5}{\sum_{i \in k} b_i n_{LHI_i}} \tag{14}$$

where b_i is defined as in EQ(12b) and the other terms are analogous to those of EQ(13). Values for each event type are given below in Table 2.

Table 1
Information on Site and Respondent Selection

Site	*z*	*s*	*t*	*w*	$\bar{r}^1$	$\bar{r}^2$	$\bar{r}^3$	$\bar{r}^4$	$\bar{r}^5$	Screener	LHI
Jails											
Cook County Jail	.251	365	21	1	.258	.640	.346	1.00	.916	583	185
Drug Treatment Programs (Ambulatory)											
EHS Christ Hospital	.011	52	6	2	1.00	.760	.447	1.00	.824	38	14
Riveredge Hospital	.041	52	3	2	1.00	.222	.500	1.00	1.00	2	1
Healthcare Alternative	.013	52	12	3	1.00	.813	.068	1.00	.600	74	3
Reed Treatment Clinic	.029	52	16	3	.870	.517	.911	1.00	.951	45	39
South Suburban	.053	52	5	3	.918	.800	.222	1.00	.875	36	7
Drug Treatment Programs (Detoxification)											
Jackson Park Hospital	.366	122	28	1	.375	.656	.760	1.00	.990	127	95
Little Company of Mary	.105	122	6	1	1.00	.607	.647	1.00	.818	17	9
South Suburban	.064	122	5	2	1.00	.931	.556	1.00	1.00	27	15
Woodlawn Organization	.210	122	24	2	.500	.622	.683	1.00	1.00	120	82
Chicago Lakeshore	.080	122	27	1	.949	.573	.663	1.00	.930	86	53
Drug Treatment Programs (Residential)											
Chicago Clergy	.029	72	15	1	1.00	.836	.508	1.00	1.00	122	62
Homeless Shelters											
House of Mary and Joseph	1.00	365	40	1	.084	.498	.473	1.00	.826	256	100
Pacific Garden	1.00	365	61	1	.061	.824	.396	1.00	.887	538	189
SOUSA Overnight Shelter	1.00	365	34	1	.086	.720	.299	1.00	.813	268	65
Hilda's Place	.144	365	36	1	.216	.707	.227	1.00	.757	164	28
R.E.S.T. Warming	.094	365	16	1	.143	.581	.569	1.00	.732	72	30
Addison	.057	365	3	3	.222	1.00	.500	1.00	1.00	4	2
R.E.S.T. Women's	.114	365	18	3	.171	.827	.176	1.00	.750	91	12
San Jose Obero	.128	365	11	3	.249	.796	.012	1.00	1.00	82	1

Table 2
Mean Weighted Response Rates

	Booking Facilities	Treatment Programs	Homeless Shelters
$\bar{r}^2$	**.640**	**.736**	**.673**
$\bar{r}^5$	**.916**	**.933**	**.778**

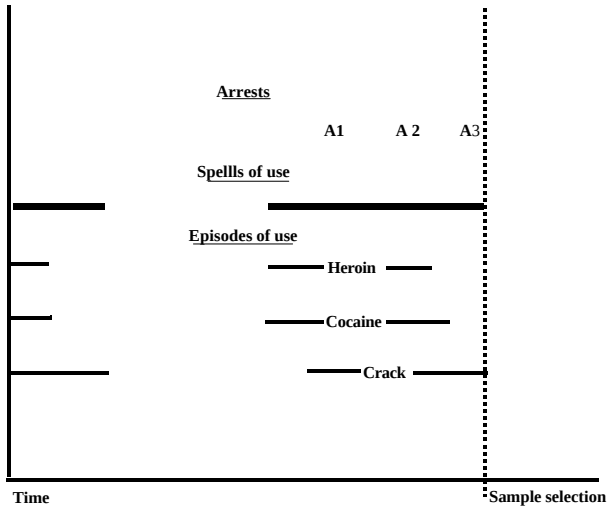
4. FINDINGS

We present our preliminary findings in this section, which is organized in a manner consistent with our general approach to the estimation problem. Only basic information on the two components of the model and on the population of hardcore drug users is provided here, and we expect to release more detailed descriptive material in a separate report.

4.1 Characteristics Of *n*, The Rate At Which Events Are Generated

Individuals experience spells of non-use and use. Our model is based on information about events that are generated during the *most recent* spell of use. One such spell of use is depicted below in Figure 2. Each spell comprises one or more episodes of use of at least one of the drugs of interest in the current study–heroin, cocaine, and crack. An episode involves use of a given drug on at least two days a week for at least two months.

