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A Thoretical and Empirical Investigation of Public Health Subsidies for STD Testing

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A THEORETICAL AND EMPIRICAL INVESTIGATION OF THE EFFECTS OF PUBLIC HEALTH SUBSIDIES FOR STD TESTING*

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The paper investigates, both theoretically and empirically, the private demand for STD testing and for protection against infection with emphasis on testing for the AIDS virus (HIV) and on the effects of public subsidies for such testing on the incidence of sexually transmitted diseases We discuss the theoretical conditions under which subsidizing testing either increases or decreases disease incidence and provide evidence on the empirical significance of those conditions

I INTRODUCTION

Despite the magnitude of the AIDS epidemic and its significance for public policy, economists have paid little attention to the causes and consequences of its growth and the effect of alternative policies on that growth[1] or on sexually transmitted diseases generally One of the keystones of AIDS prevention strategy in the United States and abroad is the encouragement through subsidization and otherwise of testing for the presence of the human immunodeficiency virus (HIV), which causes AIDS [2] Virtually all public institutions with fiscal authority that have responded to the epidemic have included HIV testing in their prevention efforts Since the licensing of the HIV antibody test in 1985, the number of persons taking publicly provided tests in the United States has increased from 79,000 in the first year to 1 3 million in 1990 When private testing is included, it is estimated that by 1992 15 percent

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1 Bloom and Glied [1991], Posner [1992], and Philipson [1993] discuss some economic aspects of AIDS, but, apart from Bloom and Glied's very brief discussion of potential social benefits of HIV testing [Bloom and Glied 1991, p 1802], they are not the aspects that interest us in this paper Philipson and Posner [1993] is a comprehensive analysis of analytical and policy issues related to this paper, but Sections III, IV, and V of the present paper have no counterpart in the more qualitative discussion of the book

2 The testing is prior to the counseling The purpose of the counseling is to help people who test positive to deal with their situation

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of the U S population had been tested, with the fraction steadily increasing over time, holding age constant [National Center for Health Statistics 1992]

This paper asks what determines the demand for testing against sexually transmitted diseases (STDs) generally and for HIV testing in particular, and what effect public subsidies have on this demand, as well as on the incidence of the diseases themselves Answering these questions is important for several related reasons First, a sensible decision on allocating resources to alternative interventions to prevent the growth of STDs (the most dangerous of which today is AIDS), of which HIV testing is only one,[3] depends on an understanding of their relative effectiveness Second, an understanding of the private demand for testing can shed light on behavioral responses to disease-control policies in general This is important because of ethical constraints on experimental evaluation of preventive disease programs Third, understanding the effects of voluntary HIV testing is important for evaluating the benefits and costs of one of the most controversial proposals for controlling AIDS, *mandatory* HIV testing

Section II sets forth a model of individual choice of sexual consumption under conditions of uncertainty concerning HIV infection status [4] We interpret unprotected, and hence potentially infective, sex between two individuals as an economic trade in the sense of being, ex ante, a mutually beneficial activity to the parties involved whether monetary transfers are made or not We argue that the market for sexual trades has many features similar to other economic markets and that the problem of AIDS can be viewed as a problem of market participants' uncertainty concerning the quality of the services exchanged Persons who are infected with the AIDS virus may be asymptomatic for many years, so that their infection status is not apparent to a potential sexual partner In a market having these characteristics, HIV testing is a device by which traders can learn about quality The main beneficiary of the test is therefore not the person testing, but rather his potential partner This pattern has parallels in conventional markets, where, for example, a seller might undertake to test his product for the benefit of the consumer We are primarily interested in the

3 An alternative, examined in Philipson and Posner [1992], is public education in how to avoid becoming infected by HIV

4 We recognize of course that AIDS is not transmitted solely by sexual intercourse However, that is the major path of transmission, and much of our analysis is applicable to the second most common path as well— the sharing of needles by intravenous drug users

implications of such quality assurance for the volume of sexual trade and hence for the incidence of sexually transmitted diseases that are spread by trade between persons of different infection status (positive to negative) Our type of market-oriented analysis, in which infections are interpreted as a by-product of mutually beneficial ex ante activities, is missing from the extensive epidemiological literature on AIDS and other STDs (see Coyle, Boruch, and Turner [1991], Crisp [1989], Fox et al [1987], Higgins et al [1991], Lyter et al [1987], and Tauer [1989])

Section III discusses the implications of our analysis for the demand for testing under several hypotheses regarding the determinants of that demand Our first benchmark alternative concerns the demand for testing of individuals who are motivated to seek treatment if infected, as is common in the case of curable STDs, such as syphilis Screening for disease helps such individuals detect infection earlier and thereby get treatment earlier, when it may be more effective than if they wait until the disease becomes symptomatic No effect of testing or screening on *secondary* infections, i e , those generated by the tested individual, is assumed under the treatment-induced explanation for test demand, although presumably the earlier an infected person is cured, the fewer other people he will infect Second, we consider alternative hypotheses regarding the demand of the respective sexual partners, who are considering tests as quality verifications, for sexual trades in the absence of testing [5] Here the most important point is that subsidizing testing, whether inframarginally, by making it available, or marginally, by cutting its price, may decrease or increase the incidence of an STD depending on the nature of the sexual trade (i e , protected or unprotected) demanded in the absence of testing Since new infections are due to the volume of trade between individuals of different infection status, the effect of testing on the incidence of an STD comes about through its effect on this volume The type of trade that occurs in the absence of testing is therefore central to the effects of testing on incidence We show that if the pretesting status quo is safe sex, testing is likely to increase the incidence of the STD if only one partner tests, while if the pretesting status quo is risky sex, testing is likely to reduce incidence We also analyze the case in which transfers are possible between partners to induce a previously unwilling partner either to alter his choice between

5 This is a particularly important extension of the analysis of HIV testing in our book [Philipson and Posner 1993], along with the empirical analyses (Section IV) and the more comprehensive analysis of testing demand

safe and risky sex, or to test, as in "test trading," where a test by one party is exchanged for a test by the other.

Section IV reports the results of an empirical investigation of the alternative motives for testing, utilizing an unusually detailed data set concerning sexual behavior, HIV testing, and the HIV infection status of both heterosexual and homosexual residents of San Francisco in 1988–1989. After correction for other measurable factors determining the demand for condoms (a principal method of safe sex), our evidence suggests that, compared with the no-testing case, a negative test result does *not* increase the propensity to engage in safe sex, although a positive test result does. We argue that such a finding is inconsistent with the epidemiological benchmark model of test demand, but cannot distinguish well between the alternative hypotheses (that testing increases or decreases disease incidence). We also analyze how the demand for testing is related to infection risk. We find suggestive evidence that the demand is positively related to the probability of infection of the tester and negatively related to the same probability of the partner and discuss the disease implications of such demand. Our evidence also suggests that test trading (in which one sexual partner agrees to test in return for the other's doing so) does take place.

An important assumption of our analysis is that each party to a sexual encounter knows as much or as little about the other's infection status as the other does, i.e., that there is no private information. This assumption is relaxed in Section V, which briefly discusses extensions of and future research areas suggested by our analysis. In particular, we discuss the important issues of altruism and quality signaling in sexual markets with STD risk, as well as the likely effects of mandatory testing.

