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CRIMINAL PROSECUTION AND HIV-RELATED RISKY BEHAVIOR

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ABSTRACT

We evaluate the consequences of prosecuting HIV+ people who expose others to the risk of infection. We show that the effect of aggressive prosecutions on the spread of HIV is a priori ambiguous. Aggressive prosecutions tax risky behavior and thus deter unsafe sex and limit the number of sexual partners. However, such penalties might also create unique incentives for having sex with more promiscuous partners such as prostitutes and consequently increase the spread of HIV. We test these predictions using unique nationally representative data on the sexual activity and prosecutions of HIV+ persons. We find that more aggressive prosecutions are associated with a reduction in the number of sexual partners and increased likelihood of safe sex. However, they are also associated with increased likelihood of having sex with prostitutes and not disclosing HIV+ status. Overall, our estimates imply that doubling the prosecution rate could decrease the number of new HIV infections by 12% over a ten-year period.

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Introduction

> *"The criminal law has a role to play both in deterring those infected with HIV from putting the lives of others at risk and in protecting the public from irresponsible individuals who refuse to comply with public health orders to abstain from high-risk activities."*
>
> —Supreme Court of Canada, R. v. Cuerrier, [1998] 2 S.C.R. 371

Private decisions about risky behavior such as unprotected sex, drinking and driving, and drug use often impose costs on society that are not considered by the individual in making behavioral choices. This result is often invoked as a justification for explicitly taxing certain products and imposing fines and penalties. However, it is often unclear whether such policy actions do more harm or good. The primary argument against such policies is that the demand for risky behavior is fairly inelastic and thus these policies do little to deter such behaviors. For example, most would agree that the fear of dying is powerful and pervasive. Yet, whether capital punishment deters crime is a highly contentious issue among economists (Donohue and Wolfers, 2006; Becker, 2006; Rubin 2006). Taxing risky behavior may also engender behavioral responses harmful to society. For example, Peltzman (1975) argues that strict seat belt laws might encourage reckless driving; Miron and Zwiebel (1995) posit that free markets for drugs might reduce violence, property crime and other unintended consequences of drug prohibition; and Philipson (2000) argues that mandatory vaccinations might reduce private demand for prevention.

In this paper, we analyze the consequences of prosecuting HIV+ people who expose others to the risk of infection. In the United States, all states are endowed with criminal laws to prosecute individuals infected with HIV who expose others to the virus, and a several hundred such prosecutions have taken place between 1986 and 2001 (Lazzarini et al., 2002). However, states differ in how often, if at all, they charge people under these laws. We develop an economic model of risky sex with law enforcement, and empirically evaluate the effect of stringent law enforcement on the sexual behavior of HIV+ individuals. Our paper extends previous work on sexual behavior and HIV incidence to the study of criminal penalization. Previous work in this area has analyzed the effect of public policy, such as information campaign (Posner and

Philipson, 1994; Boozer and Philipson, 2000) and subsidized testing (Posner and Philipson, 1995), on sexual behavior and HIV incidence.

Using unique nationally representative data on the sexual activity and state-level prosecutions of HIV+ individuals, we find that the sexual activity and propensity for unsafe sex of HIV+ is quite responsive to more aggressive prosecution. Thus, at first glance, a tax on risky behavior appears to be welfare enhancing – it deters unsafe sex and sexual activity by HIV+ individuals and consequently limits the spread of HIV.

However, these laws also have some unintended but rational behavioral responses. In particular, our model shows that, under certain circumstances, such penalties create unique incentives for having sex with more promiscuous partners such as prostitutes for whom it is more difficult to trace the source of infection. The increased sexual activity with more-risky partners could actually increase the spread of HIV. We also show that fear of prosecution reduces disclosure of HIV+ status to potential partners. We test these predictions using data on the sexual activity of HIV+ individuals and HIV-related prosecutions. We find that more aggressive prosecutions are associated with an increased likelihood of having sex with prostitutes and not disclosing HIV+ status.

To illustrate the implications of our empirical results for the transmission of HIV, we use our estimates to simulate the number of new HIV infections generated over 10 years under various law enforcement scenarios. The increase in sexual activity with prostitutes offsets partially, but not fully, the positive impact of the laws on HIV incidence. When ignoring the increase in sex with more promiscuous partners, our estimates imply that stringent law enforcement against HIV+ individuals would decrease the number of new infections by 16% over a ten-year period. Taking into account the overall effects of law enforcement, we find that stringent law enforcement could decrease new infections by 12%.

1 An Economic Model of Risky Behavior with Criminal Enforcement

In 1996, Johnson Aziga, a Uganda-born Canadian had unprotected sex with at least 13 women without disclosing that he was HIV+. Mr. Aziga was charged with aggravated sexual assault; and, after two of them died of complications from AIDS, he was charged with murder. (There is a certain irony in that Mr. Aziga was employed by the Ontario Ministry of the Attorney General in 1996). His case is still pending and has received much attention in Canada. Aziga's case closely mirrors that of Trevis Smith, a linebacker with the Canadian Football League's Saskatchewan Roughriders. He was charged with sexual assaulting two women because he had unprotected sex with them and did not disclose his HIV status. Smith is currently free on bail; the conditions of his release require him to practice safe sex, tell all future partners he is HIV-positive, and use condoms.

In this section, we develop an economic model of how such prosecutions affect behavior. The model allows HIV+ agents to choose several dimensions of risky sexual behavior including the number of offers for sex to potential partners; propensity to practice safe sex; disclosure of HIV+ status; and promiscuity of potential sex partners. Potentially, the two partners jointly make some of these decisions, such as to engage in sexual intercourse and practice safe sex. Alternatively, the HIV+ person may make a take-it-or-leave-it offer specifying all the dimensions of the sexual encounter that the partner can accept or reject. For simplicity, the model abstracts from the joint decision-making process and assumes that an HIV+ agent meets a partner who is willing to have sex.[1] The HIV+ person then decides whether to propose sex to this partner, whether to practice safe sex, and whether to disclose HIV status.

Consider a representative risk-neutral HIV+ person who resides in a state that prosecutes HIV-infected individuals for exposing others to the virus through sexual contact. Let $\Pi > 0$ denote the disutility from being prosecuted and $Pr(pros)$ be probability of being prosecuted. The probability of being prosecuted in turn depends on the likelihood that a potential partner would report the sex act to the state and the probability that the state would prosecute conditional on receiving a report:

$$P(pros) = P(reported) \times P(prosecuted \mid reported) = P(reported) \times \rho \qquad (1)$$

The parameter ρ is the key policy of interest—states with higher values of ρ have more stringent law enforcement against HIV+ individuals.

The probability of being reported ($P(reported)$) depends on the outcome and circumstances of the sexual encounter. A partner is more likely to report the HIV+ person if he gets infected with

[1] This framework follows our data—we have information on the actions taken for sex offers that have been realized, but we do not know anything about offers that have been rejected. Those are anyway irrelevant for the transmission of HIV.

