Does Birth-Control Promote Promiscuity or Improve Health Care? Evidence from Sexually Transmitted Diseases

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Abstract

I examine the behavioral response to new birth-control methods by exploiting inter-state variation in the introduction of the birth-control pill and abortion. Since sexual behavior is hard to observe directly, I use incidence of sexually transmitted diseases as a proxy for risky sexual behavior. I find that STD incidence rose after the legalizations but argue that changes in incidence might overstate changes in sexual behavior because of the way in which diseases spread. The estimated effect of the legalizations on STD incidence disappears after I control for disease dynamics, and the upper bound of these estimates falls dramatically. In light of these findings, I suggest an alternative explanation for observed increases in STD incidence: doctors might have diagnosed more cases of STDs as women came in to obtain prescriptions for the pill. I suggest ways of identifying these changes in STD screening from changes in sexual behavior and find evidence consistent with increased screening, especially among women. However, I find no evidence of increased screening of other, related diseases in data from the National Hospital Discharge Survey.

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Introduction

The moral and political debate over birth-control is as old as the oldest birth-control methods. Those in favor have argued that birth-control gives women control over their bodies and their lives. Those against have argued that birth-control methods are unnatural or amoral, facilitate promiscuity, and encourage risky sexual behavior. The debate is certainly not new to the United States: many states banned birth-control in the late 1800s on moral grounds, only to repeal these laws a half century later with the onset of women's rights and the legalization of the birth-control pill.[1] More recently, the public debate over birth-control has revolved around the morning-after pill, a powerful hormonal contraceptive which, if used within 72 hours of unprotected sexual intercourse, can reduce the risk of pregnancy by up to 89%. Despite the long and historical debate over birth-control, there is little empirical evidence on whether sexually active individuals, especially women, change their sexual behavior when they gain access to new birth-control methods. This study aims to fill that gap.

I examine sexual behavior at the time of the legalization of two important birth-control methods in the United States: the birth-control pill and abortion. The birth control pill is a hormonal treatment taken orally once a day. It virtually eliminates the chances of pregnancy. Abortion is a surgical procedure that makes it possible to terminate an unwanted pregnancy. Both these methods reduce the cost of unprotected sex (sex without a condom) by eliminating the risk of an unwanted child. Thus, we expect individuals to have engaged in more unprotected sex following the legalizations of the pill and abortion.

I focus on the pill's legalization for 18-21 year olds and exploit plausibly exogenous variation in the timing of the pill's introduction for this age group: in the late sixties and seventies, most states lowered the age of majority from 21 to 18, but did so at various times. While this was presumably done to give more rights to Vietnam soldiers and veterans, it also gave 18-21 year old women access to the pill without parental consent for the first time.[2] Additionally, I examine the legalization of the pill for minors, and the legalization of abortion for both adults and minors. The timing of these legalizations also varied across states, but was probably endogenous to social norms and attitudes toward sex in each state. Nonetheless, all four legalizations reduced the cost of obtaining the relevant birth-control method for the population in question and we would expect risky sexual

[1] Connecticut was the last state to repeal these laws, which were commonly known as the Comstock Laws. It did so in 1965 following the Supreme Court's decision in Griswold vs. Connecticut.

[2] This identification strategy was employed by Goldin and Katz (2001) in their study of the pill's effect on women's labor market and marriage prospects. A similar strategy was employed by Donahue and Levitt (2001) in their work on abortion and crime.

behavior to increase with each legalization.

Since sexual behavior is hard to measure directly, I use incidence[3] of two sexually transmitted diseases–gonorrhea and syphilis–as a proxy for risky sexual behavior. This approach was first used by Stratmann and Klick (2003) to measure the effect of the legalization of abortion on risky sexual behavior. I expand on their approach in three ways: First, as mentioned above, I include the introduction of the birth control pill in the empirical analysis. I also include the legalization of the pill and abortion for minors. I find that incidence rose roughly 10% following the legalization of the pill for 18-21 year olds. Furthermore, because the introduction of the pill and abortion were correlated within states, I find that including all four legalizations reduces the measured effect of abortion on incidence to roughly half the measured effect when only abortion is included in the specification.

