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DETERMINANTS OF DRUG INJECTION BEHAVIOR: ECONOMIC FACTORS, HIV INJECTION RISK AND NEEDLE EXCHANGE PROGRAMS

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ABSTRACT

This study examines the effects of local cocaine and heroin prices, AIDS rates, and needle exchange programs on drug injection and needle sharing by adult male arrestees in 24 large U.S. cities during 1989–1995. Regressions that control for personal characteristics including income, fixed city and year effects, and city-specific trends indicate that needle exchange programs decrease both injection and sharing. Increases in previous year AIDS prevalence reduce injection by both sharers and non-sharers, leaving the proportion of injectors who share unchanged. Higher cocaine prices lead to less cocaine injection and more sharing, but heroin prices do not effect injection or sharing.

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I. Introduction

The injection of illegal drugs such as heroin and cocaine is associated with substantial costs in terms of crime, criminal justice, and social services. Beyond these, drug injection is a major public health problem. In particular, drug injectors risk infection with blood-borne diseases such as HIV and hepatitis B and C through the sharing of infected needles, and can transmit these diseases to needle-sharing or sexual partners and their own children. The Centers for Disease Control and Prevention (CDC) attributes 42 percent of U.S. cumulative non-pediatric AIDS cases with known exposure category, and 45 percent of such cases reported in 2000, to drug injection. Almost three-quarters of these cases stem from sharing needles, with the rest resulting from unprotected sex with a drug injector. Moreover, 82 percent of cumulative pediatric cases with identified exposure category, and 86 percent of such cases in 2000, involved transmission from a mother infected through drug injection or having sex with a drug injector to her fetus or newborn child (CDC 2001).

The number of injection drug users in the U.S. is unclear. Estimates include 900,000 by the CDC and 1.64 million by the National Association of State Alcohol and Drug Abuse Directors, with an average of three injections daily (Lurie et al. 1998). The Treatment Episode Data Set (TEDS) indicates that 192,000 entrants to publicly funded drug treatment facilities in 1999 injected the primary drug for which they sought treatment (SAMHSA 2001). According to the 1999 National Household Survey on Drug Abuse (NHSDA), slightly over three million individuals have previously injected drugs (SAMHSA 2002).

A rich source of information on drug injectors is data collected on arrestees in 24 large U.S. cities by the Drug Use Forecasting (DUF) program of the National Institute of Justice (U.S. Department of Justice, 1998). During 1989–1997, 8.9 percent of arrestees reported injecting drugs in the past six months. Prevalence declined steadily during the period, from 16.2 percent to 8.3 percent for females and 12.0 percent to 6.7 percent for males, although rates among males, who make up around 70 percent of AIDS cases attributable to drug injection, remained level since 1994.[1]

The drugs most often injected are cocaine and heroin. In DUF, 75 percent of arrestees previously injecting drugs have injected cocaine and 69 percent have injected heroin, while 34 percent have injected amphetamines and 20 percent have injected other drugs. Similarly, the 1999 NHSDA estimates that 1.93 million individuals have injected cocaine while 1.44 million have injected heroin and 1.08 million have injected stimulants (SAMHSA 2002). While cocaine use greatly exceeds heroin use, heroin is far more likely to be injected than is cocaine. For instance, rates of positive drug tests in DUF are 42 percent for cocaine and only 8 percent for heroin, but rates of past six month injection among those testing positive for use are 46 percent for heroin and only 12 percent for cocaine. Similarly, in the 1999 TEDS (SAMHSA 2001), rates of injection among those seeking treatment were 66 percent for heroin users (down from 77 percent in 1992) but only 6 percent for cocaine users.

This paper examines drug injection behavior among male DUF arrestees during 1989–1995.[2] In particular, it investigates how recent injection and needle sharing responds to three factors: economic incentives, specifically income and prices of cocaine and heroin; perceived HIV infection risk, represented by AIDS prevalence; and needle exchange program presence.

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[1] Extrapolating from DUF to the general arrestee population, which Hunt and Rhodes (2001) argue is reasonable, Federal Bureau of Investigation (1998) data on U.S. arrestee counts imply past six month drug injection by 1.08 million arrestees nationwide in 1997. If all drug injectors can be considered hardcore drug users, this translates to 2.16 million past six month drug injectors overall according to the Rhodes et al. (2000) estimate that roughly one-half of hardcore drug users are arrested annually.

[2] Though data collection began in late 1987 and continues today, I use data from 1989–1995 because many sample cities were not added until 1989, needle sharing questions were eliminated in mid-1995 when the survey instrument was altered, and needle exchange program data are incomplete after 1995. The injection rates cited earlier include data only through 1997 because the sampling frame was altered in 1998 when DUF expanded to 35 cities and became the Arrestee Drug Abuse Monitoring program.

Injected drugs are goods that are bought and sold in a market, albeit illegal, and thus should adhere to microeconomic principles regarding the impact of prices and income. The same is true for needles used to inject drugs, suggesting relationships between economic factors and needle sharing that are the opposite directions to those for purchased goods. Syringes cost about 25 cents each when legally obtained from a pharmacy. However, five states have laws requiring a prescription to purchase syringes, and all but three states have drug paraphernalia laws that penalize syringe possession and distribution (Ruiz-Sierra 2001, Sidwell et al. 2001).[3] On the illegal market, in contrast, syringes sold as "new" cost several dollars and often are in fact repackaged after being used by others who might be infected with HIV (Des Jarlais et al. 1996). Many studies have examined the impact of prices and income on cocaine and heroin use, but few have focused explicitly on injection, and none have investigated needle sharing.

Similarly, several studies have examined the impact of AIDS prevalence on sexual behaviors that expose individuals to HIV infection risk. These studies assume that increases in local AIDS rates raise perceived probabilities of HIV infection and use AIDS data because they are much more extensive than are HIV data. The CDC statistics cited earlier suggest that HIV infection risk is as relevant for drug injection, which has not been studied, as for risky sex.

Economic research has also yet to study needle exchange programs (NEPs). Since NEPs provide sterile syringes in exchange for used ones in an effort to reduce blood-borne infection transmission by drug injectors, they are expected to decrease needle sharing. NEPs also reduce the cost of drug injection. Consequently, many lawmakers have assumed that NEPs encourage drug use, leading to a 1989 ban on federal NEP funding that is still in place. But most NEPs also refer clients to drug treatment and offer HIV testing and counseling. As NEP customers are

[3] The five states with prescription laws are California, Delaware, Illinois, Massachusetts, and New Jersey. The three states without paraphernalia laws are Alaska, Iowa, and South Carolina, although some localities within the former two have ordinances restricting syringe possession and sale.

placed into treatment programs and provided with information on injection-related HIV risks and even their own HIV infection status, injection propensity and frequency should fall.

As of July 2002, 211 NEPs existed in 37 states, Washington D.C. and Puerto Rico (Purchase 2002) despite the federal funding ban and previously described laws that make NEPs illegal in many areas. NEPs are funded either by permissive states and localities or privately, with some NEPs operating secretly and others in tacit agreement with local law enforcement agencies. Data are difficult to obtain. For instance, an October 1999 survey (Singh et al. 2001) was completed by only 84 percent of known programs, some of which asked for their identity not to be revealed. The 107 responding programs operate at health van stops, sidewalk tables, cars, storefronts and health clinics, are open for an average of 20 hours per week, have a median yearly budget of $38,000, and exchanged 19.4 million syringes. For DUF cities, time series of NEP characteristics are unavailable, but information on the date of first NEP opening allows for examination of how program presence impacts injection behavior.

The DUF data analyzed here are useful for various reasons. Most importantly, information is available on recent drug injection and needle sharing. In addition, arrestees represent a sizable fraction of drug injectors in the population, the sample size is large, and the sampling scheme allows for merging of several relevant variables that are measured at the city or metropolitan area level. Results show that, controlling for arrestee characteristics, indicators for arrest city and survey year, and city-specific behavioral trends, each of the main factors under examination have a significant impact on drug injection behavior.

The paper proceeds as follows: Section II reviews the pertinent literature from economics and other disciplines, Section III discusses the data, Section IV outlines the estimation methodology, Section V presents the results of the analysis, and Section VI concludes.

II. Literature Review

The previous literature germane to this analysis can be divided into three topics. Two of these, the effects of drug prices (and income) on drug use and the impact of disease infection risks on risky or protective behavior, have received attention from economists. The third, the impact of NEPs on injection behavior, has been studied only by disciplines outside of economics.

Economic Factors. The only study that explicitly examines the impact of prices and income on drug injection is Bretteville-Jensen (1999), who analyzes heroin injection by 1,834 males in Oslo, Norway. She estimates heroin price elasticities of –0.36 for dealers and –1.51 for non-dealers and income elasticites of 0.59 for dealers and 0.51 for non-dealers.

Other studies have estimated price elasticities of cocaine and heroin use without regard to mode of administration. In monthly 1970–73 data from 15 Detroit communities, Silverman and Spruill (1977) estimate a long-run heroin own-price elasticity of –0.25. Using 1923–38 data on the Indonesian opium market, Van Ours (1995) estimates short-run price elasticities of –0.7 for consumption and –0.4 for the number of users. DiNardo (1993) finds that in state-level 1977–87 Monitoring the Future (MTF) data, past month cocaine participation by high school seniors is unrelated to the cocaine price. From aggregate DUF data on positive tests for each drug, Caulkins (1996) imputes population-wide participation price elasticities of –1.48 to –2.08 for cocaine and –0.53 to –1.80 for heroin. Saffer and Chaloupka (1999) estimate participation price elasticities of –0.28 for cocaine and –0.94 for heroin among 1988–91 NHSDA respondents. Three additional studies estimate past year participation cocaine price elasticities. Chaloupka et al. (1999) estimate elasticities for MTF high school seniors of –0.88 in pooled 1982 and 1989 data but only –0.24 in 1989. Using a rational addiction framework, Grossman and Chaloupka (1998) estimate elasticities of –0.42 among 18 to 27 year-olds in the 1976–85 MTF panels and follow-ups when individual-specific fixed effects are included and –0.72 when they are omitted. Controlling for fixed state effects in pooled 1990–97 NHSDA data, DeSimone and Farrelly (2003) estimate an elasticity of –0.36 for respondents aged 18–39.