HIV and can identify the HIV+ person as the source of infection. Thus, the probability of being reported depends on three behavioral choices made by the HIV+ person:

- *Practice unsafe sex* (c): A partner is more likely to become infected if they do not practice safe sex during the sexual encounter; therefore the probability that a partner will report a sex act with the HIV+ person increases with unsafe sex ($\frac{\partial P(reported)}{\partial c} > 0$)
- *Disclose HIV+ status* (d): a partner is more able to identify the HIV+ person as the source of infection if the person has disclosed HIV+ status; therefore the probability that a partner will report a sex act with the HIV+ person increases with disclosure ($\frac{\partial P(reported)}{\partial d} > 0$)
- *Avoid non- promiscuous partners* (δ): a partner who is less promiscuous, i.e. more "exclusive," can more easily identify the person who infected her; therefore the probability that a partner will report a sex act with the HIV+ person increases with the exclusivity of their relationship ($\frac{\partial P(reported)}{\partial \delta} > 0$). The exclusivity level δ follows a distribution $\Gamma(\delta)$ on the support $[\underline{\delta}, \overline{\delta}]$.

For simplicity, we also assume that the cross derivative of the probability of being reported with respect to each of these choices is zero. For example, we assume that the change in the probability of being reported implied by a change in disclosure is independent of the level of safe sex practiced. We also assume the second derivatives have the usual properties: $\frac{\partial^2 P(reported)}{\partial c^2} < 0, \frac{\partial^2 P(reported)}{\partial d^2} < 0, \frac{\partial^2 P(reported)}{\partial \delta^2} < 0$.

The exclusivity of the partner, the practice of unsafe sex and disclosure also influence the value of the sexual encounter. We assume that everything else equal the HIV+ person prefers less promiscuous partners; prefers unsafe sex and prefers to disclose HIV+ status because of altruistic concerns. We assume the HIV agent values honesty and hence, *ceteris paribus*, would prefer to disclose HIV status.[2] In other words, the value of sex (V) with a particular partner

[2] In our nationally representative sample of HIV+ persons, 83% of respondents either strongly agree or agree that it is their duty to tell all new partners that they are HIV+.

increases with the exclusivity of the relationship ($\frac{\partial V}{\partial \delta} > 0$) with the partner, increases with having unsafe sex ($\frac{\partial V}{\partial c} > 0$) and increases with disclosure ($\frac{\partial V}{\partial d} > 0$). For simplicity, we also assume that the cross derivative of the value of sex with respect to each of these choices is zero. This means that the change in the value of sex implied by a change in disclosure is independent of the level of safe sex practiced.

When matched with a partner *i*, the HIV+ person observes whether this partner is promiscuous, i.e. the exclusivity level δ_i. After observing the exclusivity level, the agent faces first a discrete choice (whether to propose sex or not) and if he decides to propose, he chooses the levels of disclosure d and unsafe sex c to maximize expected utility.

Let's focus first on the optimal levels of disclosure and safe sex conditional on making a proposal. The HIV+ person solves the following maximization problem:

$$\max_{c,d} \left\{ V(\delta_i, c, d) - \rho P(reported)\Pi \right\} \tag{2}$$

The objective function will be concave in *c* and *d* if the Hessian matrix is negative definite. The following conditions guarantee this concavity (Appendix 1 provides more detail):

Condition 1: For all *c*, $\frac{\partial^2 V}{\partial c^2} - \Pi\rho \frac{\partial^2 P(reported)}{\partial c^2} < 0$ and for all *d*, $\frac{\partial^2 V}{\partial d^2} - \Pi\rho \frac{\partial^2 P(reported)}{\partial d^2} < 0$.

A sufficient condition for this condition to hold for all $\rho \in [0,1]$ is:

Condition 1': $\frac{\frac{\partial^2 V}{\partial c^2}}{\frac{\partial^2 P(reported)}{\partial c^2}} \geq \Pi$ for all *c*, and $\frac{\frac{\partial^2 V}{\partial d^2}}{\frac{\partial^2 P(reported)}{\partial d^2}} \geq \Pi$ for all *d*.

This means that a decrease in unsafe sex *c* or disclosure *d* leads to a sharper decrease in the marginal value of sex than in the marginal probability of being reported.

If condition 1 is satisfied, the optimal levels d^* and c^* satisfy the following first-order-conditions:

$$\frac{\partial V}{\partial c} = \Pi\rho \frac{\partial P(reported)}{\partial c} \tag{3}$$

$$\frac{\partial V}{\partial d} = \Pi\rho \frac{\partial P(reported)}{\partial d}. \tag{4}$$

Equation (3) states that the HIV+ agent chooses the level of unsafe sex to equalize the marginal disutility from unsafe sex to the marginal benefit from safe sex. On the one hand, increasing unsafe sex increases the value of sex. On the other hand, it increases the chance of being reported to the state and being penalized for having sex. Equation (4) states that the HIV+ agent chooses the level of disclosure to equalize the marginal disutility of disclosure to the marginal benefit of disclosure. On the one hand, increasing disclosure reduces guilt and thus increases the value of sex. On the other hand, increasing disclosure is costly as it increases the chance of being reported to the state.

Given the optimal levels of disclosure and safe sex, the HIV+ person will propose to have sex if the expected utility of proposing is higher than the expected utility of not proposing, which we normalize to *M*, i.e. he will propose to a partner of exclusivity level δ_i if

$$\left[V(c^*, d^*, \delta_i) - \rho P(reported)^* \Pi\right] \geq M \;. \qquad (5)$$

1.1 The Effects of Stringent Law Enforcement

We now analyze the effect of a change in the stringency ρ of the HIV law on the choices of the HIV+ person. For all the propositions we assume that condition 1' is verified. Formal derivation of the comparative static is provided in the appendix.

<u>Proposition 1:</u> *More stringent law enforcement increases safe sex*
Intuitively an increase in ρ increases the marginal cost of unsafe sex, as reducing the probability of being reported to the state is more valuable in states that tend to prosecute at higher rates. Therefore, as the expected punishment increases, the HIV+ person seeks to reduce the transmission of HIV to the partner and will thus practice safer sex. More formally, we see from equation (3) that a decrease in the practice of unsafe sex *c* increases both $\frac{\partial V}{\partial c}$ and $\frac{\partial P(reported)}{\partial c}$ but condition 1' ensures that $\frac{\partial V}{\partial c}$ increases faster.

<u>Proposition 2:</u> *More stringent law enforcement decreases disclosure of HIV+ status*
Similarly, an increase in ρ increases the marginal cost of disclosure, as reducing the probability of being reported to the state is more valuable in states that tend to prosecute at higher rates. Therefore, as the penalty increases, the HIV+ person seeks to avoid being reported and is thus less likely to disclose.

Proposition 3: *More stringent law enforcement decreases the probability of a sexual encounter*

This result directly follows from the fact that more stringent enforcement reduces the expected utility from sex as it increases the expected punishment. To see this more formally, consider Equation (5) that shows that the agent is going to propose sex to a partner of exclusivity level δ_i if $\left[V(c^*, d^*, \delta_i) - \rho P(reported)^* \times \Pi\right] \geq M$. With an increase of the stringency of law from ρ to ρ^{**}, the new decision rule is $\left[V(c^{**}, d^{**}, \delta_i) - \rho^{**} P(reported)^{**} \times \Pi\right] \geq M$, where d^{**} and c^{**} are the new optimal levels of disclosure and safe sex conditional on making a proposal. Because d^* and c^* are the optimal levels when the stringency is ρ, we have:

$$\left[V(c^*, d^*, \delta_i) - \rho P(reported)^* \times \Pi\right] \geq \left[V(c^{**}, d^{**}, \delta_i) - \rho P(reported)^{**} \times \Pi\right] \qquad (6)$$

Moreover, since $\rho^{**} > \rho$, we also have

$$\left[V(c^{**}, d^{**}, \delta_i) - \rho P(reported)^{**} \times \Pi\right] > \left[V(c^{**}, d^{**}, \delta_i) - \rho^{**} P(reported)^{**} \times \Pi\right] \qquad (7)$$

These 2 inequalities in equations (6) and (7) can be combined to show that:

$$\left[V(c^*, d^*, \delta_i) - \rho P(reported)^* \times \Pi\right] > \left[V(c^{**}, d^{**}, \delta_i) - \rho^{**} P(reported)^{**} \times \Pi\right] \qquad (8)$$

Equation (8) implies that all partners with characteristics δ_i who are proposed to have sex under the stringency of law ρ^{**} would also be proposed sex under the stringency of law ρ. It is harder for equation (5) to be verified when the law is more stringent. So, the HIV+ person is less likely to engage in sexual activities with a more stringent law.

