

Crystal Clear? The Relationship between Methamphetamine Use and Risky Sexual Behavior

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We estimate the causal effect of methamphetamine use on risky sexual behavior using monthly California county-level data on amphetamine-related hospital admissions and syphilis diagnoses from 1994 to 1997. Public health officials have cited methamphetamine control as a tool with which to decrease sexually transmitted infections, based on previous research that finds a strong positive correlation between methamphetamine use and risky sexual behavior. However, the observed positive correlation may not be causal, as both the methamphetamine use and risky sexual behavior could be driven by a third factor such as a preference for risky behavior. To circumvent this possible endogeneity, we exploit a large exogenous supply shock in the methamphetamine market that occurred in mid-1995. While we find that the supply shock had a large negative effect on methamphetamine use, we find no evidence that this decrease in methamphetamine use decreased syphilis rates and some evidence that it increased the syphilis rate in women. One possible explanation is that the large increase in the price of methamphetamine that followed the shock induced some addicts to exchange sex for money and drugs, thereby raising syphilis transmission.

JEL Codes: K36, I18, J12.

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I. Introduction

Risky sexual behavior and sexually transmitted infections (STIs) constitute a major health problem in the United States. According to the Centers for Disease, Control and Prevention (CDC), there are about 19 million new STIs each year, costing the healthcare system \$16.4 billion annually. Previous research suggests a high degree of correlation between methamphetamine use and the incidence of STIs ([Halkitis, Parsons and Stirratt 2001](#); [Shoptaw and Reback 2007](#); [Taylor et al. 2007](#)), and public health officials have increasingly targeted rising methamphetamine use as a factor in increasing STI rates.¹ However, drawing a causal inference from this correlation is difficult, as a third factor, perhaps a preference for risky behavior, might drive both methamphetamine use and risky sexual behavior. Determining causality is important, since if the relationship between methamphetamine use and risky sexual behavior is not causal, policies to reduce methamphetamine use may not reduce risky sexual behavior and STI prevalence.

The goal of this paper is to determine whether there is a causal relationship between methamphetamine use and risky sexual behavior. To circumvent the potential endogeneity between methamphetamine use and risky sexual behavior, we utilize a large exogenous shock to the supply of methamphetamine as an instrumental variable for methamphetamine use in two-stage-least-squares estimation. Our exogenous supply shock stems from the closure by the Drug Enforcement Agency (DEA) of two pharmaceutical companies in May 1995. These two pharmaceutical companies had been supplying more than 50 percent of the core ingredients used in the U.S. methamphetamine market. Previous papers examining this supply shock find that it increased methamphetamine prices from \$30 per gram to \$100 per gram and decreased the substance's purity from 90 percent to 20 percent ([Dobkin and Nicosia 2009](#)), causing amphetamine-related hospital admissions to drop by 30 percent to 50 percent ([Cunningham and Liu 2003](#); [Dobkin and Nicosia 2009](#)).

We start by re-examining the effect of the supply shock on methamphetamine consumption, using amphetamine-related hospital admissions from the California Office of Statewide Health Planning and Development (OSPHD) to proxy for methamphetamine use. Similar to previous studies examining the closure's effect on methamphetamine consumption, we find that the supply shock reduced methamphetamine consumption by between 30 to 40 percent. Next, we examine the dynamics of the supply shock's effects. We find that the first two months of the supply shock caused a 28 percent decrease in amphetamine-related hospital admissions. In the following three months, the supply shock reduced the admissions rate by 41 percent, and in the last three months of the shock, the amphetamine-related hospital admissions rate fell by about 22 percent.

We then turn to estimating the causal impact of methamphetamine use on risky sexual behavior, using the supply shock as an instrument for methamphetamine consumption and monthly county-level early-stage syphilis reports in California from the California Department of Public Health (CDPH) to measure risky sexual behavior. We find little evidence of a positive effect of methamphetamine use on syphilis rates. Our estimate of the elasticity of risky sexual behavior with respect to methamphetamine is -0.02. Broken down by gender, we find some evidence that the amphetamine shock increased women's risky sexual behavior. One possible

¹ See, for example <http://www.cdc.gov/hiv/resources/factsheets/meth.htm>

explanation is that the amphetamine shock induced some women to trade sex for drugs, increasing the incidence of risky sexual behaviors and thus STIs.

Our paper makes several contributions to the literature examining substance use and risky sexual behavior. First, it is the first paper to estimate a causal relationship between methamphetamine use and risky sexual behavior. Although other papers have estimated causal relationships between alcohol and marijuana consumption and risky sexual behaviors, no papers have examined methamphetamine use. Second, we are the first to use a supply shock to estimate a relationship between substance use and risky sexual behavior. Other papers have estimated the effects of supply shocks on substance consumption or used supply shocks to measure the effects of drug use on other negative social outcomes such as crime and foster care, and we believe this identification strategy is well suited to estimating a relationship between substance use and risky sexual behavior and STIs ([Anderson 2010](#); [Cunningham and Finlay 2011](#); [Dobkin and Nicosia 2009](#); [Nonnemaker, Engelen and Shive 2011](#)). Our paper joins other economics papers that estimate causal relationships between substance use and risky sexual behaviors through using substance prices and taxes in reduced form specifications ([Grossman, Kaestner and Markowitz 2004](#); [Grossman and Markowitz 2005](#)). Our identification strategy provides advantages over using prices as a measure of substance use. We are able to measure substance use at the county and month level, providing more data variation than previous studies, and the supply shock is a truly exogenous variable without endogeneity concerns stemming from the use of prices. Lastly, we decompose the dynamic effects of the supply shock on methamphetamine consumption.

The remainder of the paper is laid out as follows. Section II provides background on methamphetamine and risky sexual behavior, Section III outlines the empirical strategy, Section IV summarizes the data, Section V details the results, and Section VI concludes.

II. Background

A. Prevalence of Methamphetamine Use

Methamphetamine is a stimulant that affects the brain and central nervous system. It is easily manufactured from ephedrine or pseudoephedrine, a common decongestant used in cold medicines such as Sudafed, and a few other chemicals. While the majority of methamphetamine in the U.S. is manufactured in large operations, small methamphetamine manufactures, known as “meth labs,” have become common in recent years ([Hunt, Kuck and Truitt 2006](#)). Its ease of manufacture makes methamphetamine an especially hard drug to combat.

In 1997, 2.5 percent of U.S. residents age 12 and over had ever used methamphetamine, and methamphetamine use was concentrated among men, with 3.3 percent of men and 1.6 percent of women over age 12 ever using methamphetamine, and concentrated in the Western U.S., where 4.5 percent of residents age 12 and over had ever used methamphetamine. In 2002, just over 5 percent of U.S. residents 12 and over had ever used methamphetamine ([SAMHSA 2004](#)) and 0.7 percent had used methamphetamine in the past year. Currently, methamphetamine use is concentrated among those of ages 18 to 25 ([SAMHSA 2004](#)) and use is split almost equally between males and females ([Hunt, Kuck and Truitt 2006](#)).