AIDS Rates. Among several studies that examine effects of perceived infection risks on propensities to engage in risky behaviors or protect against disease transmission by regressing behavioral indicators against local disease prevalence rates, three analyze the response of sexual behaviors to AIDS rate changes. Ahituv et al. (1996) estimate a positive effect of state AIDS rates on the likelihood that 1984–90 National Longitudinal Survey of Youth respondents use condoms during intercourse. Levine (2001) finds little relationship between state AIDS rates and lifetime or current sexual activity and birth control use among 1991–97 Youth Risk Behavior Survey respondents. DeSimone (2002) shows that during 1989–95, promiscuous sexual behavior by DUF arrestees decreases when metropolitan area AIDS rates rise.

Needle Exchange Programs. The economics literature has yet to study NEPs. Many health researchers have examined impacts of individual programs, but few have estimated aggregate impacts across NEPs. Lurie and Reingold (1993) summarize the early results. They report no evidence that NEPs increase drug use by clients or in communities, limited evidence that NEPs reduce injection frequencies, and abundant evidence that NEPs reduce needle sharing.

Subsequent studies have produced similar results. Seven government-funded reports conclude that NEPs reduce rates of HIV infection but do not increase drug use (Lurie and DeCarlo 1998, Ruiz-Sierra 2001). In New York City, NEPs decreased risky injection behavior by up to 73 percent, and injectors using NEPs were two-thirds less likely to contract HIV than other injectors (Des Jarlais et al. 1996). Injectors attending Oakland NEPs were 2.5 times more likely than other injectors to stop sharing needles after six months (Blumenthal et al. 2000). In combined data from four cities, NEPs decreased the number of injections per syringe by 44–85 percent and significantly raised the likelihood that syringes were used only once (Heimer et al. 1998). In San Francisco during 1986–92, daily injection frequency among injectors fell from 1.9 to 0.7 and the fraction of new injectors fell from 3 percent to 1 percent (Watters et al. 1994). Washington D.C. NEP participants reported drops of 50 percent in crack cocaine use, 29 percent in the number of drug injections, 18 percent in heroin use, and two-thirds in needle sharing (Drug Strategies 1999, Klein et al. 1997), compared with the month prior to program entrance. A worldwide survey of 81 (mostly U.S.) cities found that HIV infection rates among injectors decreased by 5.8 percent annually in the 29 cities with NEPs and increased by 5.9 percent annually in the 52 cities without NEPs (Hurley 1997). In Hawaii, which opened an NEP in 1990, HIV infection rates fell from 5 percent in 1989 to 1.1 percent in 1996 (Vogt et al. 1998).

In sum, previous economics studies suggest that injected drugs are normal goods with respect to income and prices of cocaine and heroin, which implies the opposite relationship for needle sharing if illegally-obtained syringes are sufficiently costly, and the possibility of a negative effect of local AIDS prevalence on both drug injection and needle sharing. Meanwhile, prior health research indicates that the opening of an NEP in a city could reduce proximate needle sharing while also not increasing, and possibly reducing, drug injection.

III. Data

This study examines annual DUF data from 1989–1995 on arrestees in 24 large U.S. cities.[4] Hunt and Rhodes (2001) describe the data in detail. DUF samples individuals arrested in

[4] These cities are Atlanta, Birmingham, Chicago, Cleveland, Dallas, Denver, Detroit, Fort Lauderdale, Houston, Indianapolis, Kansas City, Los Angeles, Miami, New Orleans, New York, Omaha, Philadelphia, Phoenix, Portland (OR), Saint Louis, San Antonio, San Diego, San Jose, and Washington D.C. All are sampled annually during the period except Atlanta, Denver, and Omaha in 1989, Miami in 1990, and Kansas City after 1992.

the participating cities during one two-week period each quarter. Those booked within 48 hours of arrest are asked at booking to provide information about their drug use along with a urine specimen. Over 90 percent agree to an interview, and about 80 percent of those interviewed provide urine samples that are screened for various drugs. The data available to researchers includes only arrestees providing urine samples. I analyze males aged 18 and above.[5]

The DUF data are uniquely suited to this study for many reasons, the most obvious being that they contain information on recent drug injection and needle sharing. Beyond that, arrestees are a natural group to study because their rates of drug injection are much higher than those of the population at large: lifetime drug injection prevalence among males age 18 and above is 1.7 percent in the NHSDA (SAMHSA 1999) but is 14.1 percent in DUF. Another advantage is that sampling is restricted to 24 large cities, meaning that estimates of prices and HIV risks faced by respondents are more precise than when measured at the state level, and making it plausible that a simple indicator of local NEP presence could influence reported injection behavior. Moreover, the sample size of 122,623 provides sufficient power to detect relatively small effects.

Dependent Variables. The dependent variables in the regression analyses are four binary indicators of injection behavior based on self-reported drug injection and needle sharing and results of urinalyses for cocaine and opiates that detect use within the previous 72 hours.[6] The first indicates any drug injection in the previous six months without regard to specific drugs.

[5] I drop respondents aged 17 and younger based on the typical legal distinction between adults and juveniles. Separate adult and juvenile questionnaires are administered, but the adult sample includes some respondents aged 17 and younger, while the juvenile sample includes some respondents aged 18–21. I omit the entire juvenile sample because past six month injection rates are low (around 0.5 percent) and personal income is not observed. Neither inclusion of 17 year old adult sample respondents nor omission of respondents age 66 and above (the latter group forming only 0.32 percent of the sample) changes the results. For the adult female sample, which is roughly one-third the size of the male sample, personal income and AIDS effects are similar to, but slightly weaker than, those for males, NEP program impacts are negative but smaller than for males and generally insignificant, and the effects of price on injection are usually insignificant for cocaine but positive and significant for heroin.

[6] Although codeine, morphine and methadone are also opiates, I assume that all positive opiate tests represent heroin use. In the 1999 TEDS, the number of individuals seeking heroin treatment was ten times the number seeking treatment for all other opiates combined (SAMHSA 2001).

This likely underestimates true injection propensities, as respondents evidently underreport cocaine and heroin consumption despite agreeing to submit to urine tests for these drugs. For instance, 44 percent of sample respondents test positive for cocaine and 8 percent test positive for opiates, but only 21 percent report using cocaine and 6 percent report using heroin in the past 72 hours. Rhodes et al. (2000) estimate that, taking into account false positive tests, the percentage of respondents truthfully reporting use is 61 for cocaine and 73 for heroin.

I also construct indicators for current cocaine and heroin injection. Since respondents do not identify the drugs they currently inject, I consider current cocaine (heroin) injectors to be those who report both past six month injection and any lifetime cocaine (heroin) injection, and also test positive for cocaine (opiates). Beyond self-reporting and test errors, these measures overestimate actual current injection of the corresponding drug, because some positive tests likely reflect non-injection administration by arrestees who injected the drug in the past six months but not in the previous 72 hours. As Table 1 indicates, just over a quarter of recent injectors do not currently inject either drug, a similar fraction currently inject both drugs, and injection of cocaine but not heroin is twice as prevalent as injection of heroin but not cocaine.

The remaining dependent variable, an indicator of recent needle sharing, is examined separately for samples of all respondents and only those reporting past six month injection. Respondents are coded as sharing needles if they report past six month injection, ever sharing needles, and sharing some or most of the time (as opposed to not sharing anymore).

Explanatory Variables. DUF respondents separately report income obtained from legal and illegal sources in the past month. I specify total past month income as the sum of these two amounts, and include the percentage of income from illegal sources as an additional variable.[7]

The remaining explanatory variables of interest are city or metropolitan level measures

[7] The income and price variables are converted to 1997 values using the CPI for all urban consumers.

that are matched with individual DUF responses. Data on cocaine and heroin prices are collected by undercover drug agents, mostly from the Drug Enforcement Administration (DEA), and recorded in the DEA's System to Retrieve Information from Drug Evidence (STRIDE). These prices should be fairly accurate since an unreasonable price offer might tip off the seller and endanger the agent.[8] Transaction sizes are standardized to pure gram units because, as Caulkins and Padman (1993) and Rhodes et al. (1994) show, quantity discounts exist for both drugs.[9]

For each drug, I impute annual prices for DUF metropolitan areas from STRIDE observations on individual purchases using the OLS regression

$$\log p = \alpha_0 + \alpha_1(\log w + \log \hat{r}) + m\alpha_2 + y\alpha_3 + (m \times y)\alpha_4 + \eta, \qquad (1)$$

where p is the price, w is the total gram weight, r is the purity (pure weight divided by w), $\log \hat{r}$ is the predicted value from a regression of log r on log w, m, y, and $m \times y$, m and y are vectors of indicators for metropolitan area and year, respectively, $m \times y$ is a complete set of interactions between metropolitan area and year, and η is the error term.[10] For a particular area and year the predicted price is $\exp(\alpha_0 + \alpha_2^m + \alpha_3^y + \alpha_4^{m\times y})$, the median price for one gram of 100 percent pure drug in the area and year with corresponding indicators set equal to one. I follow Caulkins (1994) in excluding outliers before estimating equation (1).[11] Although the DUF

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[8] Horowitz (2001) argues that STRIDE cocaine and heroin price data are not representative of actual market prices, but most previous drug price studies have used STRIDE, and Caulkins (2001) and Rhodes and Kling (2001) strongly disagree with the implication that STRIDE data are not a useful source of information for drug policy.

[9] Amounts injected per session vary, but are typically between 0.1–1 pure grams for cocaine and 10–60 pure milligrams for heroin (Rhodes et al. 1994).

[10] For metropolitan areas with insufficient STRIDE observations to construct annual price series, I combine data from non-DUF metropolitan areas of similar population size that are in the same census division or region. These areas are Indianapolis, Omaha, and San Jose (defined to include data from Oakland and San Francisco) for both drugs and Birmingham, Kansas City, New Orleans, and Phoenix for heroin. In addition, heroin price data are combined for four pairs of cities with the same price assigned to each: Fort Lauderdale and Miami, Houston and San Antonio, Cleveland and Indianapolis, and Kansas City and Saint Louis.

[11] The number of STRIDE observations in the equation (1) samples is 21,196 for cocaine and 7,458 for heroin. I omit 500 cocaine and 492 heroin prices with purity below 0.001 percent or above 100 percent, which signify data errors or purchases of trivial drug amounts. Next, I regress log price on log weight and year indicators, and for each year discard observations with predicted prices per bulk gram of less than one-eighth or greater than eight times the

sampling areas are cities (and occasionally counties), drug prices correspond to the metropolitan area to include additional STRIDE observations that improve the precision of the price series.