Second, I consider the effect of disease dynamics on STD incidence. Like all infectious diseases, STDs pass from one individual to another and grow faster when more individuals are infected with the disease; as in any model with positive social multipliers, aggregate responses are larger than individual responses. Using aggregate responses to estimate individual responses might lead us to exaggerate the impact of the legalizations on individuals' sexual behavior. Thus, I develop and estimate simple structural models of disease spread adapted from epidemiology. I find that controlling for disease dynamics practically eliminates the estimated effect of all the legalizations on STD incidence and dramatically reduces the upper bound of estimates of all the legalizations' effect on STD incidence. There are two possible interpretations of this result. It might be that individuals' response to the legalization of the pill was small but positive. This small increase in risky sexual behavior was then amplified due to the infectious nature of the disease, leading to much larger aggregate levels of STD incidence. Alternately, it might be that something other than increased sexual activity caused at least some of the measured increase in STD incidence.

Finally, in light of these findings, I consider an alternative explanation for increased STD incidence following the legalizations. Gonorrhea and syphilis cases are only registered when infected individuals seek treatment. The rate at which they do so is called the screening rate; as the screening rate rises, so does incidence, even if the total number of infections does not change. In this case, STD incidence might have increased as more women came to the doctor to obtain prescriptions for the pill, especially if many of these women also received a physical examination at this time. Thus, I consider endogenous changes in screening rates and suggest ways of identifying these changes from changes in sexual behavior in data on STD incidence. I find some evidence that STD incidence rose following the legalizations because of higher screening rates–especially among women–and not

[3]Incidence is defined as the number of newly reported cases in a given period.

just because of increased risky sexual activity. However, I fail to find evidence that screening rates rose for other, related diseases in data from the National Hospital Discharge Survey.

Nonetheless, this finding has serious policy implications. One benefit of prescription-only or surgical birth-control methods is that they come packaged with improved health care and increased screening for STDs; currently, women who wish to obtain the birth-control pill or an abortion must see a doctor to obtain the desired method of birth-control.[4] The improvements in health care associated with these birth-control methods might overshadow the costs of increased risky sexual activity. Until recently, the morning-after pill was, like the birth-control pill, also available only with a prescription. However, the FDA recently legalized an over-the-counter (OTC) version of the morning-after pill called Plan B, eliminating the need for a doctor's visit. This separated the morning-after pill from the health-care with which it was packaged and may lead to increases in sexually transmitted diseases and associated conditions.

The remainder of the study is organized as follows: Section 2 provides background information on the public debate on contraceptives, the legalization of the birth-control pill and abortion, and gonorrhea, syphilis, and associated conditions. Section 3 describes the data. Section 4 outlines a model of sexual behavior and health care, and suggests how changes in both might effect STD incidence. Section 5 describes the results and Section 6 concludes.

Background Information

The Public Debate on the Morning-After and Birth-Control Pills

On May 5, 2004, the FDA denied approval of an over-the-counter (OTC) morning-after pill on the grounds that it might alter sexual behavior of young teens. The decision went against the recommendation of the FDA's own panel of scientific advisors, who voted 24-3 in favor of legalizing the morning-after pill. The panel argued that the pill could safely be used by young teens and that it might eliminate approximately half of the 3 million unplanned pregnancies which occur in the United States each year. This opinion was shared by women's rights groups, who accused the FDA of bowing to political pressure from conservatives. On the other hand, opponents of the legalization argued that over-the-counter access would modify behavior in socially undesirable ways:

> "...studies from countries that have made the morning-after pill available without a prescription [suggest that] it creates a public health hazard, with no decrease in pregnancies, no decrease in abortion, but a substantial increase in sexually transmitted

[4]The same is true of the IUD, or in-utero device. This device is implanted in a woman's uterus during a simple surgical procedure. It prevents conception by irritating the lining of the uterus.

diseases."[5]

Following its original decision, the FDA repeatedly delayed a final decision on the morning-after pill, prompting a senior official to resign in September, 2005. Finally, on August 23, 2006, the morning-after pill was legalized for over-the-counter use by women 18 and over.

The current public debate over the morning-after pill mirrors the debate over the birth-control pill four decades earlier. At the time, the pill was credited with promoting promiscuity among young women, and discussions on sexuality and morality often assumed a causal link between the pill and the sexual revolution. In July, 1966, U.S. News and World Report printed the following panicked headline:

> "Is the pill regarded as a license for promiscuity? Can its availability to all women of childbearing age lead to sexual anarchy?