B. Effects of Methamphetamine Use

When methamphetamine enters the body it triggers the release of large amounts of dopamine and other neurotransmitters. Brain cells and nervous system cells communicate through neurotransmitters, and the increase in these neurotransmitters produces sensations of self-confidence, energy, alertness, pleasure, and sexual arousal. The high from methamphetamine is very long compared to other substances, lasting from 8 to 24 hours. In comparison, the high from cocaine lasts from 30 minutes to one hour. Methamphetamine is highly addictive, and the trajectory of methamphetamine use from initial use to steady use and addiction is steep, even when compared to cocaine and heroin ([Gonzalez Castro et al. 2000](#); [Hser et al. 2008](#)).

Given its addictive properties and intense, long-lasting highs, methamphetamine use disrupts many aspects of individuals' lives. As methamphetamine affects the levels of dopamine and neurotransmitters, its use leads to reduced levels of neurotransmitters and can lead to depression and suicidal thoughts ([CDC 2007](#); [Gonzales, Mooney and Rawson 2010](#)). In addition to mental disorders, methamphetamine use can also lead to tooth decay (commonly referred to as "meth mouth"), weight loss, skin lesions, stroke and heart attack ([CDC 2007](#); [Gonzales, Mooney and Rawson 2010](#)). Methamphetamine use is also associated with a host of social problems. It has been connected to upwards of 90 percent of the domestic dispute cases in the United States ([Gonzales, Mooney and Rawson 2010](#)), and increased child abuse and foster care admissions ([Cunningham and Finlay 2011](#); [Gonzales, Mooney and Rawson 2010](#)).

C. Correlation between Methamphetamine Use and Risky Sexual Behavior

Many studies also find associations between methamphetamine use and risky sexual behavior. [Molitor et al. \(1998\)](#) find that methamphetamine users have more sexual partners, use condoms less often, visit prostitutes more frequently, and have sex with a known injection-drug user more often than non-methamphetamine users. [Zule et al. \(2007\)](#) find that in heterosexuals, methamphetamine use by both partners is associated with a wide range of high-risk behaviors, including vaginal and anal sex without a condom and sex with a new partner. Although the associations between methamphetamine use and risky sexual behaviors are stronger for men, the relationships hold for both men and women. [Rawson et al. \(2002\)](#) find that 73.5 percent of male methamphetamine users and 66.7 percent of female methamphetamine users state that "sexual pleasure is enhanced by the use of [methamphetamine]." Furthermore, 52.9 and 55.6 percent of male and female methamphetamine users, respectively, state they are more likely to practice risky sex while on methamphetamine ([Rawson et al. 2002](#)). Compared to non-methamphetamine users, heterosexual women using methamphetamine are 6.7 times more likely to exchange money or drugs for sex; men who have sex with men (MSM) and who are methamphetamine users are 3.4 times more likely to exchange money or drugs for sex; and heterosexual male methamphetamine users are 2.4 more likely do so ([Molitor et al. 1998](#)).

The correlation between methamphetamine use and risky sexual behavior has caused public health officials to suggest methamphetamine control as a means of reducing STIs since the 1990s ([Corsi and Booth 2008](#); [Halkitis, Parsons and Stirratt 2001](#); [Handsfield and Schwebke 1990](#); [Molitor et al. 1999](#); [Molitor et al. 1998](#); [Shrier et al. 1997](#)). [Molitor et al. \(1998\)](#) state, "With the realization that methamphetamine use has been related to unsafe injection practices, the importance of including methamphetamine prevalence in epidemiologic profiles and

prevention strategies becomes apparent.” Their sentiments have been echoed by public health officials. The CDC states that “HIV and STD prevention and treatment programs could be enhanced to include assessment for methamphetamine use, with referrals to methamphetamine treatment, primary testing, and sexual health promotion.” ([CDC 2007](#)).

Much of the research examining methamphetamine use and STIs focuses on MSM. The prevalence of methamphetamine use is particularly high among MSM. One study found that 20 percent of MSM aged 15 to 22 in 7 urban areas used methamphetamine during the past 6 months, and almost 6 percent used methamphetamine at least once a week ([Thiede et al. 2003](#)). The same study found that 32 percent and 28 percent of MSM of ages 15 to 22 in Los Angeles and San Francisco, respectively, used methamphetamine in the past 6 months and 12 percent and 9 percent, respectively, used methamphetamine at least once a week ([Thiede et al. 2003](#)). Studies also consistently find a positive association between methamphetamine use and risky sexual behavior among MSM ([Brewer, Golden and Handsfield 2006](#); [Koblin et al. 2003](#); [Mansergh et al. 2006](#); [Molitor et al. 1998](#); [Shoptaw and Reback 2007](#); [Taylor et al. 2007](#)). Studies find positive relationships between methamphetamine use and HIV transmission ([Brewer, Golden and Handsfield 2006](#); [Molitor et al. 1998](#); [Shoptaw and Reback 2007](#)) and between methamphetamine use and syphilis transmission ([CDC 2001](#); [Shoptaw and Reback 2007](#); [Wong et al. 2005](#)).

D. Causal Mechanisms

There are many possible causal mechanisms for the positive relationship between methamphetamine and risky sexual behavior and STIs. First, some effects of methamphetamine may make it a complement to risky sexual behaviors. Methamphetamine creates sensations of euphoria, pleasure and sexual arousal while it lowers inhibitions and clouds judgment. As noted above, methamphetamine users state that they participate in risky sexual behavior more often when using methamphetamine. Second, other effects of methamphetamine may increase the likelihood of STI transmission. Methamphetamine’s effects on judgment may decrease condom use. While methamphetamine causes sexual arousal, it also impedes the ability to obtain an erection ([Halkitis, Parsons and Stirratt 2001](#)). Thus, MSM who take methamphetamine may be more likely to engage in receptive anal sex, which is much more likely to result in STI transmission ([Halkitis, Parsons and Stirratt 2001](#)).³ In addition, methamphetamine addicts may resort to exchanging sex for money to support their drug habit.⁴

However, the positive correlation observed between methamphetamine and risky sexual behaviors and STI transmissions may be due to a third factor such as a preference for risky behavior. Thus, the positive correlations outlined above are not necessarily causal. Previous economic studies of substance use and risky sexual behavior find that correlations observed between substance use and risky sexual behavior may not be causal. For example, ([Grossman, Kaestner and Markowitz 2004](#)) study the link between alcohol and marijuana use and teen sexual behavior. Using the National Longitudinal Survey of Youth 1997 cohort, the authors explicitly

³ Among gay men, these phenomena are sometimes referred to as “crystal dick” creating “instant bottoms” ([Halkitis, Parsons and Stirratt 2001](#)). Note that with the introduction of Viagra in 1998 and its eventual widespread availability, the problem of “crystal dick” was alleviated to some extent, and the co-usage of methamphetamine and Viagra has been hypothesized to have contributed to increases in STIs ([Mansergh et al. 2006](#)).