Annual AIDS rates per 1,000 residents are reported on the CDC Wonder web site (at http://wonder.cdc.gov/). The data used here correspond to the 1987 CDC definition of AIDS.[12] Rates are for the metropolitan area because city-level rates are not published. I specify the one-year lagged rate, which eliminates the possibility of reverse causation and conceivably represents the state of knowledge regarding infection risks at the time the injection decision is made.

NEP-level time series on budgets, clients served and needles exchanged are not available. Hence I simply control for local NEP presence with indicators of whether a program has existed in the city of arrest for 0–5 months and 6 or more months as of the interview month. This allows for a delayed effect, which might occur if injection behaviors take time to adjust or simply because the injection variable spans the previous six months. Lurie and Reingold (1993) provide origination dates for 37 programs known to exist by August 1993, including programs in eight DUF cities. Information on whether and when NEPs opened in remaining DUF cities through 1995 was graciously provided by Dave Purchase, chair of the North American Syringe Exchange Network (Purchase 2002). Table 2 lists the month and year in which the first NEP opened in DUF cities with at least one program.[13]

Figures 1–2 present time series of the dependent variables, while Figures 3–4 do the same for the primary explanatory measures. In Figure 1, past six month injection rates declined sharply from 1989 to 1991 and again from 1993 to 1994, and remained relatively constant during

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yearly mean. Finally, I exclude observations with an observed price per pure gram of greater than $3,000 for cocaine and $20,000 for heroin. The latter two steps eliminate only 171 cocaine and 284 heroin price observations.

[12] In 1993 the CDC expanded the definition to include many cases that previously would not have been counted.

[13] The first program in San Francisco, which is 41 miles from San Jose, opened in November 1988, while that in Boulder, which is 28 miles from Denver, began in May 1989. Since many NEP programs are mobile units that travel to many different locations within a city, it seems unlikely that drug injectors would travel such distances to exchange needles, and thus I ignore the presence of these nearby programs. Results with the NEP variables recoded to include programs in San Francisco and Boulder, though, are quite similar.

the remaining years. Current injection of both drugs moved similarly until 1992, after which cocaine injection continued to decline while heroin injection held steady. The needle sharing series mimics that of any injection. Part of the drop in needle sharing results from sharers quitting injection, as falling injection rates were accompanied from 1990–95 by a 30 percent decrease in the fraction of injectors who share (Figure 2). No explanatory variable series can explain these results by itself. In Figure 3, prices spiked upward during the first couple years, but sharing among injectors declined precipitously in the second year; prices then fell substantially, but injection rates failed to climb in response. Lagged AIDS rate movements are roughly the inverse of those for any injection (Figure 4), but not of those for sharing by injectors in several years. Similarly, the steepest decline in injection and sharing occurred before the opening of seven needle exchange programs between December 1990 and October 1992, which triggered drastic increases in the proportion of respondents living in cities with NEPs.

All regressions also control for various respondent characteristics. These include age and age squared, years of completed education and its square, indicators of black, Hispanic, and other race (mutually exclusive, with white omitted), indicators of being married, divorced, widowed, and living with a boyfriend or girlfriend, and indicators of (legal) full and part-time employment.

Table 3 provides summary statistics for all respondents (left panel) and past six month injectors (right panel), among whom needle sharing is separately analyzed. Past six month injection is reported by 8.5 percent of respondents, but only 60 (43) percent of these are classified as current injectors of cocaine (heroin). Thirty percent of injectors, representing 2.6 percent of all respondents, share needles. Drug injectors have higher incomes, face lower drug prices and AIDS rates, and are more likely to live in a city with an NEP. To some extent these comparisons simply reflect heterogeneity between injectors and non-injectors, but they also anticipate some of the regression results.[14]

IV. Methodology

I estimate probit regression models of the form

$$\Pr(y = 1 \mid x) = \Phi(x\beta) \tag{2}$$

where y is a binary injection or sharing indicator, $\Phi(.)$ is the cumulative normal distribution, x is the vector of explanatory variables, and β is the vector of parameters to be estimated. Tables 5–8 report marginal effects $\partial\Phi/\partial x$ and their associated standard errors. Denoting $\bar{x}$ as the vector of explanatory variable means and $\phi(.)$ as the normal density function, the marginal effect of variable x_k equals $\phi(\bar{x}\beta)\beta_k$ for continuous x_k and $\Phi(\bar{x}\beta \mid x_k = 1) - \Phi(\bar{x}\beta \mid x_k = 0)$ for binary x_k. The tables also report elasticities, $\bar{x}(\partial\Phi/\partial x)/\Phi(\bar{x}\beta)$, for continuous variables and percentage changes in outcomes induced by changes from 0 to 1, $(\partial\Phi/\partial x)/\Phi(\bar{x}\beta)$, in binary variables, and list pseudo-R^2 statistics ($1 - L_e/L_c$), where L_c and L_e are log likelihoods from the corresponding constant-only and regression models, respectively.

Because most explanatory variables of interest are measured at the city (or metropolitan area) level, all regressions include vectors of city and year indicators. These control for both the documented downward trend in injection propensity and unobserved city-specific, time-invariant factors that are correlated with injection or needle sharing. Consider Table 4, which shows rates of recent injection and sharing (among all respondents) by city and year, with rates in bold for years in which NEPs were open for the entire year and, in the mean and trend columns, for cities that gain NEPs during the period. Weighting each city and year equally, mean rates in cities

[14] For instance, the income difference is partially explained by the relative involvement among each group in illegal activities that generate income, as reflected in the variable measuring the percent of income that is illegally obtained, and, as discussed subsequently, NEPs are more likely to open in cities with above average injection rates.

with NEPs are 2 to 2.5 times larger than in other cities (11.7 percent v. 6.0 percent for injection, 3.9 percent v. 1.5 percent for sharing). This positive correlation between NEP presence and both injection and sharing, however, does not necessarily imply that NEPs increase injection.[15] The relevant question is instead whether injection and sharing declined in cities with NEPs, relative to other cities, upon NEP opening. The inclusion of city and year indicators allows the analysis to address this question. Similarly, coefficients on AIDS prevalence and cocaine and heroin prices are identified by temporal changes of these variables within cities.

I compare results of regressions specified as indicated thus far to those that also control for city-specific linear trends in the dependent variable. Table 4 indicates that although injection and sharing rates are typically lower after an NEP opens, this might be merely a continuation of pre-existing downward trends, which for both behaviors are significant at the 95 percent level in seven of nine cities with NEPs and about two-thirds of cities overall. Since these trends vary widely across cities, it is unlikely that the year indicators fully account for them, suggesting that distinguishing between falling rates and NEP effects might require also controlling for city-specific trends. If rates fall faster in NEP cities because they are higher to begin with, simple trend effects might be incorrectly attributed to NEPs if city-specific trends are not included.

V. Results

Table 5 contains the main results of the analysis, comparing models that omit city-specific regressions to models that include them but are otherwise identically specified. The

[15] But it does imply that NEPs openings are endogenous, in that they are more likely to occur in cities in which the behaviors they intend to affect are more prevalent, and thus the public health situation is more urgent. Further emphasizing this, and thus the importance of including city and year indicators (and city-specific trends as described below), is evidence from city-level univariate regressions (n = 24) of a significantly positive effect of injection (and sharing) rates in 1989 (or 1990 for cities not sampled in 1989) on NEP presence, represented by either an indicator of NEP opening during the period or a variable measuring the fraction of the period in which an NEP is open.

upper panel displays results for the three injection variables. Regardless of whether trends are included, income positively affects injection of any drug and cocaine, albeit with an elasticity of around .01. In contrast, the inclusion of trends lessens negative effects (and increases positive effects) of cocaine prices. With trends, cocaine injection is own-price responsive whereas heroin injection is unresponsive to prices. The own-price cocaine injection elasticity of –.31 is within the –.24 to –.42 range encompassed by several previously cited estimates for cocaine participation, though the lack of heroin price effects contradicts existing evidence for heroin use.

The income and cocaine price results suggest that injectable cocaine is a distinct good from powder and crack cocaine, in that the comparison group of non-injectors contains a large group of respondents who administer heroin and (especially) cocaine by another method: past six month injection is reported by only 13 percent of cocaine positive respondents and 47 percent of opiate positive respondents. One consideration, particularly for heroin, is that drug dealers often pass price declines onto consumers by raising purity without changing the nominal price, so that as the price falls, purity rises and the drug becomes more convenient to snort or smoke.[16] The lack of heroin responsiveness relative to cocaine might therefore be attributable to a greater choice of close substitutes for cocaine injection, given that powder and crack cocaine are more readily available than heroin pure enough to snort or smoke. Another possible explanation for the income and price effects is that injectors consume more frequently than non-injectors.

AIDS prevalence has significant negative effects on all types of injection, supporting the hypothesis that individuals become more likely to avoid risky behavior as the inherent risk

[16] Figure 3 shows that heroin prices fell by about 60 percent from 1991 to 1995, during which average purity increased from 17.3 percent to 40.1 percent. It is thus possible that the insignificant heroin price could represent a combination of a negative "true" price effect and a positive effect through purity changes (although the heroin injection decline in Figure 2 took place entirely before prices began to fall). As an additional explanatory variable, predicted heroin purity is indeed negatively related to injection of any drug and heroin, but its insertion does not change heroin price results. Furthermore, results for cocaine purity suggest that price and purity changes are not truly independent. Thus predicted purity, which is used to predict the city-level price, is omitted from the analysis.

increases. A 10 percent increase in the previous year AIDS rate decreases the probability of injection by between two and four percent depending on the type of injection.[17]

In the long term, NEPs significantly reduce all three types of injection by 21–25 percent. NEPs also reduce injection of any drug and cocaine in the short term. This is somewhat surprising given that NEPs lower the cost of injection by providing free needles. Some previous analyses of NEP effects present similar findings, but none provide a convincing explanation. Referrals to drug treatment must play a role. Lurie and Reingold (1993) find that even though NEP clients are typically offered drug treatment only upon request and treatment slots are often scarce, 30–40 percent of clients in several cities were referred to treatment, and placement occurs more quickly than otherwise. Thus, many NEPs act as a bridge to drug treatment for injectors who visit the NEP because they are seeking treatment. In addition, the provision of HIV counseling and testing by NEPs might reduce injection rates. Presumably NEP clients are aware of HIV infection risks, but this knowledge might be enhanced by information gained from program personnel. Moreover, HIV testing eliminates uncertainty about HIV status. Watters et al. (1994) find that receiving an HIV test result, regardless of the outcome, is a strong predictor of not sharing needles. Such information could diminish injection if clients are concerned about the sterility of exchanged needles or simply that continued injection will eventually expose them to contaminated needles.