A year later, Time Magazine articulated the opposite viewpoint:

> "The consensus among physicians and sociologists is that a girl who is promiscuous on the pill would have been promiscuous without it."[6]

Not to be left out, Playboy promoted casual acceptance of the pill as early as 1963.[7]

The public debate on increased sexual activity focused on the pill and not abortion. I will do the same in my analysis, partially for this reason. However, the approach presented herein is general and may be used to analyze the effect of any of the legalizations on sexual behavior.

Legalization of the Birth-Control Pill and Abortion

In this study, I explore the link between changes in sexual behavior and the introduction of the birth-control pill and abortion. To do so, I exploit variation in the timing of legislation of the birth-control pill and abortion for some populations. In this section, I describe the legalizations and populations to which they applied.

The birth-control pill

In the summer of 1957, the FDA approved Enovid–the first pill known to work as a contraceptive–for the treatment of severe menstrual disorders. Soon thereafter, an usually high number of American women mysteriously developed menstrual disorders and asked their doctor for a prescription. Most

[5] Wendy Wright, policy director for Concerned Women for America. Quoted in Kaufman (2005).

[6] Watkins (1998), quoting *Time Magazine*, April 1967.

[7] See Figure 1.

presumably sought the drug for its contraceptive benefits. Three years later, in May of 1960, Enovid was finally approved by the FDA for contraceptive use. It was the first drug approved for long-term use by a healthy individual.[8]

In most states, married couples and single women over the age of 21 immediately gained access to the pill at this point.[9] Even in states where contraceptive use of the pill was officially outlawed,[10] enforcement was rare and women used the pill to prevent pregnancy.[11] In 1965, the Supreme Court finally ruled that birth-control must be made available to all married couples and women over the age of 21. Still, states could–and did–prohibit minors and young adults from obtaining the pill for contraceptive reasons without parental consent.[12]

Then, starting in the mid-sixties, states lowered the age of majority from 21 to 18. Some also enacted 'responsible minor' laws. These legislations gave young adults and minors access to the pill without parental consent.[13] There was considerable variation in the timing of these legislations, a fact which has been exploited in related studies.[14] Furthermore, these legislations were enacted largely in response to the war in Vietnam, suggesting that their timing was exogenous with respect to sexual behavior. Even if the legalizations were not exogenous, they may have had a discrete effect on women's choice of contraceptives by instantly reducing the costs of obtaining the birth-control pill. Indeed, at the time of the legalizations, young women who resided in states where the age of majority was 18 were more likely to have used the pill than women who resided in states where the age of majority was still 21.[15]

Abortion

Abortion was first legalized in California in 1969, then in Alaska, Hawaii, New York, and Washington a year later. Abortion was legalized nationwide in 1973 by the Supreme Court with its landmark decision on *Roe v. Wade*. A similar court decision made abortion legal for minors without parental

[8] http://www.pbs.org/wgbh/amex/pill/timeline/index.html

[9] At this time, 21 was the age of majority in most states. I define young adults as individuals between the ages of 18 and 21, and minors as individuals under the age of 18. The earliest legal age to obtain contraception varied by age. Please see *Table 2* in Goldin and Katz (2002) for more information.

[10] In 1964, there were 8 such states, including Connecticut and Massachesetts.

[11] I thank Rachel Solavechik for this point.

[12] http://www.pbs.org/wgbh/amex/pill/timeline/index.html

[13] I refer to states' lowering the age of majority and legalizing the pill for young adults synonymously. I also refer to the introduction of responsible minor laws and legalization the pill for minors synonymously.

[14] For example, Goldin and Katz (2002)

[15] See Table 3 in Goldin and Katz (2002) for details.

consent in 1976, though many states legalized abortion for minors prior to this ruling.[16] Needless to say, there is less variation in the timing of the legalization of abortion than of the pill, for both young adults and minors.

Discussion of the legalizations as a natural experiment

In this study, the legalizations of the birth-control pill and abortion act as a cost shock; that is, the legalizations reduce the cost of unprotected sex immediately at one, discrete point in time. As with any study of this sort, there are two concerns with this approach. First and foremost, one might worry that the legalizations do not represent a cost shock at all. This might happen if the legalizations were enacted after the activity in question was already accepted in practice.[17] It is quite likely that this was true to some extent for the pill; it is possible that doctors prescribed the pill to 18-21 year olds and minors even though it was illegal or that young women obtained the pill through older siblings and parents. Young women might also have claimed to suffer from menstrual problems as it was possible to obtain a prescription for the pill this way. The cost of obtaining the pill almost certainly fell for at least one group of young women–those in college–because Universities did not distribute the pill at on-campus health centers until it was legal to do so.[18] Nonetheless, to the extent that the legalizations did not actually reduce the cost of obtaining the pill, this would bias us against finding an effect on sexual behavior.