Figure 2



We see from the example given here that the individual has three episodes of use; one for heroin, one for cocaine, and one for crack. At the time of the interview, the person was using only crack. The spell of use for this individual begins with the simultaneous onset of above threshold use for heroin and cocaine, and ends at the point of interview. Drug users generate events of various kinds during their spells of use. We are interested in three types of events in particular here, since they are used in developing our model. These are arrests, drug treatment admissions and shelter stays. In the example given in Figure 2, we see that the individual generated three arrest events during his most recent spell of use. He experienced no treatment admissions or shelter stays, and the interview occurred on the occasion of his third and final arrest. As noted earlier, information on spells, episodes, and events is gathered using an LHI. This is a calendar instrument that allows retrospective data on respondent behavior to be recorded over time.

In Table 3, Table 4, and Table 5, we present unweighted material from the LHI (on various event-related characteristics) disaggregated by "Drug Use Type." This typification is used to indicate the combinations of episode types that are included in a spell. Thus, some spells involve "heroin only," others involve "heroin and crack," and so on. The information is provided separately for individuals who were selected at booking facilities, drug treatment programs, and homeless shelters.

Table 3
Drug Use Type by Event-Related Characteristics:
Individuals Selected at Booking Facilities (Unweighted Data)

Drug Use Type	Mean Number of Arrests	Mean Number of Treatment Admissions	Mean Number of Shelter Stays	Mean Spell Duration In Months	Mean Number of Arrests/ Month	Mean Number of Treatment Admissions/ Month	Mean Number of Shelter Days/ Month
Heroin	1.0	-	-	10.4	0.096	-	-
Heroin, Cocaine	2.8	1.3	0.2	39.0	0.072	0.033	0.079
Heroin, Crack	2.3	0.2	0.4	46.3	0.050	0.004	0.142
Heroin,Cocaine,Crack	1.9	0.4	0.3	42.4	0.045	0.009	0.111
Cocaine	2.0	0.3	0.2	29.6	0.068	0.010	0.111
Cocaine, Crack	1.8	0.4	0.3	35.8	0.050	0.011	0.126
Crack	1.5	0.2	0.1	32.5	0.046	0.006	0.047
All	1.8	0.3	0.2	33.4	0.054	0.009	0.095

Table 4
Drug Use Type by Event-Related Characteristics:
Individuals Selected at Drug Treatment Programs (Unweighted Data)

Drug Use Type	Mean Number of Arrests	Mean Number of Treatment Admissions	Mean Number of Shelter Stays	Mean Spell Duration In Months	Mean Number of Arrests/ Month	Mean Number of Treatment Admissions/ Month	Mean Number of Shelter Days/ Month
Heroin	0.2	0.9	-	43.9	0.005	0.021	-
Heroin, Cocaine	1.1	1.1	0.3	51.1	0.022	0.022	0.095
Heroin, Crack	0.3	0.6	0.1	37.7	0.008	0.016	0.047
Heroin,Cocaine,Crack	1.1	1.5	0.3	40.4	0.027	0.037	0.111
Cocaine	0.7	1.3	0.2	33.7	0.021	0.039	0.095
Cocaine, Crack	0.5	1.4	0.2	37.6	0.013	0.037	0.079
Crack	0.4	1.3	0.1	36.6	0.011	0.036	0.047
All	0.6	1.3	0.2	36.4	0.016	0.036	0.079

Table 5
Drug Use Type by Event-Related Characteristics:
Individuals Selected at Homeless Shelters (Unweighted Data)

Drug Use Type	Mean Number of Arrests	Mean Number of Treatment Admissions	Mean Number of Shelter Stays	Mean Spell Duration In Months	Mean Number of Arrests/ Month	Mean Number of Treatment Admissions/ Month	Mean Number of Shelter Days/ Month
Heroin	0.4	0.5	1.3	45.9	0.009	0.011	0.442
Heroin, Cocaine	1.5	0.7	1.5	53.2	0.028	0.013	0.442
Heroin, Crack	0.8	0.3	1.0	42.8	0.019	0.007	0.363
Heroin,Cocaine,Crack	1.0	1.0	1.1	57.4	0.017	0.017	0.300
Cocaine	1.0	0.4	1.1	32.8	0.030	0.012	0.537
Cocaine, Crack	0.9	0.7	0.9	44.7	0.020	0.016	0.316
Crack	0.5	0.8	1.1	35.4	0.014	0.023	0.490
All	1.0	0.5	1.1	37.8	0.026	0.013	0.458

In each of the above tables, the numbers for event counts include the event that resulted in respondent selection. The mean number of shelter days per month is a value that is conditional on the individual having spent at least one night in a shelter. The average duration of a shelter stay event was approximately 15.8 days.