[17] An alternative interpretation is that the negative AIDS coefficients primarily reflect sample selection: when AIDS rates rise, drug injectors die or become too ill to further inject drugs. Federal Bureau of Investigation (1996) arrest data suggest that in 1995, for instance, 125 of 1,000 male residents of DUF cities were arrestees. Consider the impact of a unit increase in the lagged AIDS rate (1 case per 1,000 residents), which implies an increase of about 1.8 cases per 1,000 male residents since about 90 percent of those with AIDS are men. The CDC reports that 35 percent of identifiable male AIDS cases involve injection on the part of the infected individual, meaning that the above increase represents .63 injection-related cases per 1,000 residents. Under the unrealistically conservative assumptions that all AIDS sufferers are rendered unable to inject drugs within a year, the resulting reduction in injection probability is .63/125 = .005. Thus at most about 14 percent of the estimated effect on past six month injection can be attributed to selection.

The lower panel of Table 5 displays results for current needle sharing. Income and cocaine price effects have switched signs, as predicted, and are significant except for income in the sample of all respondents. This is consistent with price-inelastic injection demand: as prices rise, injection drug expenditures occupy more of the budget, and funds to spend on clean needles become scarcer. AIDS rates are negatively related to overall sharing, but have no effect on sharing by injectors. This is intriguing, given that that the primary risk of HIV infection from injecting drugs involves using contaminated needles. Again, some injectors conceivably worry about the sterility of seemingly clean needles, and perhaps others simply recognize that injection can lead to AIDS or want to further diminish the risk by avoiding injection altogether. Meanwhile, NEPs reduce sharing among injectors by 21 percent in the long run, and diminish overall sharing by 25 percent in the first six months and by 45 percent thereafter.[18]

To appreciate these results, it is important to recognize that the effects of each variable on past six month injection, sharing among all respondents, and sharing among injectors are related because $\Pr(s) = \Pr(i) \times \Pr(s \mid i)$, where i equals injection and s denotes sharing. If E represents elasticity (or percentage change induced by a binary variable change), and z is an explanatory variable, then

$$E_{\Pr(s),\, z} = E_{\Pr(i),\, z} + E_{\Pr(s \mid i),\, z}, \tag{3}$$

though empirically this relationship is only an approximation. Thus the negative (positive) effect of income (cocaine price) on sharing by injectors is offset by an inverse effect on injection and thus translates to a weaker effect on overall sharing. Put differently, the effects of income and cocaine price on sharing among all respondents are less than the corresponding effects on sharing

[18] When selection of injectors is accounted for using a Heckman-type maximum likelihood procedure, identified by the past year AIDS rate since it does not affect sharing, results are nearly identical and the selection coefficient is insignificant regardless of whether trends are included. Results are also quite similar when samples are alternatively restricted to those who have ever injected any drug and those who have ever injected cocaine or heroin.

among injectors because non-injectors are the majority of the full sample, and price hikes and income declines decrease injection relative to non-injection. In contrast, AIDS prevalence and NEPs exert downward pressure on both injection and sharing by injectors, and the sum of these negative effects is the effect on sharing among all respondents. While the effect of AIDS on injection is sufficiently strong to produce a significant effect on overall sharing despite an insignificant effect on sharing by injectors, sizable impacts of NEPs on both injection and injector sharing, particularly once programs are in place for six months, result in large impacts on overall sharing.

It is noteworthy that a simple indicator of NEP presence, without controls for program size, has a substantial effect on injection behavior. However, Lurie and Reingold (1993) and Watters et al. (1994) report that many NEPs reach large proportions of the local drug injecting population. The earlier cited result from Hurley (1997) regarding the impact of program presence on HIV infection rates implies large reductions in injection risk behavior.

Appendix 1 displays results for the individual characteristics in the Table 5 regressions that include city-specific trends. Likelihoods of both injection and sharing rise with age to the mid-40s and fall thereafter, increase with education to grade nine (but only grade seven for sharing by injectors) and decline thereafter, are lower for blacks and those of other races than for whites, are lower for married men and higher for divorced men than for single men, are lower for workers than non-workers, are positively related with the fraction of income earned illegally, and decrease over time, though the trend is less pronounced for sharing by injectors.

Tables 6–8 display the results of various sensitivity analyses. All remaining regressions control for city-specific trends, with the exception that panel (a) of Table 8 also shows results for comparable regressions without trends. The Table 6 samples omit drug offenders (upper panel) and arrestees reporting drug dealing as their primary past month income source (lower panel). About one-sixth of respondents are arrested for drug possession, sales, or use of a controlled substance, while three percent report drug dealing. Past six month injection rates are 11.0 percent for drug offenders and 19.7 percent for dealers, as opposed to just over eight percent for non-drug offenders and non-dealers, so the responses of drug offenders and dealers to explanatory variable changes conceivably differ from those of other arrestees. In fact, though, results for these samples are quite similar to those for all respondents. The only notable differences for non-drug offenders compared to the full sample are that cocaine prices do not affect cocaine injection, NEPs do not reduce heroin injection, AIDS prevalence has larger impacts on heroin injection and overall sharing, and the sizes of NEP effects on any injection and overall sharing are 20 percent larger. For non-dealers, increases in income and AIDS rates no longer significantly reduce sharing among injectors and all respondents, respectively.

Table 7 examines samples that exclude various cities. To address the possibility that errors in measuring drug prices potentially explain why cocaine prices have no effect on overall injection and heroin prices fail to impact any type of injection behavior, the panel (a) sample is restricted to cities that do not use cocaine or heroin price data from metropolitan areas not sampled by DUF, as previously described. Though the one-third reduction in sample size reduces the significance of some results, the only substantive changes are that AIDS does not significantly affect overall sharing, and the heroin price effect on cocaine injection implies that the two drugs are substitutes (though the result is not symmetric). Thus earlier conclusions regarding prices are not altered. Panel (b) restricts the sample to the nine cities in which NEPs opened during the period. The sixty percent decrease in sample size renders income and the cocaine price insignificant in the cocaine injection equation, but does not alter the magnitudes of the effects. Other results are similar to those in Table 5, with AIDS prevalence and NEPs having stronger impacts on many types of injection behavior.

Finally, Table 8 shows results when self-reported information on past 72 hour cocaine and heroin use are utilized. In panel (a) the cocaine and heroin injection variables are constructed using reported drug use rather than drug test results, so that these variables are constructed entirely from self-report information rather than a mixture of interview responses and urinalysis outcomes. For cocaine injection the results are similar, though income and cocaine price effects are one-third to one-half larger. For heroin injection, income effects are four times larger and become significant, while short-term NEP effects also grow in size and become significant. Panel (b) excludes respondents for whom self-reported and test information does not match. Though some mismatches are produced by incorrect test results, it is likely that most are the result of lying by respondents. Although this restriction excludes 28 percent of the main sample, results are again similar. The primary difference is that the heroin price becomes significantly positive in the equations for injection of any drug and cocaine and, consequently, in the overall sharing equation.

VI. Conclusion

Controlling for individual characteristics, city and year indicators, and city-specific behavioral trends, this study finds that personal income, cocaine prices, AIDS rates, and needle exchange programs each have significant effects on arrestee drug injection behavior. Injected cocaine and injected drugs in total, as well as needles used for injecting, are normal goods for arrestees. Cocaine price increases reduce injection, but sufficiently increase needle sharing by those who continue injecting so that overall sharing rates rise. Increases in AIDS prevalence trigger reductions in injection that are large enough to lower overall sharing rates without affecting the proportion of injectors who share. Moreover, the opening of a needle exchange program reduces injection by 24 percent and sharing among remaining injectors by 21 percent, for an overall decrease in sharing of 45 percent.

These results, and their associated policy implications, parallel those of many previous economics studies of drug use and risky sexual behavior, with the additional possibility that some policies that reduce drug injection might have unintended counteracting consequences on needle sharing. Drug policy that raises cocaine prices will reduce cocaine injection but simultaneously increase needle sharing. Analogous to the findings of Ruhm (2000) that economic expansions increase rates of unhealthy behaviors, policies that increase personal income, particularly among low income individuals, will increase injection, but reciprocally reduce needle sharing by injectors. The AIDS results provide further support for the hypothesis that AIDS outbreaks are self-limiting to the extent that they will reduce behavior leading to AIDS (Ahituv et al. 1996), which means policy makers must be aware that increases in drug injection and needle sharing are potential inadvertent consequences of programs that reduce HIV transmission.

Perhaps most significantly, the needle exchange program results not only corroborate earlier evidence that NEPs reduce needle sharing, but furthermore indicate that NEPs offer the additional benefit of reducing drug injection. It must be emphasized that in this sample, injection and sharing rates are much higher in cities that started NEPs, even after NEPs opened, than in other cities. Impacts of NEPs in cities with low injection and sharing rates before NEP opening might by definition be weaker. For instance, Table 4 indicates that in 1995, average rates in four cities that opened NEPs in late 1995 and 1996 – Atlanta, Cleveland, Detroit, and Washington

D.C. – were 5.0 percent for injection and 0.8 percent for sharing, compared with 8.8 percent and 2.7 percent, respectively, in other cities including those where NEPs have been operating for years. Common sense dictates that NEPs will be more effective in cities where they have more potential clients and thus can have a larger public health impact.

NEPs already have overwhelming support in the scientific community (Ruiz-Sierra 2001) and have been publicly endorsed by both former Secretary of Health and Human Services Donna E. Shalala and former Surgeon General David Satcher. Although I neither study NEP costs nor fully account for NEP benefits, other evidence on the costs of NEPs (Lurie and Reingold 1993, Singh et al. 2001) coupled with the large effects of NEPs on drug injection and needle sharing found here imply that NEPs might be a cost-effective way to reduce the transmission of HIV, particularly in areas with above average injection and sharing rates. This concurs with conclusions from Holtgrave et al. (1998), Lurie and DeCarlo (1998), and Lurie and Reingold (1993) that NEP costs per HIV infection prevented are far below the expected lifetime cost of treating an HIV-infected individual. The current federal government ban on NEP funding and state drug paraphernalia laws limiting syringe possession and distribution might therefore be ill-conceived. For instance, in October 1998, Congress barred the District of Columbia from funding NEPs and prohibited all federal NEP funding in D.C. As a result, the original $220,000 D.C. NEP closed (though it was soon replaced by a privately-funded program) despite a fiscal impact study estimating that failing to provide needle exchange would cost D.C. $8.3 million annually. In contrast, alternatives such as pharmacy syringe sales, physician prescription of syringes for drug injection, and automated needle exchange might reduce drug injection and needle sharing and thus rates of HIV infection.