II. THE INCIDENCE OF THE DISEASE WITHOUT TESTING

Suppose that two individuals, throughout labeled a man and a woman for ease of exposition only,[6] are considering whether to engage in a risky but (ex ante) mutually beneficial sexual trade. The subjective belief of both individuals that the man or the woman is infected we denote by $p = (p_m, p_w)$. We assume that the probable infection status of potential sexual partners is inferred

6. In the United States and other developed countries, intercourse between men is in fact the major method of sexual transmission of the disease.

from information concerning their objective characteristics such as whether the potential partner is homosexual or bisexual, promiscuous, an injecting user of illegal drugs, etc. We also assume that each partner has the same information about his own and the other's likelihood of already being infected. Although the assumption is not completely plausible, people often do have a lot of information about their potential partners, and it is worthwhile to consider the simple case before going on to examine the more complicated case of asymmetric information (which we discuss briefly in Section V). That case is more complicated because then an individual's decision whether or not to test may convey to his potential sexual partners information that the latter would otherwise not have about the individual's subjective probability of being infected. The complication can be avoided, and our analysis hold up without the strong assumption of no private information, if we assume merely that the decision whether or not to test does not convey information to one's sexual partners about one's likelihood of being infected. This assumption is plausible if testing is highly costly for some people regardless of probable infection, perhaps because of stigma or other psychic costs, in which event the decision whether or not to test would convey little or no information about the individual's infection status. The relatively low fraction of the population that has been tested is consistent with this assumption.

If our two hypothetical individuals engage in a safe, i.e., nontransmittive, sexual activity, they are assumed to get expected utility (which we normalize to zero for simplicity).[7] If they engage in a risky sexual activity, that is, an activity capable of transmitting the AIDS virus or some other STD, they are assumed to get expected utilities denoted, respectively, by $u_m(p)$ and $u_w(p)$. Examples of such utility functions are $u_m(p) = B - C(1 - p_m)p_w$ and $u_w(p) = B - C(1 - p_w)p_m$, where the net benefit of risky sexual consumption over safe consumption is denoted by B and assumed to be greater than zero. As a result, risky consumption is always preferred to safe when there is no danger of infection. Casual empiricism supports this assumption, since even zero prices (e.g., the availability of free condoms on college campuses) do not lead to complete avoidance of risky sex.[8] Finally, the expected cost of risky

7 Examples of safe sex are mutual masturbation and intercourse with condoms. They are not perfectly safe, but this qualification is not important to our analysis. The assumption of zero expected utility from safe sex serves simply to normalize the analysis of risky sex by making the utility of risky sex a net figure (net of the utility of safe sex).

8 Recall, though, that sex with condoms is not completely safe.

sexual consumption is the probability of becoming infected times the cost of infection (C).

We make two weak assumptions concerning the expected utility from risky sex. The first is that the expected utility from risky sex of an individual is increasing in his or her own probability of infection:

$$\frac{du_m}{dp_m}, \frac{du_w}{dp_w} \geq 0. \tag{1}$$

This occurs in the illustrative utility function above and generally because as the probability that m is already infected rises, the probability of his becoming infected as a result of engaging in unprotected sex falls. The second assumption is that no potentially uninfected individual will engage in risky sex with an individual known to be infected:

$$u_m(p_m,1),\ u_w(1,p_w) \leq 0. \tag{2}$$

Figure I maps out the induced joint demand for sexual consumption for all possible infection probabilities p of the two individuals. The line L_m maps the probabilities of infection that make the male indifferent between safe and risky sex: $L_m = \{p: u_m(p) = 0\}$. If the probability that the female is already infected is above the line, the male prefers safe sex; if below, he prefers risky sex. For example, a man who knows that he is not infected will be willing to engage in risky sex as long as the female's probability of already being infected is below A. L_w is the corresponding line for the reservation probabilities of the female.

A risky trade is assumed to take place only when it is mutually beneficial, so if $Y(p) = 0$ denotes the state in which such a trade takes place and $Y(p) = 1$ denotes the state in which safe sex is substituted,

$$Y = 0 \text{ iff } u_m(p) > 0 \text{ and } u_w(p) > 0. \tag{3}$$

In Figure I a risky trade will take place only if either both individuals are infected or highly likely to be so, in which case there is little or no value in safe sex, or both are very likely *not* to be infected, in which case there is little danger of infection and, therefore, again little value in safe sex. The shaded regions denote these two sets of individuals, and the nonshaded regions denote individuals who are not in the market because they cannot find partners willing to have risky sex with them.

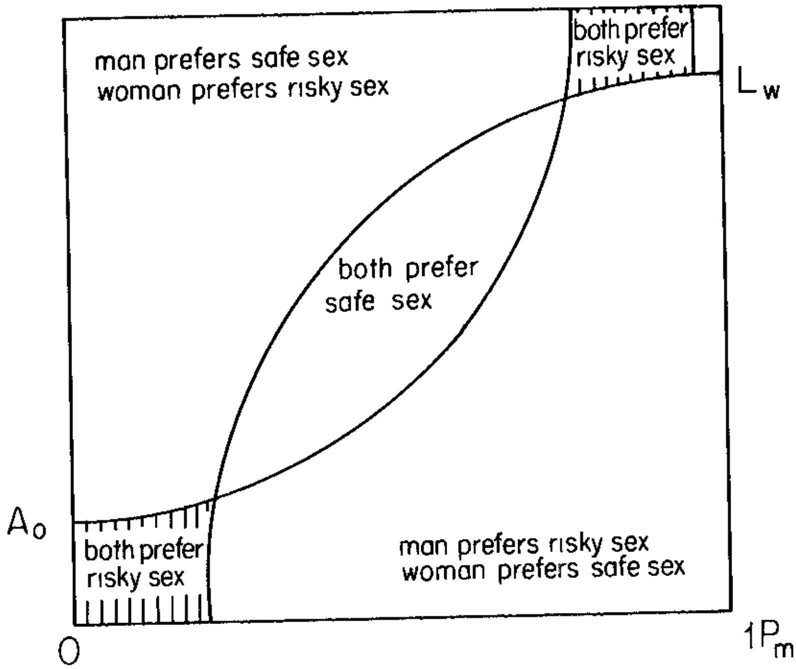

FIGURE I

Let the distribution function $F(p)$ represent the fraction of male-female pairs in the population who are in risk classes lower than $p = (p_m, p_w)$.[9] Since new infections are due to unprotected trades between individuals of different infection status, the new number of infections, i.e., the incidence of the disease, is given by

$$(4) \quad I = \int [1 - Y(p)]z[(1 - p_m)p_w + (1 - p_w)p_m]dF \equiv \int [1 - Y(p)]C(p)dF,$$

where $C(p) \equiv z[(1 - p_m)p_w + (1 - p_w)p_m]$ is shorthand for the incidence level, conditional on transmittive activity, at different risk levels. The first term on the right-hand side is the incidence among males, the second among females, both discounted by the fraction z of trades between individuals of different infection status that results in infection.