Table 6 on the following page provides the estimated average rates of institutional contact that our model gives for selected groups of individuals. There we collapse the race and ethnicity categories into Black and Other, since the information that we have to work with is relatively sparse for some groups.

Age seemed not to affect whether a hardcore drug user experienced an arrest, a treatment admission, or a shelter stay. Men were more likely than women to be arrested and to stay in a shelter, but they were no more likely to enter treatment. Blacks were more likely than members of other racial or ethnic groups to enter drug treatment.[7] A detailed discussion of the rate estimation procedure is provided in Appendix A.

[7]Other covariates were used as well. It came as no surprise that a history of arrests that predated the current spell of drug use predicted a higher than average arrest rate during the current spell of drug use, and the same was true of a history of treatment episodes that predated the current spell of drug use.

Individuals who were in their first spell of hardcore drug use at the time of sampling were especially likely to be arrested and especially unlikely to enter treatment. The data did not afford a measure of how frequently individuals used homeless shelters before the current spell of drug use.

Table 6
Estimated Event Rates for Hardcore Drug Users:
Selected Demographics by Event Type

User Type	Mean Number of Arrests/Year (95 Percent Confidence Interval))	Mean Number of Treatment Admissions/Year (95 Percent Confidence Interval)	Mean Number of Shelter Days/Year (95 Percent Confidence Interval)
Male	0.34 (0.30 to 0.42)	0.14 (0.10 to 0.18)	5.59 (4.01 to 7.52)
Female	0.24 (0.15 to 0.32)	0.17 (0.10 to 0.28)	2.13 (1.29 to 4.00)
Black	0.32 (0.26 to 0.35)	0.17 (0.13 to 0.24)	4.82 (3.73 to 6.23)
Other	0.40 (0.24 to 0.59)	0.08 (0.04 to 0.13)	4.19 (1.67 to 6.63)
Age:			
18-30	0.34 (0.26 to 0.42)	0.13 (0.09 to 0.17)	3.39 (2.49 to 4.70)
31-40	0.33 (0.27 to 0.38)	0.16 (0.12 to 0.25)	4.97 (3.83 to 6.62)
41+	0.34 (0.25 to 0.40)	0.13 (0.09 to 0.16)	6.00 (4.14 to 7.94)
All	0.34 (0.27 to 0.38)	0.15 (0.11 to 0.20)	4.66 (3.51 to 6.12)

4.2 Characteristics Of *N*, The Number Of Events Generated

The next phase of our analysis requires estimating the number of events of each kind that are generated by hardcore drug users. As mentioned earlier, the data collection process involved gathering hair specimens to adjust self-report information on drug use. Hair specimens were tested for four drugs: cocaine, heroin, phencyclidine, and methamphetamine.[8] The testing process involved a series of washes to remove external contamination before the hair was digested. Wash kinetic data was then analyzed to distinguish positives from contaminated specimens. Further, gas chromatography/mass spectrometry of the hair digest was performed to confirm low-level heroin use. The length of the hair specimen tested approximates 60 days growth. Hair assay data were merged with self-report data collected during screening, yielding information for 525 respondents. The majority (81 percent) of the hair specimens tested positive for cocaine; 23 percent tested positive for heroin.

Drug concentrations, which are reported in terms of nanograms (ng.) per milligram (mg.) of hair, vary

[8]Actually, the radioimmunoassay provides an indicator of opiate use. For our purposes here, we treat this indicator as a proxy for heroin use. This is reasonable, since nearly all opiate positives are attributable to this drug.

by drug. Of the cocaine-positive specimens, the concentrations range from a low of 5.4 ng./10 mg. to a high of 4510.0 ng./10 mg. The heroin-positive specimens range from 1.8 ng./10 mg. to 1045.0 ng./10 mg. Only 14 specimens tested positive for phencyclidine (ranging from 2.4 ng/10 mg. to 173.0 ng./10 mg.), and 8 tested positive for methamphetamine (ranging from 2.4 ng./10 mg. to 5.0 ng./10 mg.). To avoid underestimation by respondents who may be less willing to admit very recent use, we questioned them about two time periods—the past 30 days and the past 31 to 60 days. Drug concentration is cross-tabulated against self-reported frequency of use in Tables 7 through 10.