Proposition 4: *Under certain conditions, more stringent law enforcement can increase the probability of a sex offer to more promiscuous partners*

The marginal benefit of having a more exclusive partner is the marginal utility the HIV+ person gains from having sex with a more exclusive partner ($\frac{\partial V}{\partial \delta}$). The marginal cost is the increase in the probability of being reported times the expected penalty from being reported, i.e. $\Pi \rho \frac{\partial P(reported)}{\partial \delta}$. Clearly, the marginal cost is increasing in the stringency of the law: the more stringent the law, the less beneficial it is to have a partner who is exclusive and who will thus have less difficulty in identifying the source of a potential infection. If ρ is sufficiently high, the marginal cost of exclusive sex is higher than the marginal benefit, and a further increase in ρ will lead the HIV+ agent to avoid more exclusive partners.

2 Data

We propose to use data on law enforcement against HIV+ individuals and data on the sexual activity of HIV+ individuals to test the implications of the economic model of risky behavior. Below we describe each of our data sources.

2.1 Criminal Statutes and Law Enforcement in the US

As of 2000, all US states certified that their criminal laws were "adequate to prosecute individuals infected with HIV who intentionally or knowingly infect or expose others to HIV."[3] Penalties for breaking the law range from a minimum of one year to a maximum of life in prison (Wolf and Vezina, 2004). The certification by states of the criminalization of exposure to HIV comes from the 1990 Ryan White Comprehensive AIDS Resources Emergency Act which required such warranty from the states in order for them to receive AIDS relief grants for AIDS treatment and care. The motivation at the time was concerns about the safety of blood supply (Wolf and Vezina, 2004).[4]

States have taken three general approaches to prosecute HIV+ individuals who expose others to the risk of HIV: (i) adopt HIV-specific laws; (ii) rely on existing sexually transmitted diseases (STD) laws; or (iii) use general criminal statutes such as assault or reckless endangerment (Lazzarini et al, 2002). As of 2005, 24 states have HIV-specific laws. In most states, the HIV-specific laws refer to sexual activity, exchange of bodily fluid, needle sharing and organ donation. In some cases, the laws also address other activities such as spitting that have little or no risk of spreading HIV. Most of these laws focus on intentional HIV exposure rather than actual infection. In four states, it is exposure without disclosure that constitutes a crime.[5] Some states have also passed sentence enhancement laws that punish more severely a criminal who is HIV+ (e.g., prostitutes). The STD laws, most of which were passed before 1930, punish exposure to a communicable disease or STD (Lazzarini et al, 2002).

We use data from Lazzarini et al. (2002) to measure prosecutions against HIV+ individuals who expose others to the risk of HIV. Lazzarini et al. (2002) have compiled data

[3] Source: Ryan White Comprehensive AIDS Resources Emergency, 42 U.S.C, §300-47ff.
[4] This requirement was abandoned in 2000 as all states fulfilled the requirement.
[5] See http://www.hivcriminallaw.org/ [accessed in March 2004].

from cases decisions and newspaper articles and identified 316 prosecutions of exposure or transmissions of HIV for the period 1986-2001. Risk behaviors for prosecutions include sexual exposure (67%), spitting, biting, or scratching (23%), and syringe infection (4%). Sentences (among those that could be determined) range from life imprisonment to probation. Excluding life sentence, the median imprisonment sentence was 6 years. Prosecutions were clustered during the years 1993 to 1998, the six years preceding our data on sexual activity of HIV+ individuals, with twenty or fewer prosecutions nationwide in most other years.

2.2 The HIV Cost and Services Utilization Study

We aim to investigate the effects of prosecutions of HIV+ individuals on the risky behavior of HIV+ individuals. We use data from a nationally representative study of HIV+ patients in care, the HIV Costs and Services Utilization Study (HCSUS), to measure sexual activity of HIV+ individuals. The HCSUS employed a multi-stage national probability sample design to identify HIV+ patients over 18 years old, who made at least one visit for regular care in the contiguous United States in January or February of 1996. It does not include HIV+ patients whose only contact with the health care system was through military, prison, or emergency department facilities, or who have not made contact with the health care system for their HIV. HCSUS is a panel data set with three waves of interviews and with detailed information on the demographics, and health of respondents. However, detailed questions about sexual activity including number of partners, safe sex practices, paid sex and disclosure of HIV+ status were asked only to a random sample of 1,794 respondents who completed the third wave of HCSUS interviews. Interviews for this "Risk and Prevention" study were conducted from September to December 1998. 1,421 respondents completed the interview (a completion rate of 79%, or 84% after adjusting for mortality). This sample is representative of the 197,063 HIV+ US adults who received care in 1996 and survived until 1998. We use this subsample of HCSUS respondents for our analysis. State level variation in HCSUS has been used to identify how treatment affects risky behavior (Lakdawalla, Sood, Goldman, 2006); how insurance affects HIV-related mortality (Goldman et al, 2001; Bhattacharya et al., 2003); and how treatment affects labor supply (Goldman and Bao, 2004).

2.3 Description of Variables

2.3.1 Measures of risky behavior

Stringent law enforcement against HIV+ individuals is likely to affect the sexual activity of HIV+ individuals along several dimensions—including the number of partners, propensity for safe sex, promiscuity of partners and disclosure of HIV+ status. These are measured as follows:

- *Level of sexual activity*: We use the number of partners in the past 6 months as our key measure of the level of sexual activity. We expect the level of sexual activity to reduce with stringent law enforcement.
- *Safe sex practices*: HCSUS respondents were asked about the frequency of unsafe sex practices in past 6 months. The responses to this question were classified into the following mutually exclusive categories: no sex, never unsafe, sometimes unsafe, always unsafe. We expect stringent enforcement to reduce unsafe sex practices.
- *Disclosure of HIV+ status*: We employ an indicator variable for whether the respondent never disclosed HIV status to the 5 most recent partners. We expect that conditional of having sex; stringent law enforcement will decrease disclosure of HIV+ status.
- *Promiscuity of partners*: HCSUS did not ask about the promiscuity of potential sex partners. However, HCSUS did ask respondents whether they had sex with prostitutes or hustlers – always, usually, about half the time, sometimes, and never. Increase in the proportion of respondents having sex with prostitutes or hustlers would indicate an increase in the promiscuity of potential partners. We expect that more stringent law enforcement would increase the promiscuity of sexual partners.

2.3.2 Measure of law enforcement

Lazarrini et al. (2002) provide a very comprehensive description of U.S HIV-related laws and document the number of prosecutions that have been reported in legal decisions and the in the press. Based on their data, we employ two variables to measure the stringency of a state HIV law:

- *Strict law*: a binary variable equal to 1 for respondents who reside in states with higher than median prosecutions per 10,000 AIDS cases from 1986 to 2001;
- *Log prosecution rate*: The log of prosecutions per 10,000 AIDS cases from 1986 to 2001.