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Figure 1: Injection and Needle Sharing Rates

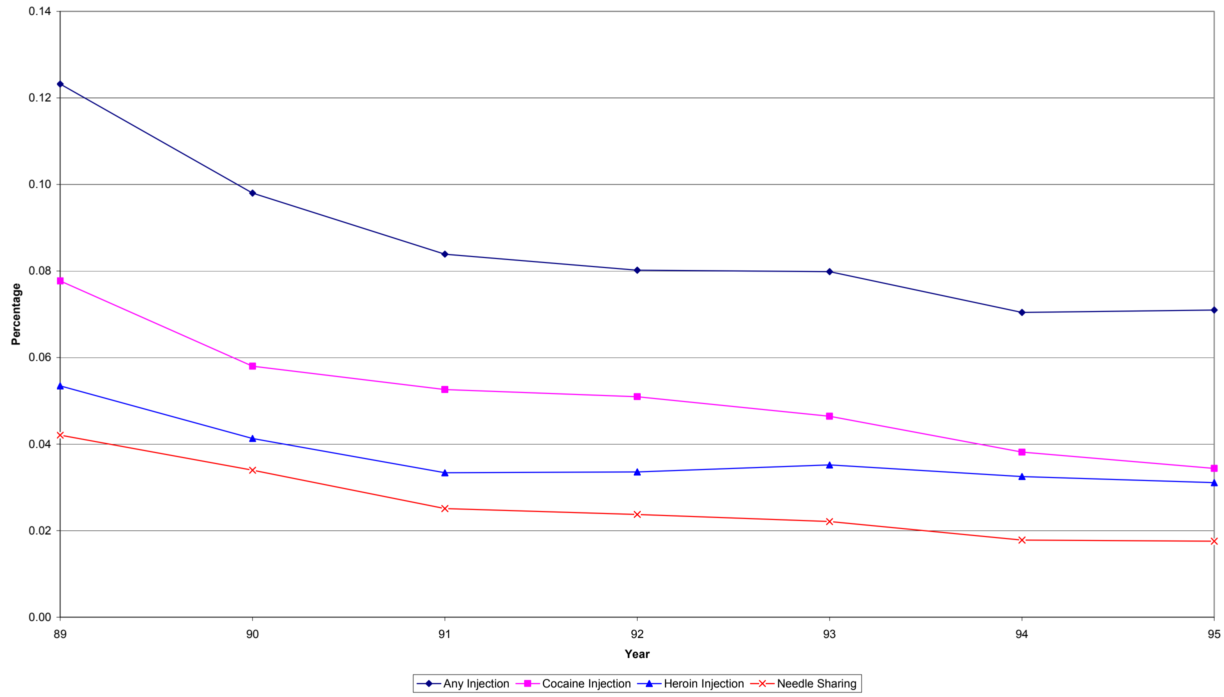

Figure 2: Needle Sharing Among Injectors

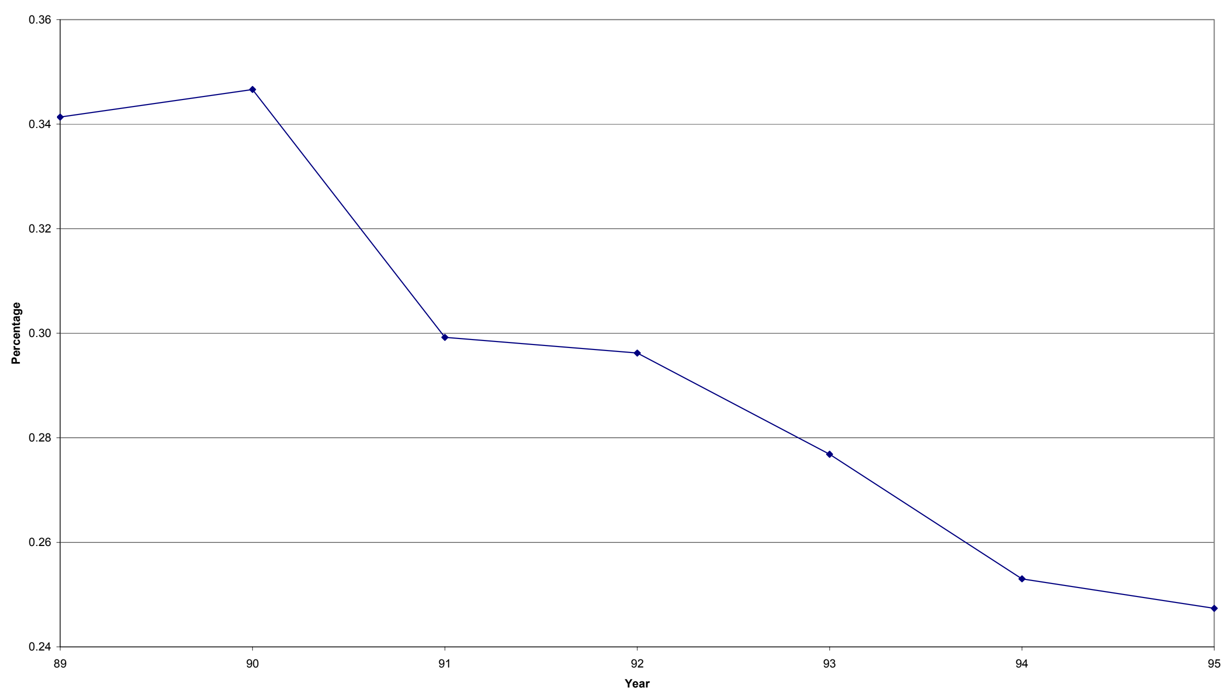

Figure 3: Cocaine and Heroin Prices

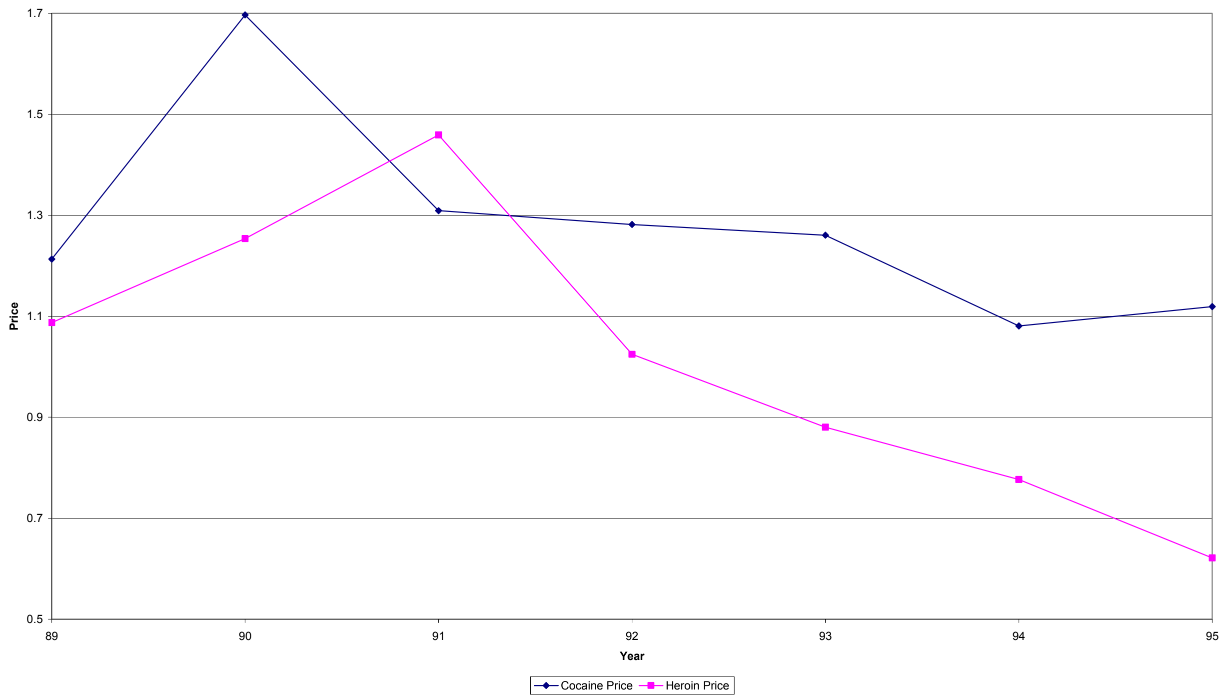

Figure 4: AIDS Rates and NEP Presence

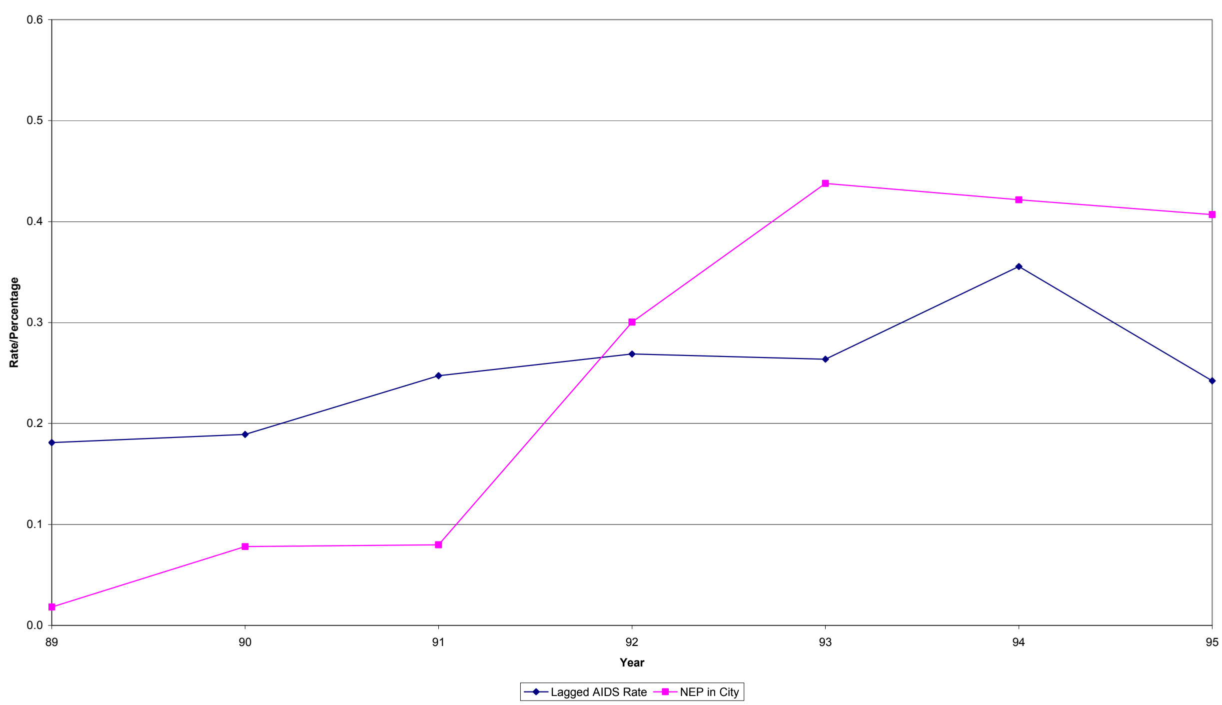

TABLE 1.—PAST SIX MONTH INJECTORS CLASSIFIED AS CURRENT COCAINE OR HEROIN INJECTORS

		Current cocaine injector		
		No	Yes	Total
Current heroin injector	No	2,778 (26.5%)	3,222 (30.7%)	6,000 (57.2%)
	Yes	1,472 (14.0%)	3,016 (28.8%)	4,488 (42.8%)
	Total	4,250 (40.5%)	6,238 (59.5%)	10,488

TABLE 2.—OPENING DATES OF FIRST NEEDLE EXCHANGE PROGRAMS IN DUF CITIES

Year	Month	City
1989	November	Portland
1990	February	New York
1991	December	Philadelphia
1992	January	Chicago, San Diego
	June	Dallas, Los Angeles
	July	San Jose
	October	Indianapolis

The remaining 15 DUF cities did not have NEPs during the sample period.

TABLE 3.—SUMMARY STATISTICS

Sample:	All Respondents (n = 122,623)		Drug injectors (n = 10,488)	
	Mean	Standard Deviation	Mean	Standard Deviation
Dependent variables				
Injected drugs past 6 months	.0855	.2797		
Currently injects cocaine	.0509	.2197		
Currently injects heroin	.0366	.1878		
Currently shares needles	.0257	.1582	.3003	.4584
Main explanatory variables				
Past month income (in $10,000s)	.1308	.3116	.1976	.4823
Cocaine price (in $100s)	1.296	.3818	1.238	.3678
Heroin price (in $1,000s)	1.046	.5535	.9389	.5008
Past year AIDS rate (per 1,000 residents)	.2541	.2009	.2312	.1633
NEP in city for 0–5 months	.0405	.1972	.0526	.2233
NEP in city for 6 or more months	.2084	.4062	.2665	.4421
Other explanatory variables				
Age	29.75	9.159	34.06	7.987
Age squared	968.9	647.8	1224	579.7
Education	11.29	2.276	11.28	2.230
Education squared	132.7	46.65	132.1	45.91
Black	.5611	.4963	.3333	.4714
Hispanic	.1818	.3857	.2445	.4298
Other	.0145	.1197	.0071	.0837
Married	.1538	.3608	.1420	.3490
Cohabiting	.1368	.3437	.1333	.3399
Divorced	.1489	.3560	.2691	.4435
Widow	.0061	.0776	.0114	.1064
Works full time	.3992	.4897	.2397	.4269
Works part time	.1432	.3502	.1237	.3292
Percent of income that is illegally obtained	.1032	.2748	.2750	.4008

Current cocaine (heroin) injectors are respondents who jointly tested positive for cocaine (opiates), injected drugs in the past 6 months, and injected cocaine (heroin) previously. Income and prices are in 1997 dollars. The AIDS rate is the number of cases in the metropolitan area per 1,000 residents.

TABLE 4.—PAST SIX MONTH INJECTION AND RECENT NEEDLE SHARING RATES, BY CITY AND YEAR

(a) Past six month injection rates

City	1989	1990	1991	1992	1993	1994	1995	Mean	Trend
San Diego	.273	.221	.209	**.171**	**.181**	**.147**	**.131**	**.191**	**-.021***
Birmingham	.117	.070	.046	.033	.034	.020	.020	.049	-.014*
Los Angeles	.177	.160	.137	.132	**.117**	**.106**	**.103**	**.133**	**-.012***
Chicago	.105	.063	.059	**.032**	**.026**	**.031**	**.038**	**.051**	**-.011***
New Orleans	.105	.089	.061	.046	.045	.043	.035	.061	-.011*