⁴ Methamphetamine and risky sexual behavior may also be substitutes. People with a preference for risky behavior may turn to risky sexual behavior if the high from methamphetamine is not available.

account for potential third factors using a bivariate probit model and individual fixed-effects OLS regressions. They find little evidence for an effect of alcohol or marijuana use on teen sexual behavior. Similarly, [Grossman and Markowitz \(2005\)](#) examine the effect of alcohol and marijuana use on youth sexual behaviors. They use data from the Youth Risk Behavioral Study and account for the potential endogeneity between alcohol, marijuana and sexual behaviors by using alcohol and marijuana prices as instrumental variables. As do [Grossman, Kaestner and Markowitz \(2004\)](#), the authors find very limited support for the proposition that alcohol and marijuana use increases sexual encounters but do find some support for the proposition that alcohol and marijuana use decreases condom and birth control use.

E. Exogenous Variation in Methamphetamine Use

Our paper estimates the causal impact of methamphetamine use on risky sexual behavior and uses a supply shock to the market for methamphetamine in May 1995 to circumvent the possible endogeneity between methamphetamine use and risky sexual behaviors. In May 1995, the DEA raided the Pennsylvania-based Clifton Pharmaceuticals company, seizing about 25 metric tons of pseudoephedrine powder ([Subcommittee on Crime of the Committee of the Judiciary 1995](#)). The seized products filled five 53-foot semi-trailers and were enough to manufacture about 15.6 metric tons of methamphetamine under an average meth lab conversion rate of 62.5 percent ([Dobkin and Nicosia 2009](#)). In addition, on May 31, 1995, the DEA executed a search warrant at the Atlanta offices of the Florida-based mail-order company, X-Pressive Looks, Inc (XLI), seizing about 37.5 million pseudoephedrine tablets, and shut down the company's distribution in August ([U.S. v. Prather 2000](#)). Between April 1994 and August 1995, XLI distributed more than 830 million pseudoephedrine tablets. This reduces to about 20.8 metric tons of pseudoephedrine, enough to manufacture about 13 metric tons of methamphetamine. In comparison, total methamphetamine consumption in the entire United States in 1994 was 34.1 metric tons ([Office of National Drug Policy Control 2001, Table 8](#)). [Dobkin and Nicosia \(2009\)](#) characterize the two interventions in May 1995 as the largest supply shock in US drug enforcement history.

III. Empirical Strategy

Our empirical strategy aims to identify the causal relationship between methamphetamine use and risky sexual behaviors. Thus, we seek to estimate the following equation for county i in year t and month m :

$$\log(S_{itm}) = \alpha_0 + \alpha_H \log(A_{itm}) + \alpha_D \log(D_{itm}) + \alpha_X X_{itm} + \eta_i + \rho_t + \sigma_m + \varepsilon_{itm}, \quad (1)$$

where S_{itm} is a measure of risky sexual behavior, the number of syphilis diagnoses plus one per 100,000 people; A_{itm} is a measure of methamphetamine use, the number of amphetamine-related hospital admissions plus one per 100,000 people; D_{itm} represents hospital admissions related to alcohol and other controlled substances plus one per 100,000 people; X_{itm} represents county demographic characteristics; and η_i , ρ_t , and σ_m represent county, year, and month indicators.

As both methamphetamine use and risky sexual behavior could be caused by an unobservable third factor, estimating the above equation will possibly lead to biased coefficients. To circumvent this problem, we use a large exogenous supply shock to the market for

methamphetamine. As discussed above, in May 1995, the DEA shut down two pharmaceutical companies that were providing a majority of the raw materials used to make methamphetamine in the United States. Previous research by [Cunningham and Liu \(2003\)](#) and [Dobkin and Nicosia \(2009\)](#) finds that between August 1995 and September 1996, this shock led to a temporary increase in price, decrease in purity, and decrease in amphetamine-related hospitalizations and treatment center admissions. We use this shock period as an instrumental variable in a two-stage least-squares estimation,

$$\log(S_{itm}) = \alpha_0 + \alpha_H \log(\hat{A}_{itm}) + \alpha_D \log(D_{itm}) + \alpha_X X_{itm} + \eta_i + \rho_t + \sigma_m + \varepsilon_{itm}, \quad (2)$$

where \hat{A}_{itm} is estimated by the first-stage equation,

$$\log(A_{itm}) = \beta_0 + \beta_I I_{itm} + \alpha_D \log(D_{itm}) + \beta_X X_{itm} + \eta_i + \rho_t + \sigma_m + \varepsilon_{itm}. \quad (3)$$

In Equation (3), I_{itm} is an indicator for the August 1995 to September 1996 period.

In all regressions, we control for the use of other substances that may affect risky sexual behaviors (in the D matrix). We include controls for alcohol use, marijuana use, cocaine use, and heroin use. We also include county-level variables that may determine syphilis transmissions (in the X matrix). We include county population density, as well as the percent of each county's population that is male, black, Hispanic, under age 18, and between the ages of 18 and 39. We cluster the standard errors at the county level ([Bertrand, Duflo and Mullainathan 2004](#)).

IV. Data

We proxy for risky sexual behavior with monthly, early-stage syphilis diagnoses at the county level from the California Department of Public Health (CDPH). The counts are based on syphilis diagnoses sent from medical providers and laboratories to local health departments, which forward them to the CDPH. These data represent the population of early-stage syphilis diagnoses in California.

Syphilis is a sexually transmitted disease that is caused by the bacteria *Treponema pallidum*. Transmission occurs by direct contact with a syphilis sore. In 2010, 45,834 people in the U.S. were diagnosed with syphilis at any stage ([CDC 2011b](#)). Caught in its early stages, syphilis is easily treated with an injection of antibiotics. Syphilis infections generally go through three stages. In the primary stage, one or a few sores develop around the area where syphilis entered the body. The sores develop in as few as 10 days, although usually around 21 days, and last for 3 to 6 weeks. If the disease is not treated, the infection moves to a secondary stage. In the secondary stage, the original sores usually heal, but rashes develop on different parts of the body. Without treatment, the rashes usually heal and the disease moves into its latent and late stages. In the latent and late stages, syphilis remains dormant, often for many years, and then may reemerge, often attacking the brain or other vital organs.