Tables 1a and 1b present the distribution of respondents per state for states with strict law and non-strict law respectively. About half of our sample lives in a state with strict law.

3 Empirical Framework and Identification

We use multivariate regression models to investigate the association between stringent law enforcement and measures of risky sexual behavior described above. We estimate ordinary least squares models for “number of partners”; probit regressions for “never disclosed to 5 most recent partners” and “sex with prostitutes or hustlers”; and ordered probit models for the categorical variable for unsafe sex practice. Standard errors are adjusted for clustering at the state level.

We estimate 2 sets of models. Covariates in the first set of models include age, gender, an indicator variable for non-white, a set of indicator variables for education (less than high school, high school, some college) and stage of disease. There are three categories in clinical stage: asymptomatic, symptomatic, and AIDS. Patients have AIDS if they manifest conditions such as Kaposi's sarcoma, toxoplasmosis, or other life threatening conditions typically associated with AIDS. Symptomatic HIV+ patients manifest some conditions related to their infection, but not one of the AIDS defining conditions.

Our identification comes from interstate variation in stringency of law enforcement. However, it is possible that stringency of law enforcement is related to the attitudes towards sex, religiosity and other determinants of sexual activity. If this is the case, then the first set of models which include only individual controls might be biased as they attribute all cross-state differences in sexual activity to differences in the stringency of law enforcement across states. One solution to this problem is to include state fixed effects and exploit changes in law enforcement to identify the effects of laws on sexual activity. Unfortunately, this is not feasible as panel data on sexual activity of HIV+ individuals is not available.

However to test the robustness of our results, we estimate an additional set of regression models that include several state level measures that are likely to be correlated with sexual activity as additional covariates. These covariates include percent of state population living in urban areas, abortion rate, teen pregnancy rate, percent of state population that prays several times a week and percent of state population with a college education. Urbanization data are based on the 2000 Census as reported in the Statistical Abstract of the United States: 2004–05.

Data on abortion and teen pregnancy rates (pregnancies/abortions per 1000 females aged 15–44) in 1999 are based on the survey by the Alan Guttmacher Institute (Finer and Henshaw, 2003), and population estimates from the U. S. Census Bureau. Data on frequency of prayers are from the 1998-2002 General Social Surveys that collect nationally representative data on social attitudes and behaviors. Data on percent college educated are from the 1998 current population survey (CPS) [6].

Another concern with using cross state variation is that HIV+ persons with a high propensity for risky sex might migrate out of states with aggressive prosecutions leading to a spurious correlation between risky sex and prosecutions. To test this hypothesis, we used the HCSUS panel data on the respondents' state of residence in each wave of the data (1996 to 1998) to investigate if promiscuous HIV+ individuals migrated to states with less stringent law enforcement. We found that less than 3% of the HCSUS sample migrated across states and there was no systematic pattern in the migration. Furthermore, prior research also documents that state level policies are uncorrelated with unobserved determinants of health and sexual practices among the HIV+ population. For example, Lakdawalla, Sood, Goldman, (2006) used variation in state Medicaid policies as instruments to estimate the effect of treatment on sexual activity of HIV+ persons. They showed that state level policies were uncorrelated with unobserved determinants of health and sexual practices of HIV+ persons.

4 Results

Table 2 presents descriptive statistics on the distribution of number of partners, safe sex practice, paid sex and disclosure of HIV+ status according to the strictness of law enforcement, as defined in Section 3.3.2, against transmissive activity by HIV+ individuals. The trends in the raw data are remarkably consistent with the predictions from the economic model. The results show that HIV+ individuals in "strict law" states have fewer partners on average (5.9 compared to 2.5). This difference comes from that fact that respondents in strict law state are more likely to abstain from sex (30% versus 37%) and less likely to have more than 2 partners (22% compared to 31%). HIV+ individuals in strict law states are also more likely to practice safe sex. For example,

[6] In an additional check, we used the HCSUS panel data on the respondents' state of residence in each wave of the data (1996 to 1998) to investigate if promiscuous HIV+ individuals migrated to with less stringent law enforcement. We found that less than 3% of the HCSUS sample migrated across states and there was no systematic pattern in the migration.

58% of HIV+ individuals in strict law states always practice safe sex (or never practice unsafe sex) compared to 53% of HIV+ individuals in states without strict laws. The raw data also show that even though strict law enforcement is associated with reduced sexual activity and safer sexual practices; it does have some negative consequences. In particular, strict legal enforcement is associated with an increase in sex with hustlers and reduced disclosure of HIV+ status. For example, respondents in strict law states are twice as likely not to reveal their HIV status to their sexual partners. Similarly, among respondents with more than one sex partner, 85% of respondents in states with strict law report having sex with hustlers or prostitutes compared to 76% of respondents in non strict law states.

While these descriptive statistics are supportive of our theory, they do not condition on factors other than strictness of law enforcement. Table 3 presents some individual characteristics by strictness of law enforcement and shows that respondents who reside in a strict law state are more likely to be female, white, and less educated. However, there are no differences in the health status of respondents across the two types of states.

Table 4 presents the estimation results. For each behavior, we present two specifications each using one of the two measures of stringency of HIV laws – "strict law" an indicator for whether the prosecution rate is higher than the median prosecution rate and "log prosecutions," the log of prosecutions per 10,000 AIDS cases. The striking result from Table 4 is that the stringency of law enforcement significantly affects all the risky behaviors and verifies the results obtained from the descriptive statistics presented earlier. HIV+ individuals living in strict law states have on average one less sexual partner than HIV+ people in states without strict law. The results from the continuous measure of prosecution rates show that a 100% increase in prosecutions is associated with 0.4 less sexual partners. The coefficients from the ordered probit regression of unsafe sexual practices show that more stringent law enforcement against HIV+ individuals who expose others in the population to the risk of HIV is also associated with HIV+ individuals practicing safe sex. The mean marginal effects from the ordered probit specification (not presented in the table) show that a 100% increase in the prosecution rate is associated with a 2.4 percentage point increase in the probability of abstinence, a 2 percentage point increase in the probability of always practicing safe sex (never practicing unsafe sex), a 2.8 percentage point reduction in the probability of sometimes practicing unsafe sex, and a 1.6 percentage point decrease in the probability of always practicing unsafe sex. Thus, the results show that stringent law enforcement is likely to reduce the spread of HIV by reducing both the level of sexual activity and the propensity for unsafe sex.

However, the coefficients from the probit models in the last 2 columns of Table 4 suggest that these laws also have some perverse effects. Among respondents with more than one partner, respondents living in states with more stringent laws are significantly more likely to have sex with prostitutes or hustlers and significantly less likely to disclose their HIV+ status to their partners. Both of these behaviors could increase the transmission of HIV. The mean marginal effects from the probit model show that a 100% increase in prosecution rate is associated with a 6.8 percentage point increase in the probability of having sex with prostitutes or hustlers and 2.4 percentage point reduction in the probability of disclosing HIV+ status.