New York	.152	.141	**.102**	**.121**	**.110**	**.087**	**.084**	**.114**	**-.011***
Detroit	.104	.051	.055	.050	.038	.035	.025	.051	-.010*
Houston	.059	.084	.074	.053	.040	.025	.021	.051	-.010*
Philadelphia	.153	.093	.099	**.100**	**.083**	**.093**	**.069**	**.099**	**-.010***
San Antonio	.186	.161	.151	.147	.148	.146	.102	.149	-.010*
Atlanta		.066	.040	.032	.030	.021	.016	.034	-.009*
Kansas City	.061	.044	.042	.032				.045	-.009*
Cleveland	.069	.052	.042	.046	.039	.020	.023	.041	-.007*
Dallas	.090	.100	.075	.076	**.070**	**.070**	**.054**	**.076**	**-.006***
Wash. D.C.	.078	.087	.078	.086	.076	.057	.054	.074	-.005*
San Jose	.087	.104	.107	.086	**.084**	**.087**	**.066**	**.089**	**-.004***
Ft. Lauderdale	.033	.021	.014	.010	.007	.012	.011	.015	-.003*
Phoenix	.147	.133	.112	.132	.123	.110	.135	.128	-.003
Portland	.245	**.177**	**.175**	**.208**	**.203**	**.172**	**.207**	**.198**	**-.003**
St. Louis	.073	.054	.057	.047	.047	.050	.056	.055	-.002
Miami	.005		.018	.023	.027	.009	.019	.017	-.001
Indianapolis	.100	.074	.108	.124	**.111**	**.095**	**.088**	**.100**	**.000**
Omaha		.065	.036	.039	.049	.044	.057	.048	.000
Denver		.073	.079	.073	.067	.084	.123	.083	.007

(b) Needle sharing rates (all respondents)

City	1989	1990	1991	1992	1993	1994	1995	Mean	Trend
Los Angeles	.097	.099	.074	.067	**.054**	**.044**	**.032**	**.067**	**-.012***
San Diego	.133	.092	.078	**.060**	**.083**	**.050**	**.051**	**.078**	**-.012***
San Antonio	.071	.075	.071	.058	.038	.045	.031	.056	-.008*
Chicago	.041	.017	.011	**.007**	**.005**	**.005**	**.007**	**.013**	**-.005***
New Orleans	.036	.029	.018	.008	.011	.007	.007	.017	-.005*
Philadelphia	.043	.029	.020	**.017**	**.011**	**.018**	**.008**	**.021**	**-.005***
Portland	.091	**.069**	**.046**	**.068**	**.064**	**.049**	**.050**	**.062**	**-.005***
Cleveland	.024	.024	.009	.010	.003	.003	.006	.011	-.004*
Houston	.026	.030	.026	.017	.013	.008	.007	.018	-.004*
New York	.049	.043	**.021**	**.024**	**.021**	**.022**	**.021**	**.029**	**-.004***
Birmingham	.019	.014	.005	.006	.000	.003	.002	.007	-.003*
Kansas City	.017	.005	.007	.006				.009	-.003
Atlanta		.012	.004	.005	.005	.003	.000	.005	-.002*
Dallas	.031	.031	.022	.025	**.029**	**.021**	**.018**	**.025**	**-.002***
Detroit	.014	.013	.010	.012	.007	.000	.003	.008	-.002*
Ft. Lauderdale	.009	.009	.007	.002	.001	.001	.002	.005	-.002*
St. Louis	.019	.013	.010	.007	.007	.007	.005	.010	-.002*
Denver		.026	.022	.017	.013	.010	.021	.018	-.002
San Jose	.026	.041	.043	.029	**.030**	**.030**	**.021**	**.031**	**-.002**
Indianapolis	.018	.011	.028	.037	**.028**	**.018**	**.009**	**.021**	**.000**
Miami	.005		.003	.007	.005	.001	.008	.005	.000
Omaha		.009	.005	.002	.008	.005	.007	.006	.000
Phoenix	.050	.034	.032	.049	.036	.032	.048	.040	.000
Wash. D.C.	.004	.007	.009	.007	.004	.004	.007	.006	.000

Means weight each year equally. Trends are slope coefficients in a within-city univariate regression of rate on year. A * denotes that the trend coefficient is significant at the 95 percent level. The trends for Miami omit 1989 data.