Since syphilis symptoms develop in as few as 10 days, syphilis provides a timely indicator of risky sexual behavior. In comparison, HIV symptoms may not manifest themselves for many years ([Bacchetti and Moss 1989](#)). Examining syphilis is important not only as an indicator of risky sexual behavior. The prevalence of HIV among syphilis patients is very high. One study of syphilis patients in several large cities in the U.S. found that 18% of the patients

were also infected with HIV ([Rofls et al. 1997](#)). Medical evidence suggests that syphilis sores interfere with the body's mechanisms against HIV transmission ([Levine et al. 1998](#); [Spinola et al. 1996](#)).⁷

We use monthly amphetamine-related hospital admissions at the county level as our proxy for methamphetamine consumption. These data come from the census of hospitalizations output by the California Office of Statewide Health Planning and Development (OSPHD). The hospitalization census records the ICD codes for the principal diagnosis and additional diagnoses, and we isolate hospitalizations involving amphetamines. Consistent with [Dobkin and Nicosia \(2009\)](#), we choose ICD codes 304.4X (amphetamine and other psychostimulant dependence), 305.7X (amphetamine or related acting sympathomimetic abuse), 969.7 (psychostimulant poisoning), and E854.2 (accidental psychostimulant poisoning).

We also employ the OSPHD data to measure the use of other substances that may affect risky sexual behaviors. We include alcohol hospitalizations (ICD codes 291.X, 303.X, 305.X), cannabis hospitalizations (304.3X and 305.2X), heroin hospitalizations (304.0X, 304.7X, and 305.5X) and cocaine hospitalizations (304.2X, and 305.6X).

Table 1 provides summary statistics for our sample. The total number of observations in our sample is 2,400, corresponding to 50 counties measured over 48 months. The average rate of primary syphilis diagnoses in a county in each month is about 0.2 per 100,000 people. The average syphilis rate is higher among men than among women. The monthly average rate of hospitalization for amphetamine-related conditions is about 5.8 per 100,000 in a county. The average amphetamine hospitalization rate is only slightly higher among men than among women. We also include time-varying county characteristics that are likely to influence syphilis transmission. We include county population density, as well as the percent of each county's population that is male, black, Hispanic, under age 18, and between the ages of 18 and 39.

V. Results

A. Graphical Results

We preview our regression results by showing some suggestive graphical evidence. Figure 1 shows the aggregate trends of amphetamine-related hospitalizations and diagnoses of primary syphilis for California from 1994 to 1997. The red line marked with +'s tracks amphetamine-related hospital admissions, and the green line marked with x's tracks primary syphilis diagnoses. The dashed, vertical, black line marks August 1995, the beginning of the methamphetamine supply shock. During the four months after the supply shock, total amphetamine-related hospital admissions drop to less than 40 percent of their July 1995 value, while admissions for men drop to less than 30 percent of their July 1995 value. By October 1996, the end of the methamphetamine supply shock, amphetamine-related hospitalizations rebound to roughly 60 percent of their pre-shock value for men and women combined and 70 percent of their pre-shock value for men. However, during the methamphetamine supply shock period, syphilis diagnoses are relatively unchanged, continuing a slow trend downward that began in the early 1990s.

⁷ Another possible proxy for risky sexual behavior is gonorrhea diagnoses. Gonorrhea is the most prevalent STI in the United States, with more than 700,000 new infections every year ([CDC 2011a](#)). Like syphilis, gonorrhea symptoms develop quickly after transmission, within 2 to 5 days for women and one month for men. Unfortunately, gonorrhea diagnoses are only available annually for our time period.

B. First Stage Results

Before showing regressions that estimate the relationship between methamphetamine use and syphilis, we show evidence of the effects of the 1995 supply shock on the consumption of methamphetamine. Table 2 displays regressions of the effect of the supply shock on amphetamine-related hospitalizations, our proxy for methamphetamine consumption. We estimate the models for the years 1994 to 1997, stopping at the end of 1997 to avoid contaminating our results with the effects of subsequent methamphetamine precursor regulations.⁸

The dependent variable in all models is the log of the number of amphetamine-related hospital admissions plus one per 100,000 people in a particular county and month. We estimate models for the total rate and separately for each gender-specific rate. The independent variable of interest is an indicator variable that covers the period of the methamphetamine supply shock, August 1995 to September 1996. In addition, we include controls for hospital admissions that are due to other substances, county population density, and the percent of each county's population that is male, black, Hispanic, under age 18, and between the ages of 18 and 39. All models also include county fixed effects, and t-statistics reported in parentheses correspond to standard errors clustered at the county level.

The August 1995 supply shock reduced amphetamine-related hospitalization by roughly 38 percent. For men, the decrease was 40 percent, and for women, the decrease was 34 percent. These results are consistent with those of [Dobkin and Nicosia \(2009\)](#) who find a decrease of between 30 and 40 percent and [Cunningham and Liu \(2003\)](#) who find a decrease of between 35 and 53 percent.

To test the dynamic effects of the supply shock, we follow the methodology of [Wolfers \(2006\)](#) and separate the August 1995 to September 1996 period into four sub-periods: 1 to 2 months after the shock, 3 to 6 months after the shock, 7 to 9 months after the shock and 10 to 13 months after the shock. We also include indicators for the 2 months prior to the shock window, the 3 months after the shock window and the period more than 3 months after the shock window.

Table 3 shows the results of these regressions. After accounting for year and month fixed effects, the two months before and three months after the shock do not significantly affect amphetamine-related hospitalization rates. All sub-periods of the August 1995 to September 1996 period are associated with statistically-significant decreased amphetamine-related hospitalization rates for combined genders and men and women separately. The coefficients indicate that the effect of the shock is generally greatest during the first six months before dropping by a third towards the end of the supply-shock period. In the first two months, the shock lowered the amphetamine-related hospital admissions rate by 25 percent. In the following three months, the shock reduced the admissions rate by 41 percent, and in the last three months, it decreased the admissions rate by 22 percent. The dynamic effects of the shock are similar when examined separately for each gender, although the effects are longer lasting for women.

The coefficients for alcohol, cannabis, heroin, and cocaine admissions are consistently positive and significant in Tables 2 and 3, providing evidence of a complementary relationship between methamphetamine and other substances. A larger portion of males in a county increases amphetamine-related admissions, as does the portion of the population under age 18, while the portion of African Americans in a county decreases amphetamine-related admissions.

⁸These include the Methamphetamine Control Act of 1997, which went into effect in early 1998, the Methamphetamine Antiproliferation Act of 2000, and the Combat Methamphetamine Epidemic Act of 2005.