Table 7
Cocaine Concentration by Self-Reported Cocaine/Crack Use (Past 30 Days)

Self Reported Frequency / Cocaine Concentration	Number Reporting No Use	Number Reporting 1-7 Days Use	Number Reporting 8-31 Days Use	Total
<5 ng	87	9	6	102
5-34 ng	59	10	12	81
35-99 ng	24	9	24	57
100-399 ng	31	25	36	92
400+ ng	36	40	117	193
Total	237	93	195	525

Table 8
Cocaine Concentration by Self-Reported Cocaine/Crack Use (Past 31-60 Days)

Self Reported Frequency / Cocaine Concentration	Number Reporting No Use	Number Reporting 1-7 Days Use	Number Reporting 8-31 Days Use	Total
<5 ng	90	5	7	102
5-34 ng	63	7	11	81
35-99 ng	28	5	24	57
100-399 ng	45	17	30	92
400+ ng	40	36	117	193
Total	266	70	189	525

Table 9
Heroin Concentration by Self-Reported Heroin Use (Past 30 Days)

Self Reported Frequency / Heroin Concentration	Number Reporting No Use	Number Reporting 1-7 Days Use	Number Reporting 8-31 Days Use	Total
<2 ng	356	33	18	407
2-10 ng	15	11	14	40
11-40 ng	3	5	28	36
41+ ng	2	2	38	42
Total	376	51	98	525

Table 10
Heroin Concentration by Self-Reported Heroin Use (Past 31-60 Days)

Self Reported Frequency / Heroin Concentration	Number Reporting No Use	Number Reporting 1-7 Days Use	Number Reporting 8-31 Days Use	Total
<2 ng	360	29	18	407
2-10 ng	23	4	13	40
11-40 ng	4	3	29	36
41+ ng	2	2	38	42
Total	389	38	98	525

We began by creating an overall index. Cocaine concentration was transformed into an integer scale with a range of 1 to 5. Heroin concentration was similarly transformed into an integer scale with a range of 1 to 4. Responses to the drug use questions were placed within three categories: no use, use at less than the hardcore level, and hardcore use. Drug use was taken to be the higher of two responses: one given to a question about drug use in the last 1-30 days and another given to a question about drug use in the last 31-60 days.

Cross-tabulations showed that most people with drug concentration scores of 1 or 2 either denied use or said that they used less frequently than the hardcore level. However, when drug concentration scores were 3 or higher, respondents in treatment were very likely to admit hardcore use and rarely denied hardcore use. The drug concentration scores were therefore collapsed into a three category scale with a range of 1 to 3.

We then assigned *composite* scores to each respondent. The composite score for drug concentration was the higher of the cocaine and heroin concentration scores. The composite score for drug use was the higher of the cocaine and the heroin drug use scores. Table 11 shows a cross-tabulation of these two composite scores.

Table 11
Composite Drug Concentration by Composite Self-Reported Drug Use Scores

Self Reported Frequency Drug Concentration	Row Proportion Reporting No Use	Row Proportion Reporting < Hardcore Use	Row Proportion Reporting Hardcore Use	Number
1	.85	.07	.07	95
2	.68	.13	.19	72
3	.20	.17	.63	358

Table 11 shows that people who received a score of 1 on the hair concentration scale were unlikely to say that they were hardcore drug users. The 7 percent who nevertheless said that they were hardcore drug users may have had false-negative test results, or they may have been lying about their drug use. People who received a score of 2 were more likely to say that they were hardcore drug users, although 81 percent said that they were not. It seems very likely that those people who had scores of 3 or more were either hardcore drug users, or at least used heroin or cocaine at lesser levels—yet 20 percent said that they used neither. The problem is to account for these people who fail to report their drug use.

This was not as straightforward as it might seem, because the hair assay does not by itself provide a measure of consumption. We therefore developed a model of the relationship between self-reported drug use and the hair assay results, and then used this model to estimate the percentage of events attributable to hardcore drug users at each site type. That model is described in detail in Appendix D.

The model describes the expected proportion of the population in each cell of Table 11 in terms of actual use and the conditional probabilities of assay scores and reported use given the actual level of use. Conditional probabilities of assay scores given actual use were assumed to be invariant over sites and event types. Conditional probabilities of reported use given actual use were allowed to vary over event types, but we assumed that people rarely report a higher than actual level of drug use. Finally, we assumed that people entering treatment programs report their actual recent drug use. This last assumption was not essential, but it seemed reasonable to suppose that people entering treatment would have little reason to understate their use, given that they already had acknowledged drug use in seeking treatment. In addition, the data did not reject the hypothesis that people entering treatment reported their actual use.