We also re-estimated our models including controls for other factors. The stringency of the HIV law in a given state could be correlated with other variables (such as religiosity) influencing risky behaviors. In order to evaluate whether this is the case, we include state-specific controls to our models. In particular, we include religiosity (proportion of population that pray several times a week), abortion rate, the teen pregnancy rate, the proportion of people with a college degree and the percentage of people living in a urban area. Table 5 presents the results. Most of our results are robust to adding state-specific controls; we still find that more stringent law enforcement is associated with an increase in number of partners, increase in propensity for safe sex, and reduction in disclosure of HIV+ status. In fact adding the controls increases the magnitude of the impact of the HIV laws on risky behavior and makes the coefficients more precisely estimated. However, the results from this specification show no association between stringent law enforcement and sex with prostitutes. This is likely due to the small sample size (330 observations) as sex with prostitutes is only measured for the sample with more than 1 partner.

In another check of the robustness of our results, we estimated instrumental variable (IV) models that used the state property crime arrest rate from 1990 to 1997 (obtained from FBI uniform crime reports available online at http://www.fbi.gov/ucr/ucr.htm [access date September 6, 2006]) to instrument for the HIV specific prosecution rate. We find that the property crime arrest rate in a state is a strong predictor of the HIV specific prosecution rate (first stage F-

Statistic > 30 for most specifications). The magnitude of point estimates from the IV models were similar to those obtained from earlier models, however they were less precisely estimated.[7]

5 Implication for transmission of HIV

In this section, we use a simple simulation model to illustrate the implications of our empirical results for the transmission of HIV. We simulate the number of new HIV infections generated over 10 years in a hypothetical state under three scenarios – (1) base scenario –the state has less than the median number of prosecutions.; (2) Partial effect – the number of prosecutions increase by 100% and there is no effect of prosecutions on probability of sex with prostitutes; (3) Full effect – the number of prosecutions increase by 100% and prosecutions rates affect number of partners, probability of safe sex and probability of sex with prostitutes (as estimated in Table 4).

We assume that the population or the pool of potential sex partners consists of two types of individuals -- "ordinary" (i.e. non-promiscuous) partners and "prostitute" partners (i.e. promiscuous). We distinguish between ordinary and prostitute partners as these groups differ dramatically in their promiscuity and thus have significantly different probability of infecting other individuals in the population and spreading the infection. We assume that ordinary partners have sex both with ordinary partners and with prostitutes. However, prostitute only have sex with ordinary partners. Let n_{oo} and n_{op} be the (expected) number of ordinary partners and prostitute partners infected by an ordinary HIV+ person per period. Similarly, let n_{po} be the number of ordinary partners infected by a HIV+ prostitute per period. Given the number of ordinary partners u_t and prostitutes v_t infected at time t and a death rate of *d*, the number of HIV+ ordinary partners and prostitutes at time $t+1$ number is provided by:

$$u_{t+1} = u_t(1-d) + n_{oo}u_t + n_{po}v_t \tag{9}$$

$$v_{t+1} = v_t(1-d) + n_{op}u_t \tag{10}$$

We assume that the risk of infection follows a simple binomial of the number of unprotected sex acts (see for example UNAIDS, 2005 for a similar approach). Thus, the expected number of partners infected by ordinary HIV+ individuals and infected prostitutes is given by:

[7] Full model results are available upon request from the authors.

$$n_{oo} = \left(N - N_{prost}\right) p^{t}{}_{neg,o} \times \left(1 - \left(1 - i\right)^{C \times p_{unsafe}}\right) \tag{11}$$

$$n_{op} = N_{prost} \times p^{t}{}_{neg,p} \times \left(1 - \left(1 - i\right)^{C \times p_{unsafe}}\right) \tag{12}$$

$$n_{po} = N^{P} \times p^{t}{}_{neg,c} \times \left(1 - \left(1 - i\right)^{C^{P} \times p^{P}{}_{unsafe}}\right) \tag{13}$$

Where, N and N^P denote the total the number of sexual partners per period of ordinary partners and prostitutes respectively and N_{prost} the number of prostitute partners of an ordinary partner. $p^{t}{}_{neg,o}$ and $p^{t}{}_{neg,p}$ are the probabilities that an HIV+ person's ordinary and prostitute partners are HIV- respectively at time t. Similarly, $p^{t}{}_{neg,c}$ is the probability that a prostitute's client is uninfected. p_{unsafe} and $p^{P}{}_{unsafe}$ are the probabilities of unsafe sex for ordinary partners and prostitutes respectively. C and C^P are the number of sexual contacts per partner for ordinary partners and prostitutes respectively. Finally, i is the risk of infection per unprotected contact. Equations (11) to (13) show that the expected number people infected by a HIV+ person is an increasing function of (1) the number of partners, (2) number of contact per partner, (3) probability that the partner is uninfected, (4) probability of unsafe sex, and (5) probability of infection per unprotected contact.

We calibrate the parameters of our simulation model using existing evidence on the sexual activity of HIV+ persons, the uninfected population and prostitutes. We then use the parameter estimates from Table 4 to simulate the number of new HIV infections generated over 10 years in a hypothetical state under the different law enforcement scenarios described earlier. We next describe how we calibrate our model.

Our simulation takes place in a state inhabited by 4 millions ordinary people and 80,000 prostitutes. The HIV/AIDS infection rate at time zero is 0.002 among ordinary people and 0.05 among prostitutes,[8] yielding a total infection rate of 0.0029 —which is comparable to US estimates (CDC, 2006). We assume a death rate among infected people of 0.03 (CDC, 2006).

[8] The promiscuous population we consider may include sex workers and people who occasionally trade sex for money. Braine et al. (2006) show that there is a wide array of sexual transaction taking place in the US. There are no recent statistics of HIV prevalence among prostitutes in the US. A 1989 study from the CDC found a 13% infection rate among female prostitutes (CDC, 1989) and Morse et al. (1991) found a 17.5% infection rate among male sex-workers in the population in New Orleans. In Mexico, various studies found infection rates ranging from 0.14% to 1% among female sex workers (Gertler et al., 2003 and references therein).

Table 6 presents the parameters we use to compute n_{oo} and n_{op} for the three scenarios we consider: base scenario, partial effect and full effect. Both the partial and full effect scenarios estimate the effects of a doubling of the prosecution rate. The only difference between the partial effect and the full effect parameters is the probability of having sex with prostitutes. The partial effect scenario does not take into account the fact that increasing prosecution rates also increases the probability of having sex with prostitutes. We use the results from the descriptive statistics in Table 2 to evaluate the parameters of the baseline case (non-strict laws): the average number of partner is 5.96; the probability of sex with hustlers conditional on having more than one sexual partner is 0.76 and the probability of unsafe sex (sometimes or always) is 0.47. We use the estimation results from Table 4 to estimate the parameters for the partial and full effect scenarios. For both scenarios we rely on the specification with the log of prosecutions to estimate the effects of a 100% increase in the number of prosecutions. For example, the estimates show that that increasing prosecution rate by 100% would decrease the number of partners by 0.41, increase the probability of sex with prostitutes by 6.8 percentage points and decrease the probability of unsafe sex by 4.4 percentage points. The other parameters are independent of the stringency of law enforcement. We assume that the HIV+ individual has on average 2 prostitute partners if he has sex with prostitutes. The probability that a prostitute partner of an HIV+ is uninfected at time *t* is assumed to be equal to the proportion of uninfected prostitutes at time *t*. The probability that an ordinary partner of an HIV+ person is uninfected is assumed to be equal to proportion of uninfected ordinary people times a non random mixing factor. The non random mixing factor accounts for the fact that HIV+ persons are more likely to have sex with other HIV+ persons. We estimate the non random mixing factor to be 0.45. This, estimate is based on the HCSUS data, where 55% of the respondents report that they never or rarely have sex with partners thought not to be HIV+. The risk of infection per contact comes from the medical literature and is set to 0.006 (UNAIDS, 2005). Finally, we assume that the HIV+ individual has on average 6 sexual contacts with each partner. These yield a total of 0.058 and 0.051 expected infections for a 6-month period per ordinary partner in relaxed and strict law states respectively at time zero.