9. This is a very general matching distribution. We briefly consider assortative matching in Section V.

III THE EFFECTS OF TESTING ON DISEASE INCIDENCE

Testing for HIV or some other STD corresponds to quality verification in a model of trade under uncertainty as to quality This section analyzes the effects of such quality verification under different assumptions concerning the demand for sexual consumption in the absence of testing For each case we consider implications for the demand for testing, D, the demand for protection against the risk of infection, Y, and the incidence, I We assume that all couples face the same price q of testing, so that the analysis in Section II may be interpreted as the special case when q is prohibitively high When necessary, we will distinguish the inframarginal effects of subsidizing testing, reducing q from infinity to a finite level low enough for at least some demand to exist, from the marginal subsidy effects of reducing q by a dollar from a given level Before trading with a partner, an individual can take a test to determine his own infection status We assume that potential sexual partners of the tested individual observe his test result (T) This assumption may seem unrealistic given the elaborate efforts that are made to maintain the confidentiality of the results of voluntary HIV tests But it is difficult as a practical matter for one partner to conceal from the other the shocking news that he or she has tested positive for a fatal disease Finally, for a couple of risk level p, we generally express the benefit of testing to the individual(s) incurring the costs of the tests by $B(p)$

Let c denote the unobservable costs of testing distributed according to G The demand for testing the male m is then determined by the condition $B(p) \geq q + c$ Hence the fraction of couples in which m tests positive (i), negative (n), or goes untested (u), respectively, is given by

$$P(T = i \mid p,q) = p_m G(B(p) - q) \tag{5a}$$

$$P(T = n \mid p,q) = (1 - p_m) G(B(p) - q) \tag{5b}$$

$$P(T = u \mid p,q) = 1 - G(B(p) - q) \tag{5c}$$

If the demand for testing of the male is denoted by D_m, the total number of positive and negative tests is $P(D_m = 1 \mid p,q) = P(T = i \mid p,q) + P(T = n \mid p,q)$ The resulting disease incidence is

$$I = \sum P(T = t \mid p,q) P(Y = 0 \mid t,p,q) C(p) dF, \tag{6}$$

where $P(Y = 0 \mid t,p,q)$ is the demand for risky sex conditional on the test result $T = t$ Differences in the preferences of the partners regarding the nature of the sexual trade in the absence of testing (the pretesting status quo), as well as transfer possibilities between partners, affect the benefit of testing ($B(p)$) differently, and we therefore analyze them separately

III A Demand Induced by Desire for Treatment

We will compare our results with an alternative approach, common in epidemiological studies, in which the only private, as opposed to public, demand for disease testing comes from individuals who plan to seek treatment if they discover they are infected Screening for disease helps individuals detect their infection status earlier and thereby get treatment earlier than otherwise The a priori effect of treatment-motivated testing is uncertain If treatment is curative, making the treated individual no longer infected and therefore no longer infective, testing is likely to slow the spread of the disease In the case of HIV-AIDS, however, where treatment (as with AZT) is not curative and may actually prolong the infective potential of the treated individual by prolonging his life, the opposite effect on incidence is possible (see Anderson and May [1991]) The treatment-induced testing model therefore is test-neutral with respect to secondary infections, implying that

$$P(Y = 1 | t, p, q) \tag{7}$$

is constant across (t,p,q) In other words, HIV testing is assumed to have no effect on risky versus safe sex and therefore no effect on incidence A more subtle implication of the model is that the demand for testing should not be influenced by any characteristics of the nontested individual, since the demand is generated exclusively by the tested individual's treatment desires

III B Safe Sex Pretesting Status Quo

The first economic model we develop is for the case where the pretesting status quo, that is, the sexual trade that would occur if testing were unavailable (infinitely costly), is safe sex (or no sex) Let $V_m(p)$ and $V_w(p)$ denote the indirect utility functions (i e , the levels of utility induced by mutually beneficial trade choices) of m's and w's for a given pair of infection probabilities of the two groups Assuming that testing is errorless, so that a test amounts to learning without error whether one's infection status is positive

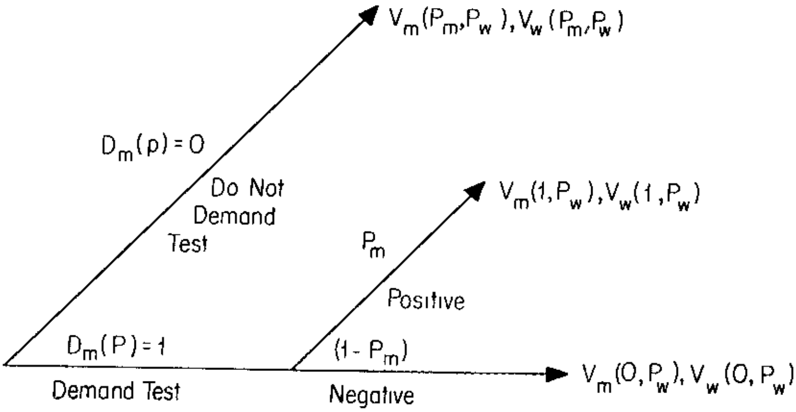

FIGURE II

or negative,[10] the benefit to m of testing is given by

(8) $$B(p) = p_m V_m(1,p_w) + (1 - p_m)V_m(0,p_w) - V_m(p_m,p_w)$$

In words, m will decide to test if the indirect expected utility of the trades resulting from testing, either those that occur when testing positive, $p_m = 1$ (so that $V_m(1,p_w) = 0$ and therefore there are no trades), or those that occur when testing negative, $p_m = 0(V_m(0,p_w) = \max\{0,u_m(p)\})$, is higher than the expected utility of not testing $(V_m(p_m,p_w))$ The demand of m for testing is shown graphically in Figure II In the special case when testing costs $q + c$ are negligible relative to the benefits of testing, the demand is increasing in m's probability of being infected but is decreasing in his partners' probability of being infected More precisely, if $q + c = 0$, then $D_m(p_m,p_w)$ is an increasing step function It is zero below a given threshold probability for which the female allows trade without testing and one thereafter, assuming that at the extreme infection probability $p_m = 1$ the male still tests although he is indifferent to whether or not to test since he knows the result Aggregating up over the different thresholds induced by different partners implies

10 Existing HIV tests are not error-free, but the error rates are low False positives are especially rare, because it is routine to retest anyone who has tested positive The existence of some errors would not affect our analysis critically A more serious problem is that infection with HIV often does not show up in the test for six months Hence a negative test result shows only that as of six months earlier the person tested was free of the virus He may have become infected since This reduces but does not eliminate the value of partner-observed HIV testing in revealing the riskiness of unprotected sex with the person tested

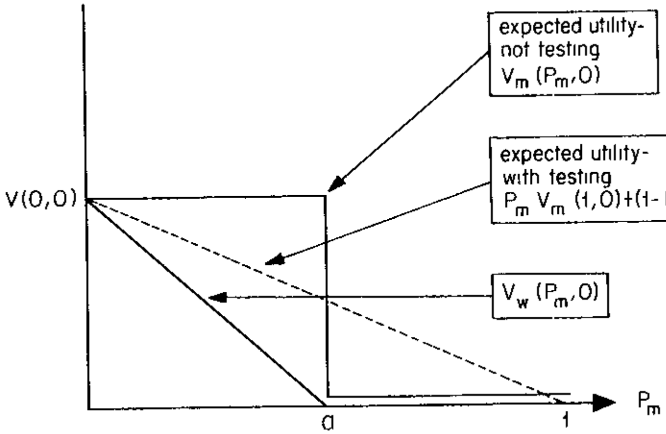

FIGURE IIIa

that the test demand as a function of the infection probability of the male alone $D_m(p_m)$ is still increasing [11] The reason is that the higher the individual's probability of being infected, the harder it is for him to obtain a risky sexual trade without being tested, but the higher his prospective partner's probability of being infected, the less likely she is to demand that he test as a condition of her consenting to a risky trade We illustrate this in Figures IIIa–c

Figure IIIa, which depicts the case where w believes she has no risk of being infected and which thus corresponds to the bottom part of Figure I, shows the expected utilities of the two individuals as a function of the probability that m is infected The steep line is the expected utility of w The dotted line indicates the expected utility to m of testing, and the solid line the expected utility to him of not testing The male who tests engages in a lottery of unprotected sex if he tests negative, or in protected sex if he tests positive If he does not test, he obtains unprotected or protected sex depending on whether his partner wants protection In the case in which m has a low probability of being infected, trade occurs without testing because w is willing to take her chances on m not being infected so there is no gain to m from testing In the case in which trade will not occur without testing, the gains from testing are the gain to m of obtaining trade In short, the private value of

11 This follows from the fact that a convex combination of increasing functions is increasing

the information yielded by the test is generated by the trades that a negative test enables m to obtain

Figure IIIa implies that all m's in region A in Figure IIIb will demand a test and that no m's in region B will demand it. Consider a pair of individuals faced with the risk levels indicated by point a. If m tests negative, this corresponds to a vertical movement to a_0, yielding a desired trade. If he tests positive, he moves to a_1 resulting in no trade. Since the indirect utility of the shaded regions is higher than that of the nonshaded regions, testing is demanded over no trade.