We found that about 86 percent of the hardcore drug users who appeared at shelters responded truthfully, while about 75 percent of those who appeared at booking facilities responded truthfully. We estimate that 46 percent of arrests, 51 percent of treatment admissions, and 46 percent of shelter stays were generated by hardcore drug users. The 95 percent confidence intervals for these estimates are 0.31 and 0.69 for arrests, 0.39 and 0.65 for treatment admissions, and 0.33 and 0.62 for shelter stays.

The estimated confidence intervals overstate the actual intervals for these estimates. As indicated in Appendix D, estimation was based on weighted estimates and the weights reflected the reported use for the entire Screener sample. The replicates are not reweighted to reflect this, and so overstate the variation in estimate. Even so, the relatively small sample of 525 hair assays did require a fairly restrictive model, and we indicate both possible modifications of the model and external data that should be considered in any future sample design.

The information provided in Table 1 of Section 3.3 can be used to provide estimates of the total number of events generated by all individuals in Cook County during calendar year 1995. These include 245,944 adult arrests, 95,513 admissions to drug treatment programs, and 539,041 shelter stays. Thus, 46 percent of arrests (113,134), 51 percent of treatment admissions (47,691), and 46 percent of shelter stays (247,959) are attributable to hardcore drug users.

4.3 Characteristics Of *H*, The Number Of Hardcore Drug Users

Our data yield three separate estimates of the size of the hardcore drug using population in Cook County. This is a deliberate consequence of our modeling approach. The first of these is based upon arrests, the second upon drug treatment admissions, and the third upon shelter stays.

The results are presented in Table 12. Drug Use Type is collapsed there into three categories. This was necessitated by our use of radioimmunoassay data as well as other considerations. The cell entries are a product of the column total and the row proportion that is labeled "Weighted" (indicating that the data have been weighted based upon the results of our modeling exercise). The "Unweighted" column provides information about the distribution of row characteristics prior to modeling.

4.4 Discussion

The estimates from the three sources should be consistent—they are all measures of the same population. Our model of the drug use career tells us that hardcore drug users generate about .34 arrests, .15 treatment admissions, and 4.66 shelter days per year. Given the preceding estimates for the number of events of each kind generated by hardcore drug users during the year, we conclude that there are about 333 thousand such individuals in Cook County based on arrests, about 318 thousand based on treatment admissions, and about 53 thousand based on shelter stays.[9] The first two estimates are quite consistent, the third is not.

Table 12
Estimated Size and Composition of the Hardcore Drug Using Population

User Type	Estimated Number (Arrest)	Estimated Number (Treatment)	Estimated Number (Shelter)	Column Proportion (Weighted)	Column Proportion (Unweighted)
Male	242,906	232,099	38,843	.73	.80
Female	89,842	85,845	14,367	.27	.20
Black	246,234	235,279	39,375	.74	.89
Other	86,514	82,665	13,835	.26	.11
Age:					
18-30	103,152	98,563	16,495	.31	.22
31-40	169,701	162,151	27,137	.51	.53
41+	56,567	54,050	9,046	.17	.24
Career Length:					
0-5 years	83,187	79,486	13,303	.25	.19
5-10 years	116,462	111,280	18,624	.35	.32
10-20 years	96,497	92,204	15,431	.29	.37
20+ years	39,930	38,153	6,385	.12	.13
Drug Use Type:					
Heroin	23,292	22,256	3725	.07	.03
Cocaine or Crack	266,198	254,355	42,568	.80	.83
Cocaine or Crack and Heroin	39,930	38,153	6,385	.12	.14
Total	332,748	317,944	53,210	1.00	1.00

[9]These are given by dividing the estimated number of qualifying events by the estimated rate at which such events occur. This can be done directly using the material provided in the text. There will be some differences between estimates that are made in this way and those that appear in Table 12, and these are attributable to rounding error.

We lack a definitive explanation for why the estimate based on shelter stays is so much smaller than the estimate based on arrests or treatment admissions, but we have a strong suspicion as to the cause. The sample frame for homeless shelters includes overnight shelters and warming centers. It appears to be accurate because it is based on number of beds that are available, and both overnight shelters and warming centers report that they generally operate at capacity. Furthermore, a reconstruction of the number of shelter events, based on our weighted counts of the number of shelter registrations on the days that we interviewed, produces almost exactly the same number as that which is found in the sample frame.