One might also worry that the legalizations were driven by demand for contraceptives and that they represent changes in 'social norms' and not just the cost of obtaining contraceptives. To try to control for changes in social norms, I include state demographics in some specifications, but this solution is effective only to the extent that changes in demographics capture changes in social norms. To the extent that changes in norms are not captured by changes in changes in demographics, this would bias us towards finding a large effect of the legalizations on sexual behavior.

In Table 3, I regress year of legalization on state demographics. An F-test of the significance of all explanatory variables reveals that we can reject that demographics–which predict incidence well (see Table 5)–predict the year in which the age of majority was lowered. However, this is not true

[16] It easier for minors to get an abortion in some states than others, though there a number of organizations which take minors across states lines to have abortions performed. I thank Rachel Solavechik for this point.

[17] For example, Connecticut outlawed birth-control methods until a Supreme Court decision in 1965 (Griswold vs. Connecticut) ruled that its laws violated individuals' rights to privacy. While this decision had important legal ramifications, it had almost no effect on individuals' access to contraceptives as Connecticut's laws were hardly enforced prior to the decision. This is evident from an earlier ruling (Poe vs. Ullman, 1961), in which Justice John Marshall Harlan II cited insufficient enforcement as grounds for dismissing the case against Connecticut. I thank both Rachel Solaveichik and Gary Becker for for this point.

[18] Unknown (1966).

for the introduction of responsible minor laws. Surprisingly we can reject that state demographics predict the year in which abortion was legalized for minors, though not for adults. Figure 1 summarizes the timing of changes in the age of majority and the introduction of responsible minor laws. Figure 2 summarizes the timing of abortion legalizations for minors and adults in all 50 states and the District of Columbia.

Gonorrhea and Syphilis

Since sexual behavior is hard to measure directly, I examine incidence[19] of two sexually transmitted diseases: gonorrhea and syphilis. Gonorrhea and syphilis are bacterial infections usually transmitted during sexual intercourse, though both may be transmitted by direct contact with contaminated materials such as blood or plasma, for example from mother to child during birth. I use incidence as a proxy for sexual behavior because STD's are the undesirable byproduct of the risky behavior in question. In this section, I describe the diseases, their symptoms, and some facts about the epidemics in the United States.[20]

Gonorrhea

Gonorrhea is a common STD. In 2002, $351,000$ new cases of gonorrhea were reported to the CDC, down from $980,000$ in 1975. The CDC estimates that only half of all new cases of gonorrhea are reported each year, so the actual number of new infections in 2002 was probably closer to $700,000$.[21] Gonorrhea is most common among teenagers and young adults, and also among African Americans. For example, in 1999, gonorrhea rates among African American men, ages 20-24 were $3,582$ per $100,000$ population, or roughly 3.5%. This was nearly 3 times the rate of $1,324$ for African American men, ages 30-34, and nearly 30 times the overall rate for men of roughly 120 per $100,000$, or 0.12%. Rates among women are now only slightly lower: roughly 116 per $100,000$, or 0.116%. However, up until the mid-nineties, gonorrhea rates were much higher among men than among women. Table 3 summarizes the age distribution of gonorrhea and syphilis cases by gender in 1995.

In men, symptoms of gonorrhea may take up to 30 days to appear, though some infected

[19] Incidence is defined as the number of newly reported cases in a given period. This is in contrast to prevalence, which is the number of infected individuals in the population at large. Not all infected individuals seek treatment.

[20] Data and statistics in this section were provided by the CDC. See http://www.cdc.gov/std/gonorrhea/STDFact-gonorrhea.htm and http://www.cdc.gov/nchstp/od/news/RevBrochure1pdfcloselookgon.htm for more information for information on gonorrhea. See http://www.cdc.gov/std/syphilis/STDFact-syphilis.htm for information on syphilis.

[21] This highlights the distinction between prevalence, which is the number of infected individuals in the population, and incidence, which is the number who seek treatment and are diagnosed with the disease.

individuals may not experience symptoms at all. Symptoms include a burning sensation while urinating and yellow or green discharge from the penis. In women, symptoms of gonorrhea are mild, and most women do not experience symptoms at all. Women who do experience symptoms often confuse gonorrhea for a mild infection and ignore the symptoms entirely. This may partially explain lower incidence among women.