Figure IIIc is the same as Figure I except that instead of depicting the demand for sexual consumption, it depicts the induced demand for testing of individuals in different risk classes. The figure illustrates that as long as trading will take place without testing, there will be no demand for testing. The demand for

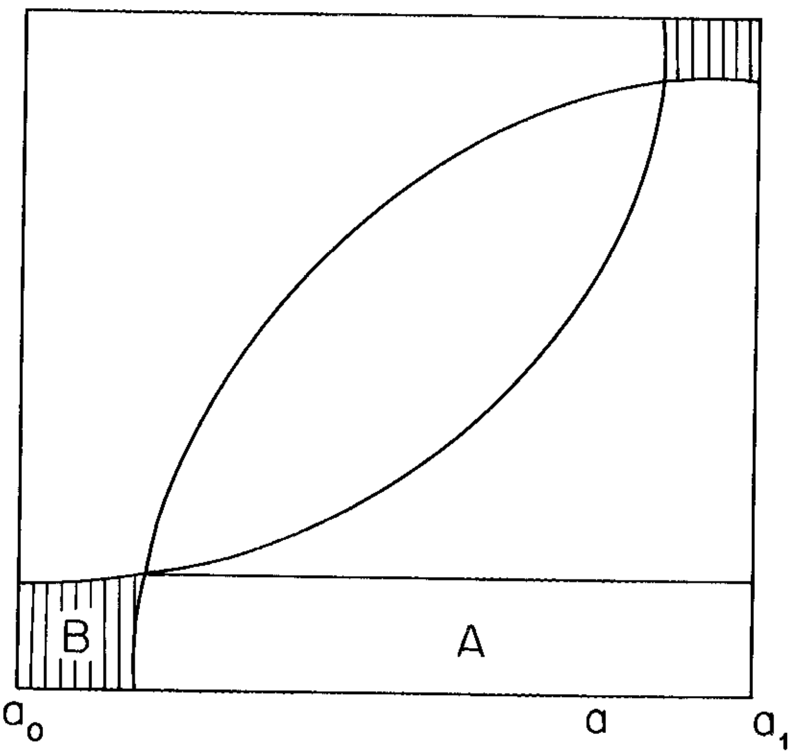

FIGURE IIIb

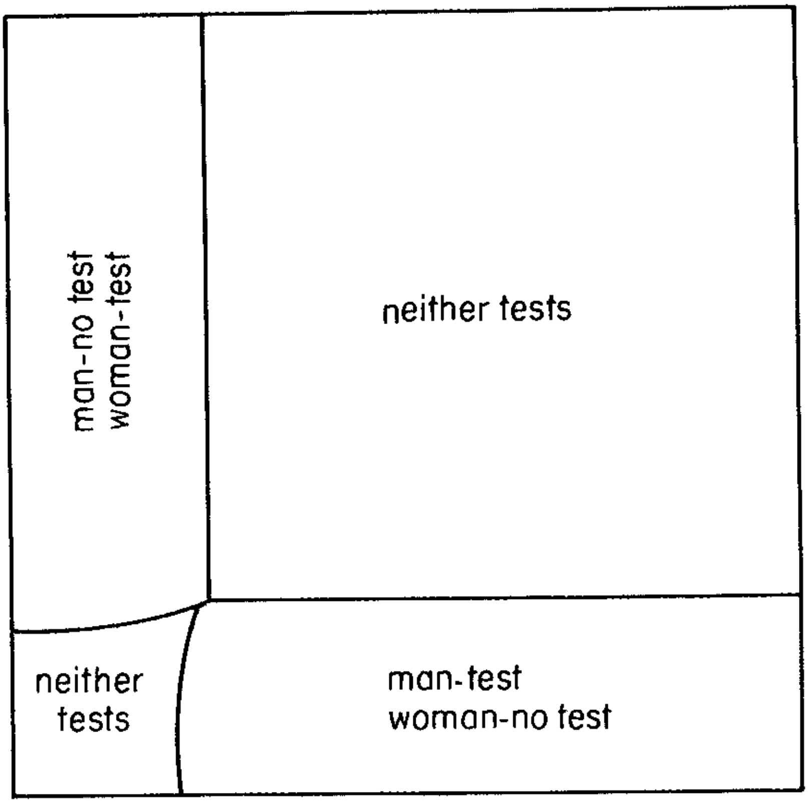

FIGURE IIIc

testing results from the desire to obtain trades when one's risk level is too high to get trades without testing. An individual who prefers and can obtain risky sex has no incentive to test.

These illustrations apply only when the costs of testing are negligible relative to its trade benefits, e.g., when $q + c$ is close to zero. In the more general case, that of costly testing, the effect of the infection probability of the tester on test demand is nonmonotonic. For low levels of infection probability, there is still no demand. For middle levels there may be, but for higher levels there may be no demand as well because the cost of the test may outweigh the expected trade benefit of testing negative, since the test is quite likely to yield a positive result, which under our assumptions confers no benefit on the tester. It is also interesting to note that the infection probability of the female interacts negatively with the male demand for testing. This is because for high levels of female infection probability the male does not test, because he himself would not want to trade even if he tested negative.

The demand for protection under the assumption of a safe sex pretesting status quo trade is determined as follows. Since some individuals (w's in our presentation) may demand protection in the absence of testing, but there is no demand for protection if testing occurs and is negative, it follows that

$$(9) \qquad P(Y = 1|n,p,q) \leq P(Y = 1|u,p,q) \leq P(Y = 1|i,p,q).$$

In words, the demand for condoms (illustrative of protection against STD transmission) is greatest when testing positive, smallest when testing negative, and in between when not testing at all. In the case in which the costs of the tests are relatively small compared with the benefits, e.g., when $u + q = 0$, the left-hand inequality becomes an equality: there is no demand for protection conditional on not testing. The left-hand inequality may also be close to equality if there is a small fraction of very high risk potential test demanders, who are the ones who would demand protection in the absence of testing.

In this case, the disease incidence can be shown to be increased by test subsidies:

$$(10) \qquad q \leq q' \text{ implies that } I(q) \geq I(q').$$

This follows directly from the fact that all individuals who engage in unprotected (and hence potentially infective) activity at the high test price q also engage in risky activity at the low test price q, since the demand for testing comes from individuals who obtain risky sexual trades without tests. In this case, therefore, both the inframarginal and the marginal incidence effects of a price reduction are positive. When trade would take place without a test because both individuals are either HIV positive or believe that their risk of being positive is very low, the introduction of testing does not lead either individual to test, so the feasibility of testing makes no difference to the incidence of the disease among these groups. For persons in risk classes in which, without the test, no risky trade would occur, the motive for testing is assumed to be to obtain consent to risky sex, so testing never retards the growth of the epidemic.