TABLE 5.—MAIN SAMPLE RESULTS WITH AND WITHOUT CITY-SPECIFIC TRENDS

Dependent variable:	Any injection		Cocaine injection		Heroin injection	
City-specific trends:	No	Yes	No	Yes	No	Yes
Past month income	.0034[b]	.0030[b]	.0023[b]	.0020[b]	.0003	.0002
(in $10,000s)	(.0014)	(.0014)	(.0010)	(.0009)	(.0005)	(.0005)
	.0102	*.0092*	*.0122*	*.0106*	*.0043*	*.0034*
Cocaine price	-.0090[a]	-.0043	-.0083[a]	-.0058[b]	.0014	-.0001
(in $100s)	(.0034)	(.0038)	(.0024)	(.0027)	(.0014)	(.0016)
	-.2672	*-.1300*	*-.4341*	*-.3118*	*-.1846*	*-.0100*
Heroin price	.0003	.0023	.0005	.0021	-.0013	-.0003
(in $1,000s)	(.0019)	(.0021)	(.0014)	(.0015)	(.0009)	(.0009)
	.0062	*.0568*	*.0225*	*.0920*	*-.1382*	*-.0379*
Past year AIDS rate	-.0284[b]	-.0354[b]	-.0197[b]	-.0251[b]	-.0175[a]	-.0153[a]
(cases per 1,000 residents)	(.0120)	(.0142)	(.0083)	(.0099)	(.0048)	(.0055)
	-.1646	*-.2086*	*-.2029*	*-.2644*	*-.4548*	*-.4096*
NEP in city for 0–5 months	-.0038	-.0053[c]	-.0053[a]	-.0055[a]	-.0009	-.0013
	(.0028)	(.0030)	(.0018)	(.0019)	(.0010)	(.0011)
	-.0858	*-.1225*	*-.2156*	*-.2277*	*-.0922*	*-.1354*
NEP in city for 6 or more	-.0058[a]	-.0102[a]	-.0064[a]	-.0060[a]	-.0019[b]	-.0020[c]
months	(.0021)	(.0031)	(.0014)	(.0021)	(.0008)	(.0011)
	-.1315	*-.2358*	*-.2606*	*-.2501*	*-.1992*	*-.2141*
χ^2 (Wald test for city trend sig.)		183.7[a]		189.1[a]		183.7[a]
Predicted injection rate at mean	.0439	.0432	.0247	.0241	.0098	.0095
Pseudo R^2	.2132	.2158	.1868	.1907	.2489	.2519

Dependent variable:	Sharing (all)		Sharing (injectors)	
City-specific trends:	No	Yes	No	Yes
Past month income	-.0005	-.0005	-.0285[a]	-.0295[a]
(in $10,000s)	(.0005)	(.0005)	(.0103)	(.0103)
	-.0077	*-.0089*	*-.0197*	*-.0205*
Cocaine price	.0012	.0030[b]	.0869[a]	.1073[a]
(in $100s)	(.0013)	(.0014)	(.0299)	(.0343)
	.1975	*.4974*	*.3771*	*.4673*
Heroin price	.0014[c]	.0011	.0402[b]	.0275
(in $1,000s)	(.0007)	(.0008)	(.0174)	(.0194)
	.1751	*.1496*	*.1325*	*.0907*
Past year AIDS rate	-.0093[b]	-.0096[c]	-.1034	-.1088
(cases per 1,000 residents)	(.0046)	(.0052)	(.1164)	(.1310)
	-.2927	*-.3146*	*-.0839*	*-.0885*
NEP in city for 0–6 months	-.0013	-.0019[b]	-.0244	-.0369
	(.0009)	(.0009)	(.0221)	(.0242)
	-.1651	*-.2466*	*-.0855*	*-.1297*
NEP in city for 6 or more	-.0020[a]	-.0035[a]	-.0337[c]	-.0599[b]
months	(.0007)	(.0009)	(.0183)	(.0258)
	-.2467	*-.4486*	*-.1181*	*-.2105*
χ^2 (Wald test for city trend sig.)		88.65[a]		38.67[b]
Predicted sharing rate at mean	.0081	.0077	.2852	.2843
Pseudo R^2	.2256	.2287	.0711	.0741

Sample sizes are 10,488 for sharing among injectors and 122,623 for remaining samples. Parentheses contain standard errors. Coefficients and standard errors are in probit marginal effect terms. Italics represent elasticities for continuous variables and the percentage effect of a 0 to 1 change in NEP indicators. Marginal and percentage effects and elasticities are evaluated at the explanatory variable means. Superscripts [c], [b], and [a] denote significance at the 90, 95, and 99 percent levels, respectively. All regressions include the variables listed in Appendix 1 as well as city indicators.

TABLE 6.—RESULTS FOR SAMPLES EXCLUDING DRUG OFFENDERS OR DEALERS

Dependent variable:	Any injection	Cocaine injection	Heroin injection	Sharing (all)	Sharing (injectors)
Specification:	(a) Excludes drug offenders				
Past month income	.0035[b]	.0022[b]	.0003	-.0002	-.0244[c]
(in $10,000s)	(.0014)	(.0009)	(.0005)	(.0005)	(.0132)
	.0113	*.0132*	*.0047*	*-.0036*	*-.0107*
Cocaine price	-.0028	-.0036	.0004	.0025[c]	.0960[b]
(in $100s)	(.0039)	(.0027)	(.0015)	(.0014)	(.0381)
	-.0926	*-.2224*	*.0665*	*.4604*	*.4231*
Heroin price	.0021	.0020	.0001	.0011	.0283
(in $1,000s)	(.0021)	(.0014)	(.0009)	(.0008)	(.0220)
	.0556	*.0995*	*.0109*	*.1596*	*.1007*
Past year AIDS rate	-.0329[b]	-.0235[b]	-.0153[a]	-.0126[b]	-.2041
(cases per 1,000 residents)	(.0152)	(.0102)	(.0053)	(.0056)	(.1478)
	-.2112	*-.2823*	*-.5169*	*-.4504*	*-.1757*
NEP in city for 0–5 months	-.0043	-.0043[b]	-.0005	-.0019[c]	-.0400
	(.0031)	(.0019)	(.0010)	(.0009)	(.0271)
	-.1087	*-.2023*	*-.0634*	*-.2602*	*-.1353*
NEP in city for 6 or more months	-.0117[a]	-.0062[a]	-.0014	-.0039[a]	-.0688[b]
	(.0031)	(.0021)	(.0010)	(.0009)	(.0287)
	-.2959	*-.2915*	*-.1879*	*-.5477*	*-.2324*
Predicted dependent variable mean	.0396	.0213	.0076	.0072	.2960
Dependent variable mean	.0808	.0476	.0329	.0251	.3107
Pseudo R^2	.2201	.2011	.2672	.2350	.0725
Specification:	(b) Excludes those reporting drug dealing as primary income source				
Past month income	.0050[a]	.0033[a]	.0007	.0001	-.0209
(in $10,000s)	(.0016)	(.0011)	(.0006)	(.0005)	(.0134)
	.0142	*.0166*	*.0090*	*.0021*	*-.0089*
Cocaine price	-.0048	-.0051[c]	-.0002	.0030[b]	.1180[a]
(in $100s)	(.0038)	(.0027)	(.0016)	(.0014)	(.0352)
	-.1474	*-.2831*	*-.0253*	*.5183*	*.5476*
Heroin price	.0022	.0019	-.0004	.0009	.0247
(in $1,000s)	(.0020)	(.0014)	(.0009)	(.0007)	(.0196)
	.0551	*.0871*	*-.0446*	*.1328*	*.0929*
Past year AIDS rate	-.0288[c]	-.0222[b]	-.0136[b]	-.0084	-.1286
(cases per 1,000 residents)	(.0148)	(.0101)	(.0057)	(.0055)	(.1356)
	-.1730	*-.2415*	*-.3722*	*-.2860*	*-.1165*
NEP in city for 0–5 months	-.0054[c]	-.0056[a]	-.0015	-.0022[b]	-.0484[c]
	(.0029)	(.0019)	(.0010)	(.0008)	(.0246)
	-.1292	*-.2405*	*-.1585*	*-.2948*	*-.1730*
NEP in city for 6 or more months	-.0108[a]	-.0067[a]	-.0024[b]	-.0033[a]	-.0548[b]
	(.0030)	(.0021)	(.0011)	(.0009)	(.0266)
	-.2551	*-.2880*	*-.2622*	*-.4450*	*-.1960*
Predicted dependent variable mean	.0421	.0233	.0092	.0074	.2797
Dependent variable mean	.0822	.0486	.0351	.0243	.2958
Pseudo R^2	.2084	.1870	.2485	.2231	.0738

Regressions in (a) include 102,449 total respondents and 8,276 injectors; those in (b) include 119,010 total respondents and 9,777 injectors. Coefficients and standard errors (in parentheses) are in probit marginal effect terms. Italics represent elasticities for continuous variables and the percentage effect of a 0 to 1 change in NEP indicators. Marginal and percentage effects and elasticities are evaluated at the explanatory variable means. Superscripts [c], [b], and [a] denote significance at the 90, 95, and 99 percent levels, respectively. All regressions include the variables listed in Appendix 1, city indicators and city trends.

TABLE 7.—RESULTS FOR SAMPLES EXCLUDING CITIES WITHOUT MATCHING PRICE DATA OR NEP

Dependent variable:	Any injection	Cocaine injection	Heroin injection	Sharing (all)	Sharing (injectors)
Specification:	(a) Excludes cities using price data from other metropolitan areas				
Past month income	.0029[c]	.0023[b]	.0002	-.0005	-.0273[c]
(in $10,000s)	(.0017)	(.0011)	(.0007)	(.0007)	(.0146)
	.0085	*.0113*	*.0023*	*-.0068*	*-.0119*
Cocaine price	-.0062	-.0083[b]	.0024	.0036[c]	.1386[a]
(in $100s)	(.0056)	(.0041)	(.0028)	(.0021)	(.0454)
	-.1581	*-.3607*	*.1937*	*.4404*	*.5312*
Heroin price	.0045	.0054[b]	-.0001	.0017	.0318
(in $1,000s)	(.0029)	(.0021)	(.0017)	(.0011)	(.0258)
	.0856	*.1775*	*-.0084*	*.1589*	*.0922*
Past year AIDS rate	-.0315[c]	-.0220[c]	-.0279[a]	-.0066	-.0298
(cases per 1,000 residents)	(.0173)	(.0123)	(.0085)	(.0070)	(.1474)
	-.2105	*-.2517*	*-.5965*	*-.2149*	*-.0299*
NEP in city for 0–5 months	-.0066[c]	-.0076[a]	-.0023	-.0019	-.0306
	(.0034)	(.0022)	(.0016)	(.0012)	(.0277)
	-.1437	*-.2810*	*-.1561*	*-.2040*	*-.0998*
NEP in city for 6 or more months	-.0101[a]	-.0088[a]	-.0029[c]	-.0040[a]	-.0626[b]
	(.0036)	(.0025)	(.0017)	(.0012)	(.0291)
	-.2198	*-.3268*	*-.2003*	*-.4175*	*-.2043*
Predicted dependent variable mean	.0461	.0269	.0144	.0095	.3063
Dependent variable mean	.0934	.0563	.0462	.0300	.3215
Pseudo R^2	.2271	.1946	.2395	.2278	.0730
Specification:	(b) Excludes cities in which no NEPs opened during sample period				
Past month income	.0058[b]	.0026	.0011	-.0015	-.0402[a]
(in $10,000s)	(.0029)	(.0019)	(.0013)	(.0013)	(.0150)
	.0111	*.0089*	*.0065*	*-.0125*	*-.0169*
Cocaine price	.0018	-.0106	.0028	.0101[b]	.1619[a]
(in $100s)	(.0097)	(.0069)	(.0050)	(.0040)	(.0520)
	.0289	*-.3061*	*.1406*	*.6986*	*.5719*
Heroin price	.0055	.0058	.0009	.0016	.0200
(in $1,000s)	(.0050)	(.0035)	(.0029)	(.0022)	(.0312)
	.0655	*.1248*	*.0346*	*.0808*	*.0528*
Past year AIDS rate	-.0843[b]	-.0739[b]	-.0361[b]	-.0417[a]	-.3152
(cases per 1,000 residents)	(.0357)	(.0257)	(.0173)	(.0162)	(.2032)
	-.3050	*-.4828*	*-.4075*	*-.6487*	*-.2518*
NEP in city for 0–5 months	-.0075	-.0097[a]	-.0026	-.0048[b]	-.0564[b]
	(.0050)	(.0032)	(.0026)	(.0018)	(.0271)
	-.1027	*-.2421*	*-.1098*	*-.2866*	*-.1713*
NEP in city for 6 or more months	-.0190[a]	-.0112[a]	-.0057[b]	-.0110[a]	-.0984[a]
	(.0056)	(.0039)	(.0028)	(.0025)	(.0301)
	-.2618	*-.2781*	*-.2430*	*-.6525*	*-.2988*
Predicted dependent variable mean	.0727	.0403	.0233	.0169	.3292
Dependent variable mean	.1179	.0713	.0554	.0400	.3395
Pseudo R^2	.1995	.1779	.2166	.2008	.0631