C. Two-Stage Least-Squares Results

Next, we show the effects of methamphetamine use on syphilis. Table 4 shows results from two-stage least-squares regressions where the dependent variable is the logged rate of primary syphilis diagnoses in a particular county and month. We run models using total primary syphilis diagnoses and diagnoses for men and women separately. The independent variable of interest in each specification is the logged rate of amphetamine-related hospital admissions in each county and month, instrumented for by the indicator variable for the period of August 1995 to September 1996. In the models examining either male or female syphilis diagnoses, we include the logged rate of amphetamine-related hospital admissions for that gender. All models also include the same controls as in Tables 2 and 3, and t-statistics reported in parentheses correspond to standard errors clustered at the county level.

Amphetamine-related hospitalizations have no statistically significant effect on total syphilis rates or male syphilis rates. However, a reduction of amphetamine-related hospitalizations is associated with a statistically significant increase in syphilis among women. The estimated elasticities of syphilis among women with respect to amphetamine-related hospitalization are -0.36 to -0.57. Few of the other explanatory variables affect syphilis transmission, including the prevalence of other substance use. The number of individuals between ages 18 and 39 increases syphilis transmission, corroborating national estimates that syphilis is most prevalent among individuals age 20 to 24 ([CDC 2011b](#)).

Following the STI literature (e.g. [Chesson, Harrison and Kassler 2000](#); [Dee 2008](#); [Francis and Mialon 2010](#)), we also run specifications including a lagged dependent variable to account for the communicable nature syphilis.⁹ Table 5 shows the results of these regressions. As in Table 4, in models with fixed effects, a reduction in amphetamine-related hospitalization has no statistically significant effect on syphilis among men, but is associated with a statistically-significant increase in syphilis among women. The estimated elasticities syphilis among women with respect to amphetamine-related hospitalization is -0.52.¹⁰

For all models, we report the Partial R-Squared and Kleibergen-Paap Wald F Statistic (KP F-Stat), measures of the strength of the correlation between our excluded instrumental variable and our endogenous variable. Additionally, we report Hausman Test P-Values to check for the endogeneity of the excluded variable. In all models in Tables 4 and 5, the KP F-Stat is very high, rejecting the null hypothesis of weak identification at the one percent level.

The Hausman P-Values suggest that methamphetamine use may not be an endogenous variable in many of the models. Thus, we also ran OLS regressions parallel to the models in Tables 4 and 5 to check the robustness of the instrumental variables framework. The results, which are available on request, are similar to those in Tables 4 and 5. The greatest change in the OLS models is that methamphetamine use is not related to syphilis even for women. However, in Tables 4 and 5, the Hausman Tests suggest that methamphetamine use may be endogenous for women, and thus OLS models may not be appropriate.

⁹ In panel data models, a lagged dependent variable causes biased coefficients, as the lagged dependent variable is correlated with the mean of the dependent variable. In long panels this bias diminishes because the lagged dependent variable only comprises 1/N of the mean. Since our panel is 48 periods long, we decided to include the lagged dependent variable rather than estimating an Arellano-Bond type dynamic panel data model.

¹⁰ We also ran models using the lagged prevalence of male syphilis when female syphilis was the outcome variable of interest and found similar results, available upon request. Additionally, we ran models using the lagged prevalence of male syphilis and male substance use and found similar results.

D. Other Potential Issues

One potential concern is that methamphetamine users substituted other drugs for methamphetamine in response to the amphetamine supply shock. [Dobkin and Nicosia \(2009\)](#) find little evidence that the shock induced users to switch to other illicit drugs. Nevertheless, we control for the prevalence of other drug use through the hospitalization rates of alcohol, marijuana, heroin, and cocaine. We find that other drug use is not correlated with syphilis transmissions, suggesting that substitution of other drugs may not be an issue.

A related concern may be that other behavioral factors, such as the introduction of antiretroviral drugs, changed the costs of risky sexual behaviors concurrently with the amphetamine shock. Previous economic research finds that the introduction of highly active antiretroviral therapy (HAART) increased the overall HIV transmission rate in the late 1990s ([Lakdawalla, Sood and Goldman 2006](#)). HAART became the standard method to treat HIV infections by 1997, and some HIV patients received early access to HAART by December 1995. However, Lakdawalla, Sood and Goldman show that the change in HIV infection rates did not begin until 1998, which is after the end date of our analysis.

Another concern may be that the amphetamine shock caused a change in purity, as the drug could be “cut” with other substances. If the drug is cut with substances that are more harmful to users, our rate of amphetamine-related hospitalizations may overstate the decrease in methamphetamine consumption. However, methamphetamine is usually cut with substances that are available as dietary supplements over the counter. For example, methamphetamine is commonly cut with methylsulfonylmethane, a dietary supplement sold at, among other places, health food stores and high-end grocery stores.¹¹ There is also evidence that, after the amphetamine supply shock, methamphetamine was increasingly cut with phenylpropanolamine, which is also available as a dietary supplement.¹²

A final concern may be that only a small number of methamphetamine users are ever hospitalized for methamphetamine consumption. If amphetamine-related hospitalizations are concentrated among one type of methamphetamine user, hospitalizations may overstate or understate the effects of the amphetamine shock. However, [Dobkin and Nicosia \(2009\)](#) find that amphetamine-related admissions for common diagnosis-related groups (which include psychoses, alcohol and drug detoxification and treatment, and pregnancy and delivery) follow the same trend. This suggests that overall hospital admissions are a reasonable proxy for methamphetamine consumption.

Furthermore, the use of methamphetamine may be even more disruptive to daily life and result in hospitalization even more rapidly and frequently than use of most other illicit drugs. When smoked, cocaine brings a high that lasts between 20 and 30 minutes, while methamphetamine brings a high that lasts between 8 and 24 hours ([Gawin and Ellinwood 1988](#); [National Institute on Drug Abuse 1998](#)). In addition, [Gonzalez Castro et al. \(2000\)](#) find that the period from first use to regular use is even shorter for methamphetamine users than for cocaine users.

¹¹ See “Information Bulletin: Crystal Methamphetamine” from the National Drug Intelligence Center at the Department of Justice, available at <http://www.justice.gov/ndic/pubs1/1837/index.htm> (accessed in January 2012).

¹² See The Clandestine Laboratory Investigating Chemists Association, available at <http://www.erowid.org/archive/rhodium/chemistry/clic.html> (accessed January 2012).

VI. Conclusion

This paper attempts to estimate the causal relationship between methamphetamine use and risky sexual behavior using county-level monthly data from California. To identify a causal relationship, we utilize a large exogenous shock to the methamphetamine market beginning in August 1995 and lasting until September 1996. We measure methamphetamine consumption using amphetamine-related hospital admissions and risky sexual behavior using syphilis diagnoses. Consistent with previous studies, we find that the supply shock had a large effect on methamphetamine consumption, proxied by amphetamine-related hospital admissions. However, we find no evidence that the drastic decrease in methamphetamine consumption affected syphilis diagnoses.