To illustrate, suppose that m is willing to engage in unprotected sex with w because the probability that w is infected, while not zero, is low, but that w is afraid to engage in unprotected sex with m because m's probability of infection is high. So at w's insistence m tests, is negative, and they have unprotected sex as a result of which m now has a positive though small probability of becoming infected, versus a zero probability had they engaged in safe (or no) sex, as they would have done if testing were infeasible. The implication is not merely that subsidizing testing increases the total volume of unprotected sexual trades, but also that it does not decrease and may increase the total volume of such trades between individuals of different HIV status. This conclusion, moreover, does not depend on assuming a particular sorting of m's to w's. Specifically, it does not assume random matching or exclude the possibility of strong assortative matching, that is, of high-probability m's with high-probability w's and low-probability m's with low-probability w's, although if all matching were between either infection-free partners or infected partners, the disease would cease to grow.

III.C. The Risky-Sex Pretesting Status Quo

The implications of test subsidies for disease incidence are altered when, in the absence of testing, risky sex would occur, presumably because both partners have a low probability of already being infected. If one or both tested, and one (but not both) tested positive, safe sex would be substituted, reducing disease incidence. Because the demand of each partner that the other test is increasing in the probability that the other is infected (though decreasing in the probability that oneself is infected), testing is unlikely to be demanded in the case under consideration (i.e., when both parties are highly unlikely to be infected already) if the test is costly. So a change from testing being unavailable because $q = \infty$ to testing being available at a finite but high q may not have a substantial effect on test demand and therefore on disease incidence. A reduction in the cost of the test within the finite range may have such an effect, however, since when q is very high some transmittive trades will take place that affordable testing—q reduced to capture some demand—would avoid. The total marginal effect on incidence depends on the matching distribution $F(p)$ (see, e.g., Anderson and May [1991], Kremer [1993], or Geoffard and Philipson [1995] for the prevalence implications of matching patterns). Notice that if q is low enough (perhaps through being subsidized by the government), our assumption that the decision whether or not to test conveys no information to one's sexual partners might become untenable, for then the only plausible inference from a refusal to test would be that the refusing individual thought he would test positive (see Section V)

The difference between the safe and risky pretesting status quos can be described in terms of differences in bargaining power of the respective partners In the safe sex pretesting status quo in effect w can compel m to test only if m has a high probability of being already infected In the risky sex pretesting status quo, w can compel m to test even if his probability of being already infected is so low that she would consent to risky sex with him if testing were unavailable or very costly

The difference between the effects of testing depending on the pretesting status quo can be summarized by the help of a simple 2×2 matrix There are two possible default positions when testing is unavailable safe sex (because one or both partners fear infection) and risky sex (because both are willing to take a chance), and two basic types of testers, those who have a high probability of already being infected and those who have a low probability This produces the following matrix

(1) high prob –risky sex default	(2) high prob --safe sex default
(3) low prob –risky sex default	(4) low prob –safe sex default

Cell (1) is likely to be relative empty, because if one partner is high risk, the other will probably demand that he test Likewise cell (4) if the parties have only a low probability of infection and testing is unavailable, they are unlikely to avoid risky sex if testing is unavailable, as the benefits of safe sex are low We therefore concentrate on cells (2) and (3) In cell (2), which was analyzed in subsection III B, testing results in a greater amount of risky sex and disease incidence, because if the tester tests negative he obtains risky sex, possibly with an untested partner who may be positive In cell (3), which was analyzed in this subsection, if a low-cost test is available, one party (or both) may insist that the other tests, leading to safe sex (or no sex) if one of them tests positive

III D Sexual Transfers and Test Trades

This section analyzes the incidence effects when monetary or other transfers between sexual or needle-sharing partners are possible Such transfers are particularly relevant to AIDS transmission in the Third World, where prostitution is an important factor in the spread of the disease (see, e g , Mann et al [1992]) When such transfers are feasible, testing may decrease disease incidence, depending on the matching distribution F We discuss both the case of transfers that alter the demand for transmittive activities and transfers that alter the demand for testing

Allowing for such transfers between partners for risky sex may be specified by assuming that all gains from trade between the partners are exploited The aggregate surplus (in money metric terms) of risky sex is given by

$$a(p_m,p_w) = u_m(p_m,p_w) + u_w(p_m,p_w), \tag{11}$$

as compared with the aggregate surplus of safe sex, which is zero For this expression to be positive, so that risky trades occur, either both partners must desire such a trade or the reservation price of the partner who does not desire it must be lower than the offer price of the partner who does The effect on this surplus of increasing the risk of one party is given by

$$\frac{da}{p_m} = \frac{du_m}{p_m} + \frac{du_w}{p_m}, \tag{12}$$

and therefore may be positive as well as negative The reason is that increased risk may increase the joint value of risky sex if the decrease in utility for the female due to the increased risk is smaller than the increase in utility for the male The condition for safe sex in the absence of any testing is now

$$Y = 1 \text{ iff } a(p_m,p_w) \leq 0, \tag{13}$$

which means that risky trades occur only when either both partners so desire or the sale price of the person opposed to testing is lower than the willingness to pay of the person desiring it

When transfers are feasible, the effects of testing on the amount of risky sex and on disease incidence are ambiguous This is because, although testing may induce new trades between negatives and positives, it may also eliminate infectious trades that would occur in the absence of testing

Let $W(p_m,p_w)$ denote the analog indirect utility function under joint demand for sexual consumption given by

$$W(p_m,p_w) \equiv \max\{0,a(p_m,p_w)\} \tag{14}$$

The joint demand of both individuals for testing one individual, say the male, is then determined by the condition,

(15) $$p_m W(1,p_w) + (1 - p_m)W(0,p_w) - W(p_m,p_w) \geq q + c$$

This is the analog joint demand condition to the condition for self-interested demand for testing by the male, discussed previously But in this case, since

(16a) $$W(p_m,p_w) > 0$$

and

(16b) $$p_m W(1,p_w) + (1 - p_m)W(0,p_w) - W(p_m,p_w) \geq q + c,$$

risky sex may be demanded without a test, yet there may be a demand for testing nevertheless, depending on the matching distribution F over probabilities of infection, illustrated in Figure I In the extreme case of perfect assortative matching and perfect information, i e , when all pairs are of types $p_m = p_w = 0$ or $p_m = p_w = 1$, then testing obviously does not matter for incidence In other cases, it does If a person in the lower left-hand corner, where in the absence of testing both partners prefer risky sex, is induced to test, and tests positive, he will cease to engage in risky sex So the larger the fraction of the population in that part of the matching distribution, the more likely is testing (induced by transfers) to reduce the number of infectious trades Persons located elsewhere in the distribution who test and test negative, however, are candidates to enter the risky-sex corner, where they may become infected

Consider now transfers made to induce the test *itself,* as opposed to transfers for sexual consumption given test results One form of such transfer is test trading between partners, i e , when each partner agrees to be tested (and to reveal the results of the test to the other partner) before engaging in unprotected sex For example, test trading coupled with consumption trading is preferred to no trading at all if

(17) $$\sum p(h)W(h) - W(p) \geq 2(c + q),$$

where $h \in \{0,1\}x\{0,1\}$ denotes one of the four possible infection configurations of a couple and $p(h)$ the probabilities of their being revealed through a test trade For example, under the expected utility hypothesis we have $\Sigma p(h)a(h) = a(p)$, and hence the gross benefit of test trading is always positive when a sexual trade would occur in the absence of testing Since infective sex will never be jointly beneficial under perfect information (for we are assuming throughout that no uninfected person has risky sex voluntarily with someone known to be infected),

$$a(1,0), a(0,1) \leq 0 \tag{18}$$

Thus, test trading can only reduce, and can never increase, incidence when it occurs between such trading parties Notice also that the demand for testing is correlated within couples More precisely, $P(D_m = 1 | D_u = 1) \leq P(D_m = 1 | |D_w = 0)$ The reason that test trading must reduce incidence while unilateral testing may or may not do so is that test trading reveals the infection status of both partners If one is infected, they avoid unprotected sex If (the only other possibilities) either both are infected or neither is, unprotected sex cannot spread the disease