But the sample frame excludes transitional and "second stage" shelter programs. This exclusion was deliberate on our part—the event counts provided by overnight shelters and warming shelters were deemed more accurate at the outset of the study. And the questions asked of individuals who completed the LHI were crafted so as to exclude stays in such settings. *But as a practical matter, respondents seemed unable to distinguish between overnight shelters and warming centers as opposed to transitional and second-stage shelters*. Additional analyses (not presented here) show that if the sites at which such events were generated had been included in the sample frame, the estimate based on shelter stays would have been much closer to the estimates based on the two other event types. In fact, the gap would have been reduced by about half. But substantial differences would have remained. For reasons explained in Appendix A, we found it difficult to model shelter stays adequately.

It is also possible that the estimate based on treatment admissions may be a bit high. Hardcore drug users frequently transfer from one treatment modality to another (such as from detoxification to residential treatment) or from one program to another (such as from ambulatory treatment program A to ambulatory treatment program B). Respondents may consider such transfers to be part of a single treatment event, while treatment providers consider them to be separate (and they are counted as such). This phenomenon would bias our population estimates upward. Detailed information provided by New York State suggests that about 15 percent of treatment admissions may involve transfers from one program to another.[10] As a practical matter, we cannot make an adjustment for this, because we do not know the extent to which respondents underreport treatment admissions. But even with such an adjustment, the estimate based on treatment admissions would be reasonably close to the estimate based on arrests.

[10]The New York State Office of Alcoholism and Substance Abuse Services (OASAS) was able to provide us with detailed information on treatment admission activity. Although there is no guarantee that patterns of treatment admission are the same in Chicago as they are in New York, it is probable that they are similar.

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Appendices

Appendix A: A Stochastic Model Of Hardcore Drug Use
Appendix B: The Screener Instrument
Appendix C: The Life History Interview Instrument

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Appendix D

ANALYSIS OF THE HAIR ASSAY DATA

We approached a random sample of people at booking facilities, treatment programs, and shelters. Each person was asked questions about recent drug use. These responses were used to estimate the percentage of people at jails, treatment programs and shelters who are hardcore users. However, hardcore users frequently deny their use, so we collected hair samples to test whether or not a respondent was telling the truth. Based on an estimation procedure described here, the self-reports and hair assay results provided estimates of the percentage of people at booking facilities, treatment programs, and shelters who were hardcore users. This estimation is not straightforward, because the hair assay does not provide a definitive test of being hardcore. To estimate the percentage of people at each place who are hardcore, we developed a model of the relationship between self-reports of drug use and the hair assay, and used that model to estimate the percentage of hardcore users among people who were arrested, entered substance abuse treatment, and stayed in shelters.

Let:

Pij = the probability that a respondent sampled at the i^{th} place (booking, treatment, or shelter) was actually using used drugs at the j^{th} level (no use, less than hardcore, or hardcore). Although P_{ij} is what is needed, it cannot be observed directly, because respondents are not always truthful about their use, and hair assay provides no clear cut-off for hardcore use. We seek to estimate Pij.

Q_{jk} = the conditional probability that hair from a respondent who used drugs at the j^{th} level tested at level k: k=1 means no detectable use, k=2 means use at a moderate level, and k=3 means heavy use.[1]

R_{ijm} = the probability that a respondent who was sampled at the i^{th} place and who used drugs at the j^{th}

[1] As explained in the main report, hair assay results are reported by concentration level. To get drug test levels based on those concentrations, we first transformed cocaine concentration into an integer scale with a range of 1 to 5, and heroin concentration into another integer scale with a range of 1 to 4. Self-reported responses to the screener's drug use questions were placed within three categories: no use, use at less than the hardcore level, and hardcore use. Cross-tabulations showed that most people with drug test levels of 1 or 2 either denied use or said that they used less frequently than the hardcore threshold. However, when drug test levels were 3 or higher, respondents in treatment were very likely to admit hardcore use and rarely denied drug use. Assuming that people in treatment would be truthful about their drug use, we collapsed the drug concentration scores into a three category scale with a range of 1 to 3. Second, we assigned a *composite* drug test level to each respondent. This composite, which was the higher of the cocaine and heroin drug test levels, is used in the analysis reported here.

level[2] will report that he used drugs at the m^{th} level. Thus, he is truthful when j=m. We assume that $R_{ijm} = 0$ for m>j; that is, a non-user will not say he is a drug user, but people who use at less than a hardcore rate may deny their use, and hardcore users may either deny use or say that they use at less than a hardcore rate. We added one additional constraint —those people interviewed at treatment programs are always truthful about their use. Thus, $R_{ijm} = 1$ for j=m and $R_{ijm} = 0$ for $j \neq m$, given i=2 (i=2 designates treatment). This assumption was adopted because people entering treatment have no reason to deny or understate their drug use. Empirical evidence about this assumption is discussed in note 4.