Oddly, we find some evidence that the decreased methamphetamine consumption associated with the August 1995 to September 1996 shock increased female syphilis transmission. One possible explanation is that the drastically higher methamphetamine prices following the shock led some women to trade sex for drugs. As noted earlier, previous medical research estimates that heterosexual women who use methamphetamine are 6.7 times more likely to have received money or drugs for sex than heterosexual women who do not use methamphetamine ([Molitor et al. 1998](#)). [Semple et al. \(2011\)](#) report that 31 percent of females enrolled in a sexual risk reduction intervention in San Diego traded sex for methamphetamine in the past two months while [Cheng et al. 2009](#) report that 34 percent of female methamphetamine users in San Diego have ever traded methamphetamine for sex. Other studies find that between 15 and 22 percent of women methamphetamine users recently exchanged sex for money ([Semple, Grant and Patterson 2004](#)). Moreover, methamphetamine use is very high among female sex workers ([Kang et al. 2011](#); [Patterson et al. 2006](#); [Rusch et al. 2010](#)). Future research should more closely examine this possible association.

Our results suggest that policies to reduce methamphetamine use may not reduce syphilis and other STIs. This is troubling, as methamphetamine use is increasingly targeted as a means of decreasing STIs among gay and bisexual men and other high-risk populations. Efforts to reduce STIs may be better centered around other policies, such as those that may increase access to health care, increase screening of at-risk populations, better help to find and treat partners of infected persons, and provide information on sexual health.

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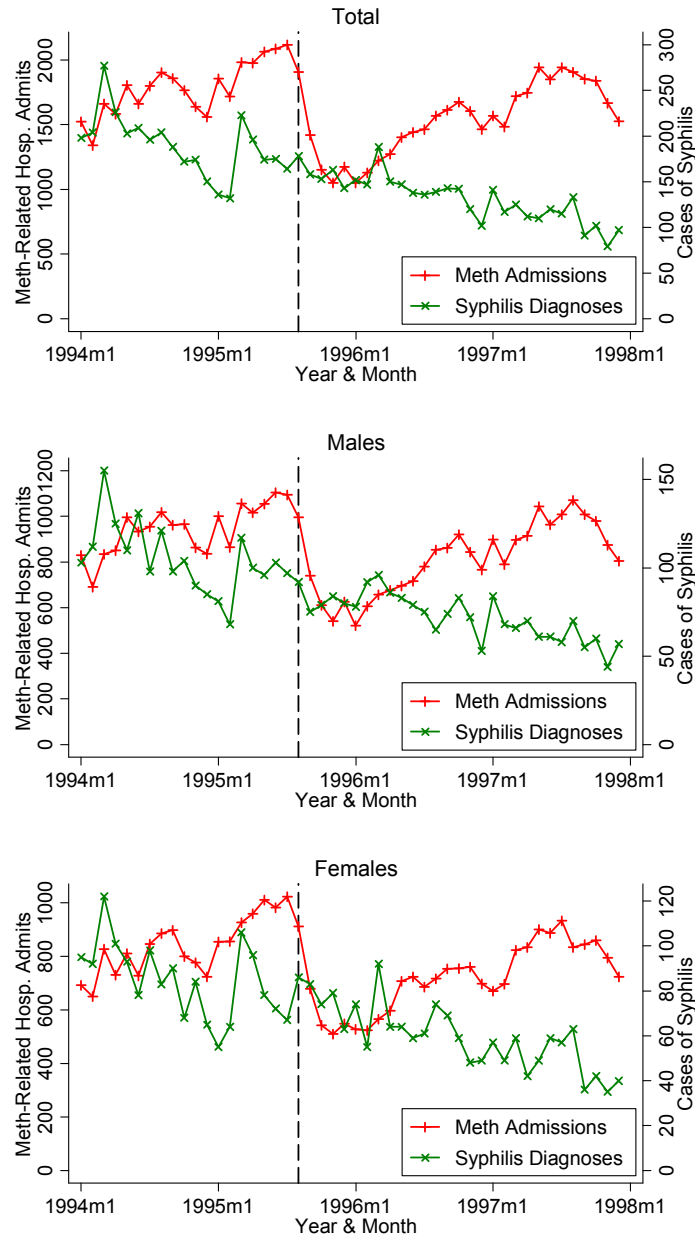
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Figure 1
Syphilis Diagnoses and Meth-Related Hospital Admissions
California 1994 to 1997



Notes

Data from the California Department of Public Health and the California Office of Statewide Health Planning and Development. The red line (marked with +s) represents the total number of amphetamine-related hospital admissions in California in each month, and the green line (marked with x's) represents the total number of syphilis diagnoses in California in each month. The vertical black dashed line marks August, 1995, the beginning of the shock period.

Table 1
Summary Statistics

	Total		Men		Women	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Syphilis Rate	0.208	0.501	0.234	0.640	0.181	0.524
Meth Admits Rate	5.824	4.491	5.885	4.845	5.775	5.607
Alcohol Admits Rate	29.818	11.057	41.574	16.192	17.970	9.277
Cannabis Admits Rate	3.367	3.299	3.414	3.246	3.335	4.640
Heroin Admits Rate	4.769	3.637	5.299	4.587	4.232	3.671
Cocaine Admits Rate	3.042	3.097	3.400	3.744	2.682	3.077
% Population Male	50.526	2.086	50.526	2.086	50.526	2.086
% Population Black	4.279	3.875	4.279	3.875	4.279	3.875
% Population Hispanic	23.018	14.268	23.018	14.268	23.018	14.268
Pop Density in 100s/sq. mile	6.944	23.048	6.944	23.048	6.944	23.048
% Population Age Under 18	27.906	4.057	27.906	4.057	27.906	4.057
% Population Age 18-39	32.144	4.243	32.144	4.243	32.144	4.243
N	2400		2400		2400	

Notes

Data from the California Department of Public Health, the California Office of Statewide Health Planning and Development, and the Census. All rates are per 100,000 people.