Table 7 presents the parameters for the behavior of an infected prostitute. Since little is known about the activities of sex workers in the US, our parameters are more speculative. We assume that a prostitute has 40 different clients per 6 months period and has an average of 3 sexual acts per client.[9] Clients are drawn from the general population so the HIV prevalence of client is the one of the ordinary population, e.g. 0.002 at time 0. We further assume that prostitutes have unsafe sex 25% of the time,[10] independently of the state laws.[11]

In the first year, the model generates an incidence of 0.0059 per 100 persons-year.[12] Figure 1 plots the 10-years cumulated number of HIV+ infections (including both primary and secondary) generated under the three scenarios. After five years, there have been 10,236 new HIV infections in the base scenario, 9,056 in the partial effect scenario and 9,290 in the full effect scenario. After 10 years, the number of new HIV infections is 25,584 in the base scenario, 21,580 in the partial effects scenario and 22,496 in the full effects scenario. These simulations results show that a 100% increase in the prosecution rate would reduce the number of infections by roughly 16% if one only considers the estimated deterrent effects of prosecution rates on number of partners and unsafe sexual practices. However, if one considers the full effect of stringent law enforcement including its perverse effect on sex with prostitutes then a 100% increase in prosecution rate reduces the number of new infections by only 12%. Thus, both the intended and unintended consequences of strict law enforcement have important implications for the spread of HIV.

6 Conclusion

HIV is a difficult disease to prevent as it involves the complex interplay of many behavioral factors—including continued sexual activity by those who are known to be HIV+. Many states have criminal statutes designed to prosecute the willful infection of others, but states differ in their willingness to prosecute such behavior. We find that more stringent prosecution of such behavior leads to two offsetting effects—reduced sexual activity but also increased use of more promiscuous partners. Our simulations demonstrate that this latter effect vitiates the deterrence

[9] Using a US survey of clients of female street sex workers, Della Giusta et al. (2006) identify two profiles of clients: the experimenters who have never been with a sex worker before and the ‘regular’ clients. We assume that 3 contacts per partner averages over these two types of clients.

[10] In Della Giusta et al. (2006), 74% of the clients of female street sex workers report always using condom with sex workers.

[11] The implicit assumption is that clients decide whether to use a condom or not, and that HIV+ clients are too few to change the average rate of condom use. Gertler et al. (2003) suggest that in Mexico, clients obtain the sex practice they want, albeit paying more for it. In a small-scale study in Australia, Pyatt and War (1997) found that client resistance was the major obstacle to female sex workers maintaining safe sex practices.

[12] Quan et al. (2002) estimate that HIV incidence in the US varies between 0.002 and 19.8 per 100 person-years depending on risk group.

somewhat—the effectiveness of these laws in preventing HIV transmission is reduced by 4 percentage points, from 16% to 12%.

Other behavioral factors surely play a role beyond those we have measured. For example, it is likely that prosecution discourages HIV testing by raising the shadow price of knowing one is HIV+. This creates uncertainty in the minds of potential partners—thereby making it more difficult for an HIV+ individual to find partners—and hence offers an alternate explanation for why we see an increase in the use of prostitutes. Furthermore, strict enforcement could also have an effect on the behavior of HIV negative individuals or on AIDS treatment, which also affects transmission rates (Lakdawalla, Sood, and Goldman, 2005). A full exposition of these links is left for further research.

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Figure 1: Number of new infections under different prosecution rate scenarios

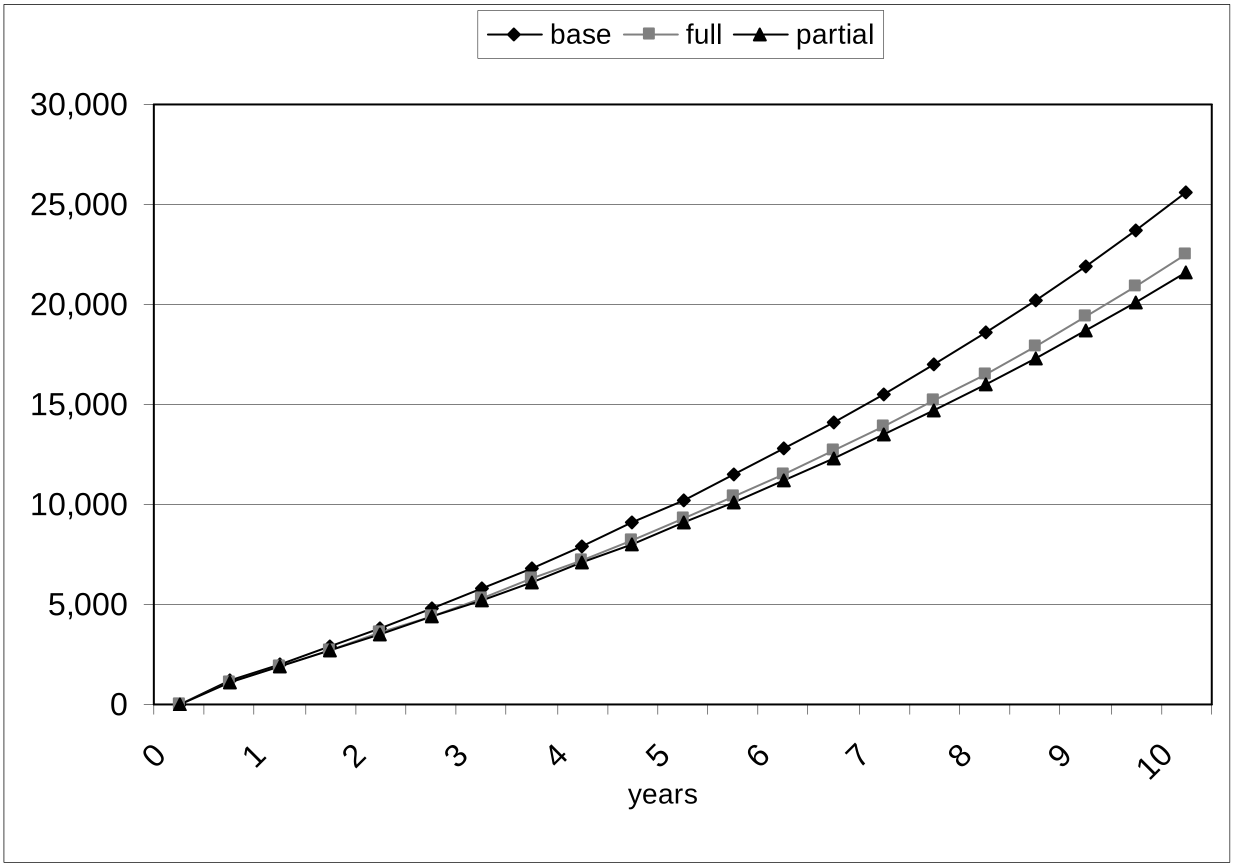

Table 1: Distribution of respondents by state

States	Freq.	Percent
Strict Law Enforcement		
AZ	5	0.7
CO	33	4.65
DC	16	2.25
FL	295	41.55
GA	29	4.08
IL	62	8.73
LA	27	3.8
MD	12	1.69
MO	45	6.34
MS	1	0.14
OH	58	8.17
OR	1	0.14
PA	57	8.03
SC	1	0.14
VA	29	4.08
WA	39	5.49
Total	710	100
Relaxed Law Enforcement		
AK	2	0.28
CA	320	45.01
DE	2	0.28
MA	23	3.23
NJ	65	9.14
NY	219	30.8
TX	80	11.25
Total	711	100

Table 2: Number of partners, safe sex practice and disclosure in past 6 months by strictness of HIV law enforcement (weighted).