We use P, Q and R to write the probability of observing the outcomes described in Table 1. Columns correspond to the respondent's reported level of drug use—no use, use at less than the hardcore level, and hardcore use. Rows report results from the hair assay—1, 2 or 3. A separate version of this table exists for respondents sampled at booking facilities, at treatment programs, and at shelters. Across all three tables, there are six unknown P terms, six unknown Q terms, and six unknown R terms—18 parameters to be estimated using weighted maximum likelihood based on 525 observations of self-reports and hair assay.

The weight for the n^{th} individual was the product of three terms. The first term is the sampling weight for the screening interview that generated the hair sample (the "a" weights defined in Section 3.3 of the main text). The second term deflates the weights so that the sum of the weights equals the actual number of hair sample observations for each event type. The third term reweights within event types so that, for each event type, the weighted proportion of hair sample observations reporting hard core use equals the weighted proportion of all screening interviews reporting hard core drug use. Formally, the weight equals $\rho_{1n}\rho_{2n}\rho_{3n}$, where

$\rho_{1n} = a_n$, where a_n is the screener weight for the n^{th} individual;

$\rho_{2n} = \dfrac{N_{HS_{i(n)}}}{\sum_{\{n \in HS_{i(n)}\}} a_n}$, where i(n) is the event type in which the n^{th} observation was sampled, HS_i is the

set of hair sample observations for the i^{th} event type, and N_{HS_i} is the number of observations in HS_i;

[2] Reported drug use was taken to be the higher of two responses: one given to a question about drug use in the last 1-30 days and another given to a question about drug use in the last 31-60 days.

and

$$\rho_{3n} = \begin{cases} \dfrac{r_{Si}}{r_{Hi}} & if\ m_n = 3 \\ \dfrac{1 - r_{Si}}{1 - r_{Hi}} & if\ m_n \neq 3 \end{cases}$$

where $m_n = 3$ indicates that the n[th] observation reported being a hardcore drug user in the screening interview, and r_{Si} is the weighted proportion of the screening interview sample for the ith event type that reported hard core use, while r_{Hi} is the weighted proportion of all hair sample observations for the ith event type that reported hardcore drug use—viz.

$$r_{Si} = \frac{\sum_{(n \in S_i, m_n = 3)} a_n}{\sum_{n \in S_i} a_n} \qquad r_{Hi} = \frac{\sum_{(n \in HS_i, m_n = 3)} a_n}{\sum_{n \in HS_i} a_n}$$

where S_i indicates the set of observations with completed screeners in the i[th] event sample.[3]

Although we will not present findings in detail, we estimated that 46 percent of arrestees, 51 percent of those entering treatment, and 46 percent of those staying at shelters were hardcore drug users. We also estimated that about 86 percent of hardcore users at shelters report their hardcore drug use truthfully, while 75 percent of those at jails admitted their hardcore use.[4] Based on a bootstrap estimate of 200 replications, a

[3] This adjustment was necessary because the proportional representation of hardcore users was larger in the hair sample than in the screening sample. Ignoring this fact would bias estimates of hardcore use based on the hair sample upward. The upward bias is large in the arrestee sample (increasing the estimate of hardcore users in this population from 52 percent to 66 percent), but it is only 2 to 4 percent in the other samples. This is because admitted hardcore use was about the same in the screener sample and the hair sample for treatment programs and shelters, so the adjustments were minimal. This was not the case for jails, where self-reported hardcore use was higher for the hair assay than for the screener data.

[4] An alternative approach is to assume that respondents in treatment programs are not necessarily truthful about their drug use, so three additional R parameters have to be estimated. Estimates based on this assumption causes the estimate of hardcore users at treatment sites to increase by 13 percentage points to 64 percent, while the other two estimates increase by 6 percentage points for arrestees and fall by 1 percent at shelters. However, based on a likelihood ratio test, we could not reject the null hypothesis that these three R's equal 1.0.