Table 2
First Stage Regression Results of Effects of Methamphetamine Shock
on Methamphetamine Consumption

	<u>Total</u>	<u>Males</u>	<u>Females</u>	<u>Total</u>	<u>Males</u>	<u>Females</u>
Shock 95: 8/95-9/96	-0.259*** (-12.14)	-0.267*** (-11.95)	-0.193*** (-6.77)	-0.378*** (-11.11)	-0.393*** (-12.02)	-0.306*** (-7.29)
Log of Alcohol Admits	0.067 (1.37)	0.064 (1.38)	0.106*** (3.30)	0.055 (1.22)	0.054 (1.17)	0.101*** (3.06)
Log of Cannabis Admits	0.240*** (9.00)	0.220*** (7.52)	0.220*** (8.80)	0.227*** (8.56)	0.208*** (7.21)	0.213*** (8.48)
Log of Heroin Admits	0.073*** (2.98)	0.092*** (3.82)	0.057*** (2.89)	0.069*** (3.00)	0.091*** (4.08)	0.059*** (3.08)
Log of Cocaine Admits	0.145*** (5.64)	0.122*** (4.73)	0.146*** (6.28)	0.136*** (5.32)	0.112*** (4.14)	0.141*** (5.88)
% Population Male	0.245*** (3.68)	0.242*** (3.23)	0.219*** (3.01)	0.215*** (2.70)	0.219** (2.63)	0.177** (2.32)
% Population Black	-0.195** (-2.04)	-0.122 (-1.36)	-0.274*** (-3.13)	-0.203** (-2.32)	-0.126 (-1.45)	-0.288*** (-3.51)
% Population Hispanic	0.012 (0.56)	0.007 (0.34)	0.021 (0.95)	0.013 (0.22)	0.000 (0.00)	0.032 (0.65)
Pop Density in 100s/sq. mile	-0.034 (-1.47)	-0.047** (-2.10)	0.022 (0.75)	-0.032 (-0.76)	-0.050 (-1.41)	0.030 (0.79)
% Population Age Under 18	0.155*** (3.48)	0.144*** (2.82)	0.098* (1.73)	0.110 (0.90)	0.135 (1.24)	0.013 (0.12)
% Population Age 18-39	-0.019 (-0.66)	-0.035 (-1.16)	0.010 (0.31)	-0.006 (-0.06)	-0.012 (-0.14)	0.013 (0.16)
Year/Mnth FE	No	No	No	Yes	Yes	Yes
Num	2400	2400	2400	2400	2400	2400
R-Squared	0.9330	0.9106	0.8991	0.9374	0.9149	0.9040
F-Stat	44.9731	31.6029	44.7852	48.7444	18.6790	40.7085

Notes

Data from the California Office of Statewide Health Planning and Development and the Census. The dependent variable in all specifications is the log of the number of amphetamine-related hospital admissions in a county and month + 1. Coefficients represent semi-elasticities, and coefficients pertaining to indicator variables are transformed by $\exp[\beta-1]$. T-statistics, shown in parentheses, are calculated from standard errors clustered at the county level. In addition to the coefficients shown, all models include county fixed effects, and the last 3 models include year and month fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3
First Stage Regression Results of Dynamic Effects of
Methamphetamine Shock on Methamphetamine Consumption

	<u>Total</u>	<u>Males</u>	<u>Females</u>	<u>Total</u>	<u>Males</u>	<u>Females</u>
Shock 95: 6/95-7/95	0.103** (2.31)	0.115** (2.29)	0.092* (1.80)	0.378 (0.74)	0.392 (1.13)	0.370 (0.14)
Shock 95: 8/95-9/95	-0.156*** (-3.20)	-0.165*** (-3.58)	-0.123** (-2.13)	-0.243*** (-5.52)	-0.249*** (-5.71)	-0.201*** (-3.28)
Shock 95: 10/95-1/99	-0.418*** (-10.02)	-0.418*** (-10.64)	-0.351*** (-7.12)	-0.405*** (-9.73)	-0.406*** (-9.64)	-0.340*** (-7.46)
Shock 95: 2/96-5/96	-0.393*** (-6.77)	-0.365*** (-6.88)	-0.359*** (-5.78)	-0.338*** (-4.28)	-0.293*** (-3.21)	-0.351*** (-5.12)
Shock 95: 6/96-9/96	-0.291*** (-3.81)	-0.259*** (-4.30)	-0.274*** (-3.43)	-0.278*** (-2.87)	-0.229** (-2.28)	-0.297*** (-3.32)
Shock 95: 10/96-1/97	-0.263** (-2.64)	-0.189** (-2.46)	-0.292*** (-3.14)	0.305 (-1.56)	0.337 (-0.72)	-0.251** (-2.63)
Shock 95: Post 1/97	0.306 (-1.17)	0.339 (-0.69)	-0.255** (-2.03)	0.344 (-0.40)	0.388 (0.32)	-0.252* (-2.00)
Log of Alcohol Admits	0.078 (1.63)	0.073 (1.60)	0.112*** (3.48)	0.064 (1.46)	0.061 (1.38)	0.106*** (3.24)
Log of Cannabis Admits	0.237*** (8.60)	0.213*** (7.34)	0.221*** (8.94)	0.227*** (8.45)	0.205*** (7.11)	0.213*** (8.55)
Log of Heroin Admits	0.083*** (3.55)	0.100*** (4.56)	0.062*** (3.23)	0.077*** (3.43)	0.098*** (4.56)	0.061*** (3.17)
Log of Cocaine Admits	0.137*** (5.27)	0.115*** (4.29)	0.140*** (5.66)	0.132*** (5.12)	0.110*** (4.01)	0.137*** (5.61)
% Population Male	0.274*** (3.84)	0.274*** (3.63)	0.232*** (2.94)	0.248*** (3.19)	0.257*** (3.20)	0.193** (2.47)
% Population Black	-0.168* (-1.77)	-0.099 (-1.09)	-0.252*** (-3.01)	-0.189** (-2.08)	-0.110 (-1.25)	-0.282*** (-3.31)
% Population Hispanic	0.042 (1.07)	0.018 (0.58)	0.074* (1.98)	-0.001 (-0.02)	-0.016 (-0.33)	0.025 (0.50)
Pop Density in 100s/sq. mile	-0.005 (-0.16)	-0.033 (-1.21)	0.067* (1.88)	-0.040 (-0.94)	-0.060 (-1.63)	0.026 (0.65)
% Population Age Under 18	0.122 (1.22)	0.163* (1.85)	-0.011 (-0.10)	0.190 (1.50)	0.225** (2.05)	0.052 (0.48)
% Population Age 18-39	-0.086* (-1.99)	-0.071* (-1.85)	-0.085* (-1.91)	-0.000 (-0.00)	-0.006 (-0.07)	0.017 (0.21)
Year/Mnth FE	No	No	No	Yes	Yes	Yes
Num	2400	2400	2400	2400	2400	2400
R-Squared	0.9371	0.9152	0.9027	0.9389	0.9171	0.9047
F-Stat	47.8332	36.4349	37.6116	71.8424	28.9516	47.7482