IV Empirical Analysis

This section empirically investigates the determinants of the demand for protection Y, as well as the demand for testing, D

IV A The Demand for Protection

The implications of our analysis of testing for the demand for risky versus safe sex can be tested empirically by regressing a measure of safe sexual behavior (such as use versus nonuse of condoms) on dummy variables for positive and negative test outcomes, respectively The coefficient of each dummy variable measures the effect on safe behavior of the outcome of the test relative to the untested population We used a data set that contains a unique level of detail on the demand for protection, as well as for testing, combined with other characteristics of respondents The San Francisco Home Health Study (SFHHS) includes measures on the sexual activity of paired individuals, as well as on each individual respondent's knowledge of his or her HIV status The population sampled for the study consisted of all persons currently unmarried, between the ages of 20 and 44, residing in San Francisco census tracts that have substantial proportions of nonwhites Between April 1988 and July 1989, a total of 1770 interviews were conducted, representing a response rate of 61 8 percent [12] We separated the data into two groups, one a smaller sample consisting of all homosexual male couples (sample size $N = 135$) and the other a larger sample consisting of all heterosexual couples ($N = 1203$)

12 Details of the study design and data are available from the authors

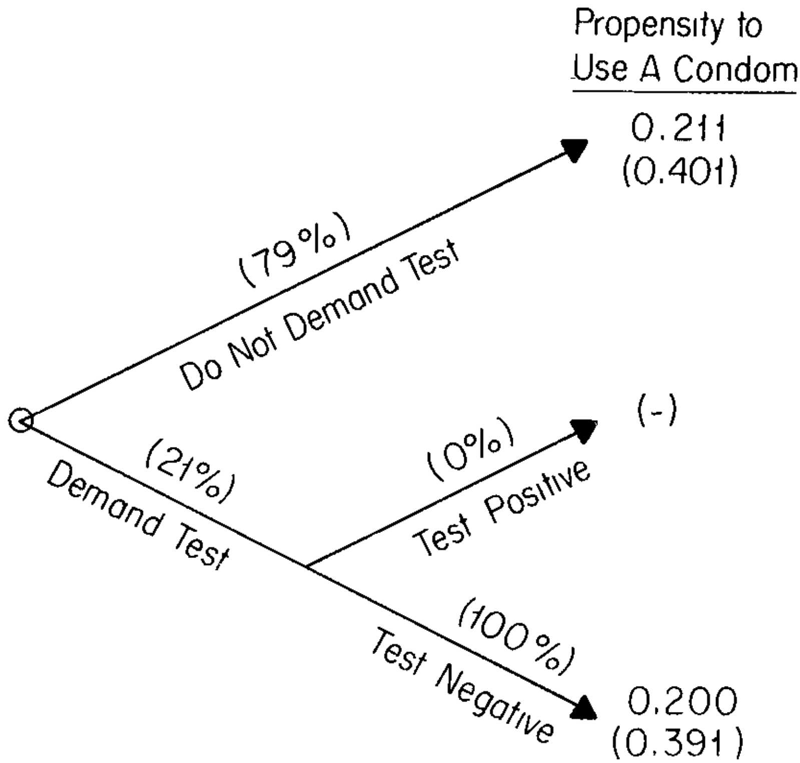

FIGURE IVa
Empirical Distributions for Heterosexual Couples (N = 1233)

Figures IVa and IVb report the unconditional propensities to test (D), to test positive or negative (p), and to use condoms (Y).[13] These figures are thus the empirical counterparts to Figure II. Notice first that the propensity to test is larger in the homosexual sample, that is, in the group which has the highest propensity, once tested, to test positive. Whereas in the heterosexual sample the propensity to test is 21 percent, and there are no positive test results, in the homosexual sample the propensity to test is 32 percent with a positive rate among those testing of 23 percent. These unconditional patterns of the data thus suggest a positive dependence between the two dichotomous variables D_m and p_m or

13. Y, our safe sex measure, is a dichotomous variable indicating condom use during vaginal intercourse for heterosexual couples and during anal intercourse for homosexual couples.

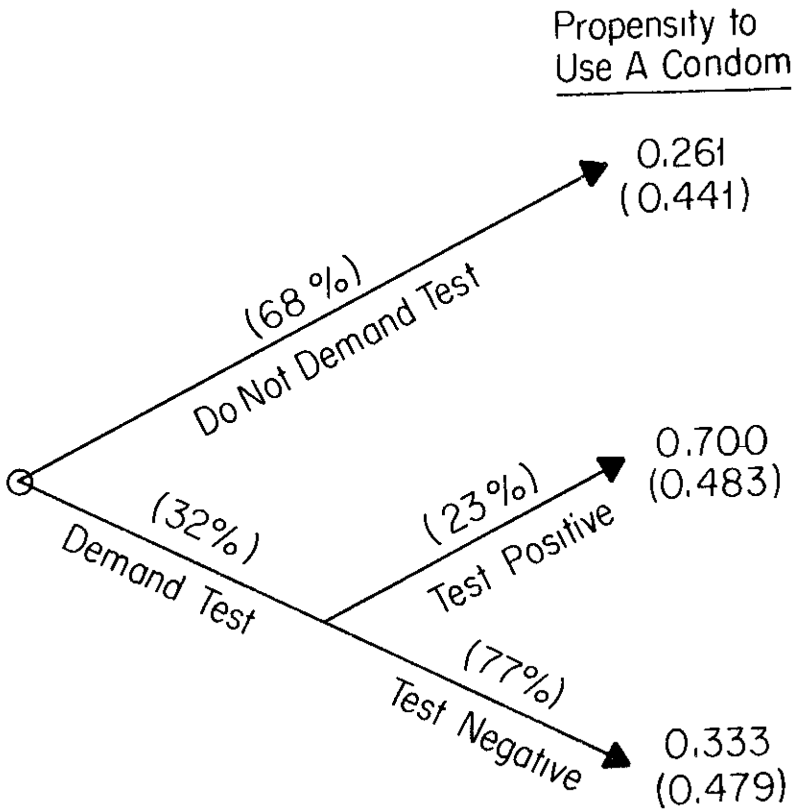

FIGURE IVb
Empirical Distribution for Homosexual Couples (N = 135)

D_w and p_u Notice also that for both the heterosexual and homosexual couples the propensities to use condoms do not differ much between the group testing negative and the group not demanding a test and that for the homosexual couples the group testing positive has a much greater propensity to use condoms These unconditional propensities to use condoms conditional on test results and not testing are inconsistent with the epidemiological benchmark, in which testing only altered the demand for treatment and had no effect on disease incidence

These unconditional features of the data hold up when we control for other observable characteristics of the persons in the sample, such as income and education Tables Ia and Ib report the

TABLE Ia
LOGIT ESTIMATES OF CONDOM USE BY HETEROSEXUAL COUPLES ($N = 1233$)