95 percent confidence interval for the percentage of hardcore users at each sampling place is 0.31 to 0.69 for arrestees, 0.39 to 0.65 for those entering treatment, and 0.33 to 0.62 for those staying in shelters.[5] Given the importance of an accurate estimate of the percentage of hardcore drug users among arrestees, those entering treatment, and those staying in shelters, a sample of 525 hair samples seems too small to provide the precision necessary for a study that goes beyond this pilot study.

There are two potential solutions to this problem. One is to increase the sample size to achieve the desired precision. A second is to make more efficient use of the data, and this might be done in two ways.

Although we have collapsed reported drug use into three categories and the results from the hair assay analysis into another three categories, in fact these two variables are measured on continuous scales. The relationship between hair assay results and self-reports of drug use might be described with much greater accuracy if it were modeled using these continuous measures instead of the nine-cell table. In turn, we would expect this greater precision to improve the estimates of P_{ij}.

Another way to increase the efficiency of these estimates would be to make greater use of the

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We have evidence that the estimates are reasonable, at least for the arrestee population. The Drug Use Forecasting (DUF) project interviews arrestees at the Cook County jail on a quarterly basis. A urine test is used to detect cocaine and heroin use in the last two to three days. About 59 percent of arrestees in Cook County tested positive for either cocaine or heroin during 1995. Not all of these are hardcore users, but interviews with those who (1) tested positive and (2) admitted recent drug use showed that 75 percentage of those who tested positive were hardcore users (defined as using cocaine or heroin on 8 or more days during the last month). This implies that about 44 percentage of arrestees who are booked at the Cook County jail are hardcore users, a figure that is consistent with the 46 percent estimate from this project.

Evidence based on substance abuse treatment programs is less definitive. According to NDATUS estimates for the State of Illinois, 66 percent of clients in substance abuse treatment abuse either drugs or drugs and alcohol combined. Of course, many of these clients abuse drugs other than cocaine or heroin, but the exact number is not reported, so the 66 percent might be considered as an upper estimate. Another problem is that the treatment population in the State may differ from the treatment population in Cook County.

[5] A less complicated way of estimating the confidence intervals would be to base them on the estimated covariance matrix. Unfortunately, the Hessian failed to invert, so the covariance matrix could not be computed. This is generally an indication that the mathematical specification is ill conditioned and that one or more parameters are estimated with considerable imprecision.

The bootstrap estimates likely overstate the confidence intervals. We did not weight each replicate to meet the side conditions on the percent hardcore. Although the confidence interval is computed for a sample of 525 observations, the effective sample size is apparently much lower than this, due to the effects of two-stage sampling and variations in weights.

screener data. The estimates are currently based on a sample of 525 observations. The only use that we make of the screener data is to adjust the weights so that the rate of admitted hardcore drug use from the screeners equals the weighted admitted rate of hardcore drug use from the hair sample. Going beyond that use of the screener data, the responses from the screener could be incorporated directly into the likelihood expression. Although the screener data would not provide any additional information about the relationship about hair-test results, it would provide additional information about self-reported drug use by place (booking, treatment, and shelter) and by site. Exploiting this additional information should provide a more efficient estimate of P_{ij}.

Furthermore, with a larger sample we could remove some of the restrictions imposed in this model. Some of these restrictions are obvious—such as the constraints on the *R* parameters. Other restrictions are not so obvious—such as assumptions that the parameters do not differ across sampling sites.

These approaches to improving the estimates based on the hair sample could not be investigated during this study. We strongly encourage that investigation before making decisions about drawing hair samples for future studies, because the desired sample size (and hence cost) of future studies depends crucially on the the accuracy of estimating P_{ij}.

Table 1

Probability Structure for Self-Reported Drug Use and Hair Test Assay

	Not a User	Not a Hardcore User	Hardcore User
Tested at Level 0	(1-Pi2-Pi3) (1-Q12-Q13) + Pi2 Q21(1-Ri22) + Pi3 Q31 (1-Ri32-Ri33)	Pi2 (1-Q22-Q23) Ri22+ Pi3 (1-Q32-Q33) Ri32	Pi3 (1-Q32-Q33) Ri33
Tested at Level 1	(1-Pi2-Pi3) Q12 + Pi2 Q22(1-Ri22) + Pi3 Q32 (1-Ri32-Ri33)	Pi2 Q22 Ri22 + Pi3 Q32 Ri32	Pi3 Q32 Ri33
Tested at Level 2	(1-Pi2-Pi3) Q13 + Pi2 Q23(1-Ri22) + Pi3 Q33 (1-Ri32-Ri33)	Pi2 Q23 Ri22 + Pi3 Q33 Ri32	Pi3 Q33 Ri33