	Non-Strict Laws	**Strict Laws**	**Total**
Number of partners			
Average number of partners	5.96	2.52	4.14
Proportion with no partner	0.30	0.37	0.34
Proportion with 1 partner	0.39	0.41	0.40
Proportion with 2 partners or more	0.31	0.22	0.26
Unsafe sex practices			
Never unsafe	0.53	0.58	0.56
Sometimes unsafe	0.38	0.35	0.36
Always unsafe	0.09	0.07	0.08
Paid Sex			
Sex with prostitutes	0.76	0.85	0.8
Disclosure			
Never disclosed	0.05	0.11	0.92

Table 3: Weighted descriptive statistics by strictness of HIV law

	Non-Strict Laws	**Strict Laws**	**Total**
Demographics			
Age (years)	39.2	38.7	39.0
Female (%)	26	31	28
Non-White	63	57	60
Education			
Less than HS (%)	23	31	27
High school degree (%)	27	32	30
Some college (%)	31	23	27
Symptoms of HIV			
Asymptomatic	5	5	5
Symptomatic	54	55	54

Table 4: The effect of the stringency of HIV law enforcement on risky behavior

	Number of partners		Frequency Unsafe Sex		Sex with Prostitutes		Never Disclosed HIV+	
Strict Law	**-0.833**		**-0.244**		**0.296**		**0.495**	
	[0.259]***		[0.072]***		[0.171]*		[0.128]***	
Log of prosecutions		**-0.410**		**-0.119**		**0.252**		**0.178**
		[0.156]**		[0.050]**		[0.113]**		[0.083]**
Age	-0.077	-0.08	-0.031	-0.032	0.013	0.016	0.006	0.007
	[0.008]***	[0.008]***	[0.003]***	[0.003]***	[0.011]	[0.011]	[0.007]	[0.008]
Female	-1.361	-1.42	-0.276	-0.29	0.264	0.263	-0.302	-0.26
	[0.274]***	[0.295]***	[0.084]***	[0.087]***	[0.235]	[0.237]	[0.184]	[0.182]
Non-White	-0.289	-0.327	-0.026	-0.035	-0.151	-0.123	0.307	0.297
	[0.161]*	[0.154]**	[0.041]	[0.042]	[0.187]	[0.193]	[0.111]***	[0.104]***
Less than High School	-1.831	-1.986	-0.228	-0.273	0.478	0.558	-0.03	0.067
	[0.395]***	[0.400]***	[0.120]*	[0.135]**	[0.284]*	[0.280]**	[0.264]	[0.276]
High School	-2.178	-2.276	-0.243	-0.269	0.141	0.176	0.404	0.469
	[0.532]***	[0.521]***	[0.084]***	[0.094]***	[0.282]	[0.298]	[0.266]	[0.283]*
Some College	-1.423	-1.459	-0.22	-0.228	0.083	0.122	0.303	0.321
	[0.278]***	[0.270]***	[0.059]***	[0.060]***	[0.198]	[0.197]	[0.295]	[0.286]
Stage--Asymptomatic	-0.805	-0.785	-0.101	-0.094	--	--	0.482	0.483
	[0.572]	[0.574]	[0.130]	[0.126]	--	--	[0.234]**	[0.236]**
Stage--Symptomatic	0.313	0.314	0.089	0.091	0.272	0.248	0.302	0.287
	[0.189]	[0.189]	[0.059]	[0.060]	[0.167]	[0.173]	[0.110]***	[0.106]***

Robust standard errors in brackets

** significant at 10%; ** significant at 5%; *** significant at 1%*

Table 5: The effect of the stringency of HIV law on risky behavior with state-specific controls

	Number of partners		Frequency Unsafe Sex		Sex with Prostitutes		Never Disclosed HIV+	
Strict Law	**-1.12**		**-0.243**		**-0.155**		**0.413**	
	[0.322]***		[0.081]***		[0.221]		[0.135]***	
Log of prosecutions		**-0.833**		**-0.197**		**0.019**		**0.276**
		[0.203]***		[0.055]***		[0.151]		[0.132]**
Age	-0.074	-0.076	-0.031	-0.031	0.011	0.013	0.004	0.005
	[0.009]***	[0.009]***	[0.002]***	[0.002]***	[0.010]	[0.009]	[0.007]	[0.007]
Female	-1.28	-1.274	-0.242	-0.238	0.134	0.116	-0.31	-0.307
	[0.278]***	[0.281]***	[0.075]***	[0.075]***	[0.254]	[0.256]	[0.186]*	[0.188]
Non-White	-0.261	-0.261	0.005	0.004	-0.218	-0.203	0.265	0.266
	[0.166]	[0.159]	[0.037]	[0.037]	[0.189]	[0.190]	[0.113]**	[0.113]**
Less than High School	-1.744	-1.798	-0.202	-0.213	0.595	0.597	-0.066	-0.038
	[0.378]***	[0.377]***	[0.124]	[0.122]*	[0.250]**	[0.254]**	[0.250]	[0.259]
High School	-2.125	-2.154	-0.214	-0.217	0.05	0.033	0.377	0.39
	[0.531]***	[0.532]***	[0.087]**	[0.086]**	[0.299]	[0.307]	[0.262]	[0.268]
Some College	-1.391	-1.407	-0.204	-0.209	0.029	0.056	0.305	0.315
	[0.275]***	[0.279]***	[0.065]***	[0.065]***	[0.222]	[0.224]	[0.282]	[0.285]
Stage--Asymptomatic	-0.86	-0.836	-0.081	-0.075	--	--	0.468	0.462
	[0.564]	[0.570]	[0.118]	[0.116]	--	--	[0.228]**	[0.232]**
Stage--Symptomatic	0.28	0.269	0.093	0.09	0.267	0.267	0.29	0.286
	[0.188]	[0.189]	[0.056]*	[0.056]	[0.152]	[0.152]	[0.108]***	[0.108]***
Abortion Rate	0.034	0.044	0.014	0.017	-0.008	-0.012	0.007	0.007
	[0.021]	[0.019]**	[0.005]***	[0.004]***	[0.016]	[0.016]	[0.008]	[0.010]
% College Educated	5.595	-1.805	4.027	2.437	-3.363	-4.701	3.394	6.537
	[9.213]	[9.559]	[1.663]**	[1.474]*	[5.065]	[3.960]	[2.993]	[2.444]***
Religiosity -- Prayer Frequency	-1.192	-9.183	-2.185	-4.008	3.446	3.016	3.748	6.608
	[3.599]	[3.220]***	[1.075]**	[0.973]***	[2.714]	[2.627]	[1.531]**	[1.586]***
Teen Birth Rate	0.003	0.02	-0.002	0.002	0.01	0.011	-0.006	-0.012
	[0.022]	[0.023]	[0.005]	[0.005]	[0.009]	[0.010]	[0.007]	[0.007]*
% in Urban Areas	-0.045	-0.095	-0.021	-0.034	-0.029	-0.021	0.012	0.026
	[0.028]	[0.037]**	[0.008]***	[0.008]***	[0.018]	[0.026]	[0.016]	[0.028]