Independent variable	Coefficient	Standard error	t value	$P > \|t\|$
Negative	0.005	0.065	0.082	0.935
Respondent's age	−0.041	0.018	−2.307	0.021
Partner's age	0.000	0.014	0.023	0.982
Respondent's ethnicity	−0.08	0.093	−0.937	0.349
Partner's ethnicity	0.042	0.049	0.864	0.388
Respondent's income	−0.043	0.046	−0.943	0.346
College education	0.494	0.200	2.468	0.014
Medical insurance	0.015	0.269	0.055	0.956
Respondent's sex	−0.047	0.180	−0.261	0.794
Constant	−0.477	0.805	−0.592	0.554

coefficient estimates for the regression equation,

$$(19)\quad P(Y = 1|T, X) = g(\beta_0 + \beta_P{*}\text{POSITIVE} + \beta_N\ \text{NEGATIVE} + \beta{*}X),$$

where g is of the well-known logistic form for the dichotomous dependent variable, Y, which stands for CONDOM demand and takes the value 1 (0) if the couple uses (does not use) condoms. The coefficients β_N and β_P of the dummies NEGATIVE ($T = n$) and POSITIVE ($T = i$) indicate the effect of a negative or positive test result, respectively, on measured levels of safe sex compared with untested individuals ($T = u$). X is a set of demographic control variables, consisting of the age of the respondent and his or her partner, the ethnicity (represented by a dummy variable that takes

TABLE Ib
LOGIT ESTIMATES FOR HOMOSEXUAL COUPLES ($N = 135$)

Independent variable	Coefficient	Standard error	t value	$P > \|t\|$
Positive	2.077	0.791	2.625	0.010
Negative	0.364	0.472	0.771	0.442
Respondent's age	−0.026	0.040	−0.661	0.510
Partner's age	−0.020	0.029	−0.676	0.501
Respondent's ethnicity	0.336	0.213	1.576	0.118
Partner's ethnicity	0.006	0.131	−0.042	0.966
Respondent's income	0.171	0.118	1.451	0.149
College education	−0.050	0.198	−0.251	0.802
Constant	−0.851	1.574	−0.541	0.590

a value of one if a person is white) of the respondent and his partner, the respondent's income, a college dummy indicating whether the respondent had more than a high school education, a medical insurance dummy, and the sex of the respondent

Table Ia reports the estimated coefficients for the heterosexual sample The coefficient of the effect of testing negative on the demand for safe sex is 0 005 and is highly insignificant (The 95 percent confidence interval for the coefficient is [−0 122,0 133]) Age has a significant negative effect on condom usage, education, as is typical in studies of health behavior, a significant positive effect The other variables are not significant

Table Ib reports the corresponding results for the sample of homosexual males Because the sample size is small (although large relative to other studies), these results are no more than suggestive The variable POSITIVE has a large and highly significant effect on condom usage, as predicted by our model This is the only significant variable in the regression, although the large standard errors may be due to the small size of the sample The positive effect of testing negative is larger than for the heterosexual sample, but not large enough to permit rejection of the alternative hypothesis that testing negative has a zero or negative effect on sexual behavior and hence STD incidence

These results are consistent with previous findings that testing per se has no effect on sexual behavior (as discussed in the review article of Higgins et al [1991], see, in particular, the studies by van Griensven et al [1989] and Wiktor et al [1990]), despite the large and significant effect on condom usage in the homosexual sample of testing positive The reason is that when positive and negative test results are combined, the latter so predominate that the net result is likely to be indistinguishable from zero, the probable effect of testing negative on sexual behavior

IV B The Demand for Testing

The SFHHS data set enables a fuller investigation of the demand for testing Table II is a list of these variables measured Notice that the dependent variable *Pr*Test*R* indicates whether the respondent tested *prior* to the survey Our analysis therefore assumes that the participation in the SFHHS was not driven by a demand for testing produced by the survey itself The independent risk variables Risk*R* and Risk*T* correspond to the infection risks p_m and p_w in our theoretical analysis The risk variable of the

TABLE II
COEFFICIENT ESTIMATES FOR DEMAND FOR TESTING DEPENDENT VARIABLE prTESTR (N = 3087)

	Model 1	Model 2	Model 3
Risk$R$	10 821	7 351	7 572
	(13 288)	(15 505)	(15 564)
Risk$T$		−0 676	−0 721
		(−4 138)	(−4 319)
PrTest$T$			1 205
			(10 631)
Age$R$	−0 019	0 003	0 003
	(−2 134)	(0 447)	(0 378)
Black$R$	−0 437	−0 190	−0 133
	(−0 2503)	(0 1531)	(−1 055)
Hisp$R$	0 145	0 206	0 284
	(0 982)	(1 62)	(2 184)
HighSchool$R$	0 137	0 013	0 051
	(0 816)	(0 081)	(0 301)
College1R	0 422	0 217	0 306
	(2 703)	(1 424)	(1 951)
College2R	0 416	0 213	0 329
	(2 242)	(1 175)	(1 765)
Grad$R$	1 032	0 765	0 813
	(5 052)	(3 829)	(3 959)
MidInc$R$	−0 615	−0 459	−0 496
	(−5 456)	(4 183)	(−4 42)
HighInc$R$	−0 139	−0 079	−0 096
	(−0 888)	(−0 516)	(−0 604)
RichInc$R$	0 413	−0 363	−0 475
	(−1 35)	(−1 185)	(−1 524)
Gender$R$	−2 212	−0 766	−0 747
	(−6 912)	(−4 704)	(−4 495)
Black$T$	0 249		
	(1 465)		
Hisp$T$	0 144		
	(1 016)		
IVDrug$T$	0 856		
	(4 54)		
Age$T$	0 024		
	(3 43)		
Gender$T$	−2 279		
	(−7 238)		
constant	0 527	−0 834	−1 140
	(1 255)	(−2 969)	(−3 939)
Log likelihood	−1462 960	−1502 005	−1442 876
Sample size	3087	3087	3081

(parentheses denotes t-statistics)

respondent is his predicted probability of infection, which was estimated by regressing his HIV status on his observable characteristics and thereafter assigning the predicted infection level to those characteristics The corresponding variable for the partner was assigned using his observable characteristics and imputing the risk by the logit regression of the respondents

The first regression equation investigates the demand for testing of the respondent as a function of his own probability of infection, controlling for other characteristics of both the respondents and his or her trading partner Equation 2 substitutes the partner's probability of infection The equations reveal that the demand for testing is positively related to the probability of infection of the tester and negatively related to the probability of infection of the partner, and that both effects are highly significant These results are consistent with our first scenario (the risky sex pretesting status quo), in which the demand for testing comes from high-risk persons who cannot obtain risky sex without testing rather than from low-risk persons who in the absence of testing would take a chance on risky sex The fact that characteristics of the partner, in particular his probability of infection, affect the demand for testing of the respondent is inconsistent with the treatment-induced model of the demand for testing Equation 3 adds to 2 the variable *Pr*Test*T*, which indicates whether the respondent reported that the trading partner had tested Controlling for the probabilities of infection of the tester and nontester, we find an independent effect of the test demand of the partner on the test demand of the respondent This suggests that test trading may be common and hence that testing may reduce incidence Indeed, the unconditional percentage of pretested respondents who knew their partner was tested was 31 percent, as opposed to 16 percent among respondents who had not tested

These empirical results are only suggestive Both larger samples and better controls are needed for more powerful tests to distinguish among the models discussed One problem is that condoms are only one method of protection and the other forms, e g , avoiding anal intercourse among homosexuals, may respond to testing as well Also, both the signs on and the magnitudes of the effects of the probabilities of infection may be biased because the observable characteristics of one partner may be correlated with characteristics of the other partner that are observable to the first partner but not to the econometrician (although such corrections may not alter the *signs* of the estimated effects)

V Concluding Remarks and Extensions

This section discusses a limited set of issues that may alter the predicted effects of testing and suggests future areas of research for determining the significance of these issues