Gonorrhea's mild symptoms conceal the disease's serious nature. If left untreated, gonorrhea can irrevocably damage internal organs and even lead to death. In women, gonorrhea may evolve into Pelvic Inflamatory Disease (PID), a common, often-painful condition which can lead to infertility. Gonorrhea also increases an individual's risk of contracting HIV.[22] Since gonorrhea is a bacterial infection, it is quickly and easily treated upon diagnosis with a number of effective antibiotics. Any damage caused prior to treatment usually cannot be reversed. Following treatment, cured individuals may become infected again.[23]

Syphilis

In the United States, syphilis is far less common than gonorrhea, with roughly 10% as many newly recorded cases each year. In 2002, there were $32,000$ new cases of syphilis. Syphilis is most common among 35 to 39 year old men and 20-24 year old women, and is very common among gay and bisexual men.[24] Today, rates among men are 3.5 times rates among women, although this was not always the case. In the late sixties, syphilis rates among men were roughly 50% higher than those among women. In comparison, gonorrhea rates among men were roughly twice those among women.

The symptoms of syphilis progress in three stages. The first sign of infection is an open sore, called a chancre, which usually appears 10 to 90 days (21 on average) after initial exposure. The chancre lasts three to six weeks and is followed–not necessarily immediately–by a rash, usually on the palms of the hands and soles of the feet. This is the secondary stage of syphilis. If left untreated, syphilis progresses to the third stage, infecting organs and joints. The third stage is latent, or hidden, as there are no outward symptoms of infection. Nonetheless, this stage of the disease is very dangerous: if left untreated for long enough, syphilis may cause dementia, paralysis, blindness, and even death. Like gonorrhea, syphilis is easily treated upon diagnosis with antibiotics, though, again, damage caused prior to treatment cannot be reversed. Following treatment, cured individuals may become infected again.[25]

[22] For a discussion of the role of untreated STD's in the spread of HIV, see Oster (2005).

[23] Jovanovic and Watstein (2003).

[24] In the medical literature, these are referred to as men who sleep with men (MSM).

[25] Jovanovic and Watstein (2003).

Discussion of STDs and externalities

As with many contagious diseases, the costs of STDs are not entirely born by the individuals who are infected, but also by the individuals they eventually infect. Individuals who choose to forego the condom in favor of the pill are more likely to contract an STD and pass it along to their partners. Such behavior increases the risks associated with sexual behavior for all sexually active adults, and not just those individuals. That is, risky sexual behavior carries with it external costs which are born by society as a whole. The purpose of this section is to present the reader with evidence on the magnitude of this externality.[26]

If all individuals were treated for gonorrhea and syphilis soon after contracting them, the costs associated with these diseases would be quite low. The one-time antibacterial treatment for both costs roughly $25.[27] The same is true for chlamydia, another sexually transmitted infection that is by far the most common in the United States (but for which for incidence data was not collected until the mid 1980s). Unfortunately, not all cases of gonorrhea, syphilis, or chlamydia are treated immediately. In fact, the CDC estimates that less than one third of all cases of chlamydia and one half of all cases of gonorrhea are reported each year.[28] That is, of the estimated 2.8 million new cases of chlamydia, and 700,000 new cases of gonorrhea each year, only 1.2 million or so are actually diagnosed and treated. The remaining 2.3 million remain untreated.

Eventually, bacterial infections such as gonorrhea and chlamydia spread from the genitals to other internal organs and can cause severe, permanent, and even life-threatening damage. For example, 40% of untreated cases of chlamydia result in pelvic inflammatory disorder (PID)[29] which in turn may lead to infertility or death. The CDC estimates that there are roughly one million cases of PID each year–most caused by gonorrheal or chlamydial infections–and that each year, "more than 100,000 women become infertile ... as a result of PID ... [and] 150 women die from PID or its complications."

To combine these figures into an estimate of the external costs of the disease, suppose that only half of individuals treat the disease, that 40% of untreated cases lead to PID, and that PID is the only important complication associated with gonorrhea and chlamydia.[30] Suppose further that gonorrhea and chlamydia[31] are neither shrinking nor growing so that each infected individual

[26]Facts and figures are taken from the CDC's online fact sheets on gonorrhea, chlamydia, and PID and are approximate.