Regressions in (a) include 83,679 total respondents and 7,817 injectors; those in (b) include 51,103 total respondents and 6,026 injectors. Coefficients and standard errors (in parentheses) are in probit marginal effect terms. Italics represent elasticities for continuous variables and the percentage effect of a 0 to 1 change in NEP indicators. Marginal and percentage effects and elasticities are evaluated at the explanatory variable means. Superscripts [c], [b], and [a] denote significance at the 90, 95, and 99 percent levels, respectively. All regressions include the variables listed in Appendix 1, city indicators and city trends.

TABLE 8.—RESULTS USING SELF-REPORTED CURRENT USE OF COCAINE AND HEROIN

Specification:	(a) Data on current cocaine and heroin use are self-reported			
Dependent variable:	Cocaine injection		Heroin injection	
Past month income	.0029[a]	.0027[a]	.0014[b]	.0013[b]
(in $10,000s)	(.0008)	(.0008)	(.0005)	(.0005)
	.0189	*.0174*	*.0156*	*.0149*
Cocaine price	-.0090[a]	-.0069[a]	.0005	-.0004
(in $100s)	(.0022)	(.0024)	(.0016)	(.0019)
	-.5747	*-.4513*	*.0562*	*-.0496*
Heroin price	.0008	.0018	-.0001	.0004
(in $1,000s)	(.0012)	(.0013)	(.0009)	(.0010)
	.0401	*.0973*	*-.0060*	*.0364*
Past year AIDS rate	-.0156[b]	-.0186[b]	-.0181[a]	-.0156[a]
(cases per 1,000 residents)	(.0075)	(.0088)	(.0051)	(.0059)
	-.1950	*-.2376*	*-.4011*	*-.3518*
NEP in city for 0–5 months	-.0038[b]	-.0048[a]	-.0019[c]	-.0022[c]
	(.0016)	(.0017)	(.0011)	(.0011)
	-.1856	*-.2430*	*-.1700*	*-.1918*
NEP in city for 6 or more months	-.0047[a]	-.0065[a]	-.0029[a]	-.0027[b]
	(.0013)	(.0018)	(.0008)	(.0012)
	-.2314	*-.3264*	*-.2504*	*-.2427*
City-specific trends:	No	Yes	No	Yes
Predicted dependent variable mean	.0204	.0199	.0115	.0113
Dependent variable mean	.0428	.0428	.0402	.0402

Specification:	(b) Excludes respondents for whom self-reports and urine tests differ				
Dependent variable:	Any injection	Cocaine injection	Heroin injection	Sharing (all)	Sharing (injectors)
Past month income	.0029[b]	.0022[b]	.0007[c]	-.0002	-.0218
(in $10,000s)	(.0014)	(.0009)	(.0004)	(.0006)	(.0142)
	.0100	*.0147*	*.0149*	*-.0046*	*-.0097*
Cocaine price	-.0035	-.0066[b]	-.0001	.0029[c]	.1246[a]
(in $100s)	(.0042)	(.0029)	(.0015)	(.0016)	(.0430)
	-.1170	*-.4258*	*-.0192*	*.5274*	*.5415*
Heroin price	.0055[b]	.0035[b]	.0007	.0017[b]	.0297
(in $1,000s)	(.0023)	(.0015)	(.0008)	(.0008)	(.0240)
	.1487	*.1803*	*.1173*	*.2531*	*.1037*
Past year AIDS rate	-.0465[c]	-.0248[b]	-.0171[a]	-.0104[c]	-.0724
(cases per 1,000 residents)	(.0163)	(.0107)	(.0047)	(.0058)	(.1596)
	-.3002	*-.3067*	*-.6933*	*-.3614*	*-.0605*
NEP in city for 0–5 months	-.0012	-.0044[b]	-.0006	-.0008	-.0308
	(.0034)	(.0020)	(.0009)	(.0011)	(.0303)
	-.0300	*-.2202*	*-.0993*	*-.1118*	*-.1032*
NEP in city for 6 or more months	-.0106[a]	-.0069[a]	-.0017[c]	-.0032[a]	-.0610[c]
	(.0033)	(.0021)	(.0009)	(.0010)	(.0326)
	-.2740	*-.3431*	*-.2787*	*-.4459*	*-.2040*
Predicted dependent variable mean	.0387	.0202	.0062	.0072	.2988
Dependent variable mean	.0781	.0458	.0324	.0245	.3140

Regressions in (a) include all respondents and injectors; those in (b) include 87,932 total respondents and 6,864 injectors. Coefficients and standard errors (in parentheses) are in probit marginal effect terms. Italics represent elasticities for continuous variables and the percentage effect of a 0 to 1 change in NEP indicators. Marginal and percentage effects and elasticities are evaluated at the explanatory variable means. Superscripts [c], [b], and [a] denote significance at the 90, 95, and 99 percent levels, respectively. All regressions include the variables listed in Appendix 1, city indicators and city trends.

APPENDIX 1.—EFFECTS OF OTHER VARIABLES

Dependent variable:	Any injection	Cocaine injection	Heroin injection	Sharing (all)	Sharing (injectors)
Age	.0188[a]	.0112[a]	.0053[a]	.0038[a]	.0183[a]
	(.0004)	(.0003)	(.0002)	(.0002)	(.0035)
Age squared	-.0216[a]	-.0129[a]	-.0058[a]	-.0044[a]	-.0198[a]
(x 100)	(.0005)	(.0004)	(.0002)	(.0002)	(.0048)
Education	.0148[a]	.0069[a]	.0035[a]	.0032[a]	.0135
	(.0010)	(.0007)	(.0004)	(.0004)	(.0090)
Education squared	-.0783[a]	-.0366[a]	-.0170[a]	-.0179[a]	-.1010[b]
(x 100)	(.0051)	(.0036)	(.0019)	(.0019)	(.0443)
Black	-.0722[a]	-.0257[a]	-.0113[a]	-.0159[a]	-.0808[a]
	(.0018)	(.0012)	(.0007)	(.0008)	(.0120)
Hispanic	-.0110[a]	.0025[b]	.0103[a]	-.0009[c]	.0178
	(.0014)	(.0013)	(.0010)	(.0005)	(.0130)
Other	-.0363[a]	-.0200[a]	-.0077[a]	-.0063[a]	-.0313
	(.0015)	(.0013)	(.0007)	(.0005)	(.0505)
Married	-.0123[a]	-.0079[a]	-.0018[a]	-.0037[a]	-.0460[a]
	(.0014)	(.0010)	(.0005)	(.0004)	(.0136)
Cohabiting	-.0008	-.0026[b]	.0003	-.0003	-.0048
	(.0017)	(.0011)	(.0007)	(.0006)	(.0141)
Divorced	. 0085[a]	.0040[a]	. 0019[a]	.0009[c]	-.0129
	(.0017)	(.0012)	(.0006)	(.0005)	(.0116)
Widowed	. 0187[a]	.0112[b]	. 0040	.0009	-.0416
	(.0077)	(.0054)	(.0027)	(.0022)	(.0404)
Works full-time	-.0309[a]	-.0176[a]	-. 0079[a]	-.0078[a]	-.0645[a]
	(.0012)	(.0009)	(.0005)	(.0005)	(.0114)
Works part-time	-.0078[a]	-.0049[a]	-.0005	-.0025[a]	-.0370[a]
	(.0015)	(.0011)	(.0006)	(.0005)	(.0139)
Percent of income	. 0826[a]	.0485[a]	.0212[a]	.0176[a]	.1065[a]
from illegal sources	(.0019)	(.0014)	(.0009)	(.0008)	(.0129)
1990	-.0109[a]	-.0076[a]	-.0033[a]	-.0032[a]	-.0487[b]
	(.0025)	(.0017)	(.0009)	(.0008)	(.0226)
1991	-.0210[a]	-.0140[a]	-.0053[a]	-.0047[a]	-.0524[c]
	(.0025)	(.0016)	(.0008)	(.0008)	(.0268)
1992	-.0238[a]	-.0160[a]	-.0058[a]	-.0046[a]	-.0232
	(.0032)	(.0021)	(.0010)	(.0011)	(.0374)
1993	-.0274[a]	-.0207[a]	-.0066[a]	-.0053[a]	-.0343
	(.0038)	(.0022)	(.0012)	(.0013)	(.0479)
1994	-.0303[a]	-.0241[a]	-.0064[a]	-.0054[a]	-.0159
	(.0045)	(.0024)	(.0015)	(.0016)	(.0638)
1995	-.0325[a]	-.0249[a]	-.0077[a]	-.0062[a]	-.0373
	(.0039)	(.0016)	(.0011)	(.0013)	(.0665)

These regressions correspond to the models with city-specific trends in Table 5 and include the variables listed there as well as city indicators. Coefficients and standard errors (in parentheses) are in probit marginal effect terms. Superscripts [c], [b], and [a] denote significance at the 90, 95, and 99 percent levels, respectively.