V A HIV Testing with Altruism

Consider the case in which an individual is altruistic in the sense that he prefers not to have risky sex when he knows he is infected [14] This violates the assumption made previously that the desire for risky sex is increasing in one's own probability of already being infected Because an altruist incurs a cost from infecting his partner, some individuals who would engage in risky sex if testing were infeasible will not engage in it if testing is feasible An individual who because of altruistic cost would not engage in risky sex if he knew he were HIV positive may test because he derives a net benefit from avoiding risky sex in that event, and if he does test positive he will refrain from risky sex However, if he tests negative, he will continue to engage in risky sex (thus putting himself at risk) and indeed, by our earlier analysis, will be more likely to obtain such trades And since our previous analysis assumes that anyone who tests positive is excluded from the market for risky sex, it is not clear whether dropping the assumption of egoism alters our conclusions It is true that, given altruism, testing results in the withdrawal from the market for risky sex of some persons who, in the absence of testing, would participate in that market because they did not know they were HIV positive But since the demand for safe sex is higher among altruists anyway, the cost to them of risky sex is higher than it is to an egoist, who does not incur an altruistic cost of safe sex, so there will be fewer altruists in the risky-sex market to begin with

V B Partner-Unobserved Tests and the Question of Equilibrium

Throughout we assumed that there was no asymmetric information We conclude with some speculative thoughts on relaxing this assumption, which are suggestive of the fuller analysis that we believe is an important task for future research Our model assumes that the sexual partner of the tested individual can always infer that individual's test result, even if only implicitly through

14 The proposition that some but not all persons in the market for risky sex are altruists is supported by studies which showed that some but not all persons who discover that they are HIV positive cease having risky sex with persons whom they do not know to be also HIV positive [Coates et al 1988, Fox et al 1987, Krajick 1988, van Griensven et al 1988]

his behavior after the devastating news of a positive result The assumption is unrealistic It is often possible to hide the knowledge of a positive HIV test from one's partner, especially in the case of casual encounters But this possibility is unlikely to be important in explaining the private demand for testing, which is what we are interested in When one's partner cannot distinguish whether the test turned out positive or negative, one faces the same opportunity set after testing as one did before testing If one cannot trade before testing, one cannot trade after, and if one could trade before testing, one can also trade afterward This implies that if individuals are pooled instead of separated after testing, the incentive for testing disappears in our model, since no trades can be obtained after a test by individuals who test negative, they will not be believed because those who test positive have an incentive to lie The principal incentive for testing, even for an egoist, would then be to determine one's own infection status for the purpose of deciding whether to engage in safe or risky sex For the egoist who tests negative, the expected utility of safe sex rises, if he tests positive, it declines There is no reason to believe that the result will be more safe sex, because if HIV positives who today, not knowing their status, practice safe sex, tomorrow test, learn their status, and drop safe sex, they will spread the disease, provided they can obtain risky trades with persons who in fact are HIV negative

Reference to pooling and separating equilibria brings to the fore the important question whether a sexual marketplace in which there is risky as well as safe sex and in which some but not all participants have tested is, as we have assumed, a possible equilibrium Suppose that it were possible to prove that one had tested negative, as suggested by several attempts already to create so called "HIV-cards" that certify the last date on which the bearer tested negative Then anyone who could not produce such proof would be suspected of having tested positive (or of having believed that he would test positive if he tested) Everyone who wanted to engage in risky sex would test, since anyone who did not would be assumed positive and would on our assumptions be excluded from the market The analogy would be to the "voluntary" disclosure of transcripts by students seeking employment The difference is that since disclosure of a transcript is essentially costless, the only inference from nondisclosure is that the nondiscloser has something to hide But since many people have an aversion to even the simplest medical tests, since proof of HIV status is in fact difficult, since there is often a lag between infection and showing up positive on the test, since many people are fearful of tests which may show they are doomed even if the probability of that result is very low, and since a decision to take the test may be interpreted as an acknowledgment that one is a member of a high-risk group (and therefore as possibly having engaged in stigmatized activities), failure to be able to disclose an HIV test result is highly consistent with other hypotheses besides knowing that one is HIV positive Consistent with this analysis, most sexually active people in this and other countries have not been tested even though HIV testing is heavily subsidized

However, if HIV testing were subsidized so generously that the vast majority of sexually active people tested, the separating equilibrium just described would become untenable Infection status would either be learned directly from disclosure of test results or be inferred from nondisclosure Matching for risky sex would become assortative, with negatives having risky sex with other negatives and positives with other positives The disease would be limited in its spread through sexual activity

V C Mandatory Testing

The discussion in the preceding section is relevant to the most controversial proposal for public intervention related to HIV testing, namely mandatory HIV testing If mandatory testing of the entire adult population were coupled with the isolation of persons who tested positive—the apparent goal of Cuban policy [Bayer and Healton 1989]—the effect in reducing the spread of AIDS could be dramatic, although the costs would be very high We shall consider two less draconian possibilities The first is universal mandatory testing, but with test results disclosed only to the person tested (his sexual partners may or may not observe the test result) The second is mandatory testing in selected occupations such as health or the military, followed by exclusion of persons who test positive

The first is (ignoring fiscal implications) the equivalent of a subsidy of voluntary testing so generous that everyone tests It would have the same effect in producing assortative matching of partners in risky sex and thus halting the spread of the disease through sex This matching and the consequent cessation of the spread of the disease would come about even though no one was under any compulsion to disclose his or her test results In effect, universal mandatory testing reduces the cost of disclosing one's infection status, thereby creating a pooling equilibrium similar to that of the student-transcript example Under a regime of voluntary testing, the cost of disclosure includes the cost (including the associated disutilities that we have stressed) of getting tested in the first place, which may be considerable. So people who tell their sexual partners that because of the cost (broadly understood) they have not been tested and therefore cannot reveal their infection status are making a plausible statement. With universal mandatory testing, the cost of disclosure falls to zero, and the statement cannot be made in a believable form.

The analysis of mandatory testing limited to particular occupations would be similar if persons in such occupations drew their sexual partners from other members of the same occupation, or of other occupations in which testing was mandatory, exclusively. But if that unlikely possibility is excluded, the analysis is similar to the analysis of subsidized voluntary testing that results in only a fraction of the relevant population being tested.

APPENDIX

Description of Variables for Test Demand Analysis

White*R*	Respondent White? Dummy
Black*R*	Respondent Black? Dummy
Hisp*R*	Respondent Hispanic? Dummy
Black*T*	Trading Partner Black? Dummy
White*T*	Trading Partner White? Dummy
Hisp*T*	Trading Partner Hispanic? Dummy
Age*R*	Respondent's Age
Age*T*	Trading Partner's Age
Gender*R*	Respondent's Gender (1 = Male)
Gender*T*	Trading Partner's Gender (1 = Male)
IVDrug*T*	Trading Partner Uses IV-Drugs
LowInc*R*	Respondent's Income <$12,000
MidInc*R*	Respondent's Income $12,000–$24,000
HighInc*R*	Respondent's Income $24,000–$60,000
RichInc*R*	Respondent's Income >$60,000
HighSch*R*	Respondent has HighSchool Highest Degree
Grad*R*	Respondent has Postgraduate Work
College1*R*	Respondent has Some College Education?
College2*R*	Respondent has College Degree?
Risk*R*	Respondent's Predicted Probability of HIV-Positive
Risk*T*	Trading Partner's Predicted Probability of HIV-Positive
*Pr*Test*R*	Respondent Demanded Test Prior to Survey
*Pr*Test*T*	Trading Partner Tested (Reported by Respondent)

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