[27]Including the cost of a doctor's visit adds significantly to the costs associated with an STD, though these are still quite small.

[28]This figure is not known for syphilis.

[29]The CDC does not report this figure for gonorrhea.

[30]Suppose, for example, that gonorrhea and chlamydia lead to similar complications in men.

[31]Let us ignore syphilis as it is very rare.

infects, on average, one other individual before he or she is cured of the disease. Then each infection carries with it the external cost of one additional infection, which has a 20% chance of leading to PID, a 2% chance of leading to infertility, and a .015% chance of leading to death.[32]

The Data

Since 1963, doctors and institutions in all 50 states have been required to report new cases of gonorrhea and syphilis to their state health department. Cases are reported without any identifying charicteristics other than gender. State health departments then send an annual report to the Centers for Disease Control and Prevention (CDC), which compiles incidence[33] data for all 50 states on a yearly basis. I merge the CDC data with data on state characteristics, including dummies which indicate the timing of the various legal changes described above.

Table 1 and Figure 3 summarize gonorrhea and syphilis incidence from 1963 to 1980. Gonorrhea incidence grew for both men and women in this period. Syphilis incidence remained roughly constant for men and fell for women, cycling somewhat. Among women, gonorrhea incidence increased very rapidly in the early seventies, right around the the time of the legalizations. This is particularly evident in Figure 4, which displays mean growth rates of gonorrhea incidence for both men and women. The disease grew (and shrank) at roughly the same rate for men and women throughout the period in question, except in the early Seventies, when, for three years, growth rates for women were over three times those of men. This spike in growth rates coincides with the legalization of the pill for 18-21 year olds in most states.

Behavioral Model and Implications for STD Incidence

Model basics

Suppose utility is made up of only two arguments: the number of risky sexual encounters in a given period, n, and some other good, x. That is, $u = u(n, x)$, where $u(\cdot)$ is increasing in both n and x.[34] Suppose that the marginal utility of consumption is not effected by the number of risky sexual encounters, n, so $u_x(x, n) = u_x(x)$ and $u_n(x, n) = u_n(n)$. Further suppose that utility is concave in

[32]This calculation ignores discounting as the disease moves from one individual to the next in the matter of weeks or months.

[33]Incidence is defined as the number of new cases of a disease. Prevalence is defined as the number of people who have the disease at any given point in time, and must be estimated from incidence data.

[34]Note that the unwelcome effects of STDs do not enter into the model directly through utility even though in practice, unhealthy individuals probably enjoy sex less than they would if they were healthy.

n, so $u_{nn}(n) < 0$. Finally, suppose the costs of risky encounters enter into utility indirectly through the budget constraint, $p_n n + x = I$, where p_n is the expected cost of a risky encounter. Individuals' behavior is then characterized by the following first order condition,

$$\frac{u_n(n)}{u_x(x)} = p_n \tag{1}$$

and individuals respond to increases in the costs of risky sexual behavior by reducing the number of risky sexual encounters they seek.

The response to the pill and abortion

We are interested in examining the role of new birth-control methods on sexual behavior. To do so, I split the cost of a risky sexual encounter into the costs associated with pregnancy and sexually transmitted diseases. These costs depend on the probabilities that an individual gets pregnant or contracts an STD and might differ for men and for women. Specifically, the expected cost of a risky encounter might be $p_n = \alpha c_p + \beta c_{STD}$, where α is the probability that an encounter results in pregnancy, β is the probability an individual contracts an STD during a single encounter, c_p is the cost associated with pregnancy, and c_{STD} is the cost of enduring and treating an STD.[35] This leads to the following first order condition,

$$\frac{u_n(n)}{u_x(x)} = \alpha c_p + \beta c_{STD} \tag{2}$$

Now suppose the birth-control pill is introduced at a price c_{pill}. The pill reduces the probability that a risky sexual encounter ends in pregnancy to $\alpha' < \alpha$. Individuals on the pill behave according to the following first order condition,

$$\frac{u_n(n)}{u_x(x)} = \alpha' c_p + \beta c_{STD} \tag{3}$$

and face the following budget constraint, $(\alpha' c_p + \beta c_{STD})\, n + x = I - c_{pill}$. From the new first order condition, we see that individuals on the pill increase n relative to x. From the budget constraint, we see that these individuals maximize with a lower nominal income but also face lower prices. Thus, the income effect is ambiguous,[36] though an individual would not obtain a prescription for the pill if it meant cutting back both n and x, as this would make her worse off than she was without the pill.[37] Therefore, we may conclude that n will rise with the introduction of the pill.