Robust standard errors in brackets

** significant at 10%; ** significant at 5%; *** significant at 1%*

Table 6: Parameters for ordinary partners

	Base Scenario	**Partial Effect**	**Full Effect**
Number of partners: *N*	**5.960**	**5.550**	**5.550**
Number of prostitute partners: N^{prost}	2	2	2
Probability of having one prostitute partner p_{prost}	**0.760**	**0.760**	**0.828**
Probability of unsafe sex p_{unsafe}	**0.470**	**0.426**	**0.426**
Probability prostitute partner is HIV- $p_{neg,p}$	0.95	0.95	0.95
Probability ordinary partner is HIV- at time 0: $p^{t}_{neg,o}$	0.449	0.449	0.449
Risk of infection per contact *i*	0.006	0.006	0.006
Number of contacts per partner *C*	6	6	6
Expected number of prostitutes infected n_{op} at time 0	0.0243	0.0220	0.0240
Expected Number of ordinary Part Infected n_{oo} at time 0	0.0336	0.0276	0.0267

Table 7: Parameters for prostitutes

	All Scenarios
Number of partners: N^P	40
Probability of unsafe sex p_{unsafe}	0.250
Probability client partner is HIV- at time 0 $p^t{}_{neg,c}$	0.994
Risk of infection per contact *i*	0.998
Number of contacts per partner *C*	3
Expected Number of ordinary Part Infected at time 0 n_{oo}	0.180

8 Appendix

1. Conditions for the Hessian Matrix to be negative definite

For the objective function $G(c,d) = V(\delta_i, c, d) - \rho P(reported)\Pi$ to be concave in c and d we need the Hessian matrix of G to be negative definite. We have:

$$\frac{\partial^2 G}{\partial c^2} = \frac{\partial^2 V}{\partial c^2} - \Pi\rho\frac{\partial^2 P(reported)}{\partial c^2}.$$

$$\frac{\partial^2 G}{\partial d\partial c} = \frac{\partial^2 V}{\partial c\partial d} - \Pi\rho\frac{\partial^2 P(reported)}{\partial c\partial d} = 0$$ since by assumption $\frac{\partial^2 V}{\partial c\partial d} = 0$ and $\frac{\partial^2 P(reported)}{\partial c\partial d} = 0$.

$$\frac{\partial^2 G}{\partial c^2}\frac{\partial^2 G}{\partial d^2} - \left(\frac{\partial^2 G}{\partial d\partial c}\right)^2 = \left[\frac{\partial^2 V}{\partial c^2} - \Pi\rho\frac{\partial^2 P(reported)}{\partial c^2}\right]\left[\frac{\partial^2 V}{\partial d^2} - \Pi\rho\frac{\partial^2 P(reported)}{\partial d^2}\right]$$

So the Hessian matrix of G is negative definite if and only if $\frac{\partial^2 V}{\partial c^2} - \Pi\rho\frac{\partial^2 P(reported)}{\partial c^2} < 0$ and $\frac{\partial^2 V}{\partial d^2} - \Pi\rho\frac{\partial^2 P(reported)}{\partial d^2} < 0$. This ensures that $\frac{\partial^2 G}{\partial c^2} < 0$ and $\frac{\partial^2 G}{\partial c^2}\frac{\partial^2 G}{\partial d^2} - \left(\frac{\partial^2 G}{\partial d\partial c}\right)^2 > 0$.

2. Proof of Propositions 1 and 2

The first-order condition (3) is given by $f(c^*, \rho) = \left(\frac{\partial V(c^*, d^*, \delta)}{\partial c} - \Pi\rho\frac{\partial P(reported)^*}{\partial c}\right) = 0.$

Note that $f(c,\rho)$ is decreasing in c by condition 1'. When ρ increases to ρ^{**}, $f(c^*, \rho^{**})$ becomes negative since $\frac{\partial P(reported)}{\partial c} > 0$ and the cross-derivatives of V and $P(reported)$ are equal to zero (so the effect of a change in ρ on d does not affect the levels of $\frac{\partial V}{\partial c}$ and $\frac{\partial P(reported)}{\partial c}$). Therefore c will decrease to c^{**} in order to have the new first-order condition $f(c^{**}, \rho^*) = 0$ holding. As the stringency of the law increases, the HIV+ person will practice safer sex

The proof of proposition 2 follows a similar logic.

3. Proof of Proposition 4

Let $\delta_1(\rho)$ be the exclusivity level such that equation (5) holds with equality for a given ρ. Using the implicit function theorem we have that:

$$\frac{\partial \delta_1}{\partial \rho} = \frac{P(reported)^* \Pi}{\left. \frac{\partial V(c^*, d^*, \delta_1)}{\partial \delta} - \rho \Pi \frac{\partial P(reported)^*}{\partial \delta} \right|_{\delta=\delta_1}} . \tag{14}$$

We consider two cases in which proposition 4 holds:

- Case 1: For all $\rho \in [0,1]$ and all $\delta \in [\underline{\delta}, \overline{\delta}]$, $\left. \frac{\partial V}{\partial \delta} - \rho \Pi \frac{\partial P(reported)}{\partial \delta} \right|_{\delta=\delta_1} < 0$

Under this condition, the expected utility of the HIV+ agent is decreasing with the exclusivity level of the partner. Looking at equation (5), we see that her decision rule for a given ρ is to propose sex to all partners with exclusivity levels $\delta \le \delta_1(\rho)$. Equation (9) clearly shows that under this condition $\frac{\partial \delta_1}{\partial \rho} < 0.$ So increasing the stringency of the law decreases the thresholds of exclusivity level below which the HIV+ agent proposes sex, i.e. increasing the stringency of the law would increase the promiscuity of partners to whom the HIV+ person proposes.

- Case 2: there exists a $\overline{\rho} \in [0,1]$ such that for all $\overline{\rho} \ge \rho$ and all $\delta \in [\underline{\delta}, \overline{\delta}]$

  $\left. \frac{\partial V}{\partial \delta} - \rho \Pi \frac{\partial P(reported)}{\partial \delta} \right|_{\delta=\delta_1} < 0$.

Since the marginal cost with respect to exclusivity of the partner is increasing in the stringency of the law while the marginal benefit is not, we can have a situation in which the expected utility of the HIV+ agent is increasing with the exclusivity level of the partner at low level of stringency and then decreasing at higher level of stringency. If the initial value of the stringency of the law is larger than $\overline{\rho}$, we are back to a case similar to the one described in case 1: increasing the stringency of the law would increase the promiscuity of partners to whom the HIV+ person proposes.

In other cases, we could on the contrary have that an increase in the stringency of law reduces the promiscuity levels of partners. For example, if we had that for all $\rho \in [0,1]$ and all $\delta \in [\underline{\delta}, \overline{\delta}]$, $\left. \frac{\partial V}{\partial \delta} - \rho \Pi \frac{\partial P(reported)}{\partial \delta} \right|_{\delta=\delta_1} > 0$, then the decision rule of the agent would be to propose sex to all partners with exclusivity levels $\delta > \delta_1(\rho)$. And in this case, we would have

$\frac{\partial \delta_1}{\partial \rho} > 0$. So increasing the stringency of the law increases the thresholds of exclusivity level above which the HIV+ agent proposes sex.