Notes

Data from the California Office of Statewide Health Planning and Development and the Census. The dependent variable in all specifications is the log of the number of amphetamine-related hospital admissions in a county and month + 1. Coefficients represent semi-elasticities, and coefficients pertaining to indicator variables are transformed by $\exp[b-1]$. T-statistics, shown in parentheses, are calculated from standard errors clustered at the county level. In addition to the coefficients shown, all models include county fixed effects, and the last 3 models include year and month fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4
IV Regression Results of Effects of Methamphetamine Consumption
on Syphilis Transmission

	<u>Total</u>	<u>Males</u>	<u>Females</u>	<u>Total</u>	<u>Males</u>	<u>Females</u>
Log of Meth Admits	-0.138 (-1.36)	-0.025 (-0.34)	-0.230* (-1.82)	-0.024 (-0.25)	0.080 (1.02)	-0.213* (-1.86)
Log of Alcohol Admits	0.026 (0.97)	0.018 (1.07)	0.031** (2.03)	0.014 (0.54)	0.011 (0.70)	0.026* (1.84)
Log of Cannabis Admits	0.023 (0.65)	-0.017 (-0.79)	0.043 (1.10)	-0.011 (-0.37)	-0.040* (-1.87)	0.034 (1.13)
Log of Heroin Admits	0.004 (0.20)	-0.005 (-0.33)	0.008 (0.50)	-0.003 (-0.19)	-0.015 (-1.00)	0.009 (0.59)
Log of Cocaine Admits	-0.014 (-0.51)	-0.002 (-0.10)	0.025 (0.96)	-0.034* (-1.67)	-0.017 (-0.85)	0.021 (0.92)
% Population Male	0.123 (0.99)	0.065 (0.69)	0.071 (0.60)	0.059 (0.55)	0.009 (0.10)	0.048 (0.49)
% Population Black	-0.295 (-1.35)	-0.166 (-1.07)	-0.211 (-0.93)	-0.297 (-1.31)	-0.176 (-1.06)	-0.215 (-0.96)
% Population Hispanic	-0.038 (-1.07)	-0.031 (-0.94)	-0.024 (-0.95)	-0.067 (-1.47)	-0.066 (-1.58)	-0.013 (-0.32)
Pop Density in 100s/sq. mile	-0.125 (-1.38)	-0.057 (-1.21)	-0.099 (-0.98)	-0.145 (-1.45)	-0.082 (-1.46)	-0.092 (-0.81)
% Population Age Under 18	-0.141*** (-2.77)	-0.106*** (-2.61)	-0.108*** (-2.34)	-0.141* (-1.74)	-0.080 (-1.13)	-0.166** (-2.15)
% Population Age 18-39	0.113*** (2.88)	0.072*** (2.61)	0.095*** (2.69)	0.180* (1.96)	0.150** (2.09)	0.087 (0.95)
Year/Mnth FE	No	No	No	Yes	Yes	Yes
Num	2400	2400	2400	2400	2400	2400
Partial R2	0.0884	0.0814	0.0380	0.0704	0.0654	0.0333
KP F-Stat	150.5258	145.9719	46.7543	126.0347	147.5793	54.2982
KP P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hausman P-Value	0.1172	0.5420	0.0545	0.7041	0.4074	0.0537

Notes

Data from the California Department of Public Health, the California Office of Statewide Health Planning and Development, and the Census. The dependent variable in all specifications is the log of the number of syphilis diagnoses in a county and month + 1. T-statistics, shown in parentheses, are calculated from standard errors clustered at the county level. In addition to the coefficients shown, all models include county fixed effects, and the last 3 models include year and month fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5
IV Regression Results of Effects of Methamphetamine Consumption
on Syphilis Transmission

	<u>Total</u>	<u>Males</u>	<u>Females</u>	<u>Total</u>	<u>Males</u>	<u>Females</u>
Log of Meth Admits	-0.113 (-1.34)	-0.021 (-0.35)	-0.198* (-1.75)	-0.028 (-0.35)	0.060 (0.92)	-0.192* (-1.83)
Lagged Syphilis Admits	0.234*** (4.38)	0.223*** (4.93)	0.177*** (2.95)	0.230*** (4.24)	0.218*** (4.87)	0.176*** (2.89)
Log of Alcohol Admits	0.020 (0.85)	0.015 (0.96)	0.029** (2.08)	0.011 (0.47)	0.009 (0.64)	0.026** (2.05)
Log of Cannabis Admits	0.022 (0.72)	-0.017 (-0.89)	0.038 (1.12)	-0.004 (-0.14)	-0.035* (-1.84)	0.032 (1.18)
Log of Heroin Admits	0.002 (0.11)	-0.004 (-0.25)	0.007 (0.45)	-0.003 (-0.15)	-0.011 (-0.75)	0.008 (0.54)
Log of Cocaine Admits	-0.015 (-0.64)	-0.004 (-0.22)	0.024 (1.00)	-0.030 (-1.57)	-0.016 (-0.89)	0.022 (1.01)
% Population Male	0.103 (1.07)	0.055 (0.75)	0.063 (0.63)	0.053 (0.63)	0.011 (0.16)	0.043 (0.53)
% Population Black	-0.238 (-1.37)	-0.136 (-1.13)	-0.182 (-0.95)	-0.243 (-1.34)	-0.146 (-1.12)	-0.189 (-0.99)
% Population Hispanic	-0.031 (-1.16)	-0.025 (-1.00)	-0.020 (-0.98)	-0.056 (-1.56)	-0.055* (-1.72)	-0.011 (-0.31)
Pop Density in 100s/sq. mile	-0.094 (-1.28)	-0.041 (-1.08)	-0.080 (-0.94)	-0.112 (-1.37)	-0.063 (-1.41)	-0.074 (-0.77)
% Population Age Under 18	-0.109*** (-2.60)	-0.083*** (-2.63)	-0.091** (-2.15)	-0.107* (-1.74)	-0.059 (-1.06)	-0.142** (-2.17)
% Population Age 18-39	0.086*** (2.83)	0.056*** (2.61)	0.079*** (2.63)	0.142* (1.93)	0.122** (2.18)	0.073 (0.93)
Year/Mnth FE	No	No	No	Yes	Yes	Yes
Num	2400	2400	2400	2400	2400	2400
Partial R2	0.0887	0.0816	0.0381	0.0703	0.0651	0.0334
KP F-Stat	151.2883	147.5547	46.4546	125.8545	148.2555	54.5966
KP P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hausman P-Value	0.1421	0.5818	0.0664	0.6498	0.4666	0.0589

Notes

Data from the California Department of Public Health, the California Office of Statewide Health Planning and Development, and the Census. The dependent variable in all specifications is the log of the number of syphilis diagnoses in a county and month + 1. T-statistics, shown in parentheses, are calculated from standard errors clustered at the county level. In addition to the coefficients shown, all models include county fixed effects, and the last 3 models include year and month fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.