[35] In epidemiology, $\beta \cdot n$ is called the infection rate.

[36] The pill is relatively inexpensive and is often highly subsidized. If $c_{pill} \to 0$, individuals will increase both n and x.

[37] An individual will go on the pill if $u(n', x') \geq u(n^*, x^*)$, where n' and x' are the solution to equation (3) and its associated budget constraint and n^* and x^* are the solution to equation (2) and its budget constraint.

The analysis for abortion is simpler. The availability of abortion reduces the cost of pregnancy, c_{STD}. Individuals will respond to this reduction in cost by increasing the number of risky sexual encounters, n.

The effect on the screening rate

The cost of obtaining an STD might depend on how often an individual goes to the doctor. For example, gonorrhea is merely unpleasant, but if left untreated, it can evolve into PID, a dangerous condition.[38] Suppose individuals may choose the frequency, r, at which they visit the doctor. This is the screening rate. Suppose further that the screening rate enters into utility only indirectly through the budget constraint in two ways: on one hand doctors' visits are costly, but on the other hand, they reduce the probability that relatively innocuous STDs evolve into more serious conditions. Formally, the cost of a risky sexual encounter is now $p_n = \alpha c_p + \beta c_{STD}(r)$, where $c_{STD}(r)$ is decreasing in the frequency of doctor's visits. Individuals' budget constraint is now $[\alpha c_p + \beta c_{STD}(r)]\, n + rd + x = I$, where d is the cost of a doctor's visit. Thus, individuals' first order conditions now include,

$$\beta n c'(r) \quad = \quad -d \tag{4}$$

Individuals on the pill will increase r primarily because they increase n. But they might also face a lower d if they already have to visit the doctor to request a prescription for the pill. Finally, all individuals will increase r as β goes up.[39]

Relating STD incidence to behavior

In this section, I link the behavior described by the model above to sexually transmitted diseases. My goal is to understand just what data on STD incidence can and cannot tell us about sexual behavior. Begin by recalling that incidence is defined as the number of newly reported cases of a disease. It does not represent the total infected population. Rather, it represents the population which came in for treatment. Our challenge is therefore to infer changes in sexual behavior from the number of individuals who go to the doctor and are diagnosed with an STD.

In the model presented above, changes in sexual behavior are embodied in n, the number of risky sexual encounters. When it comes to STDs, n helps determine the rate at which an STD grows because it determines the number of people an infected individual might infect in a given period.

[38] The CDC estimates that PID causes 100,000 cases of infertility and 150 deaths each year in the United States.

[39] Note that the effect described is only one way through which increased screening might change sexual behavior. It might also be the case that women who planned on visiting the doctor modified their sexual behavior in anticipation of these visits, by being more or less careful during sexual encounters. I thank Kevin Murphy for pointing this out.

Let I_t represent the number of infected individuals at time t,[40] N_t the number of individuals who are infected between time $t-1$ and time t. Suppose that the probability of infection is made up of two parts, γ and $\mathbf{b}$, where γ is the probability that an individual's partner is infected and $\mathbf{b}$ is the biological probability of transmission. Then,[41]

$$\begin{aligned} N_t &= (1-\gamma)\mathbf{b} \cdot nI_t \\ &\equiv \tilde{\beta} n I_t \end{aligned} \tag{5}$$

That is, each period, an infected individual infects n individuals, of whom γn are already infected, with probability $\mathbf{b}$.[42][43]

Unfortunately, we do not observe the number of new infections in a given period, N_t. Rather, we observe the number of individuals who go to the doctor and are cured of the STD.[44] Let R_t represent the number of infected individuals who go to the doctor between time $t-1$ and time t.[45] Since individuals are assumed to visit the doctor at a rate r, R_t is just,

$$R_t = rI_t \tag{6}$$

Note that N_t and R_t act in opposite directions; the stock of infected individuals grows by N_t in each period, but falls by R_t. Formally, this means that,

$$I_t - I_{t-1} = N_t - R_t \tag{7}$$

Let us examine the effect of changes in n and r–the behavioral parameters of the model–on STD incidence, R_t. First suppose individuals increase n to $n' = n + \Delta_n$. At first, the stock of infected individuals remains unchanged. From equation (6), we see that STD incidence remains unchanged as well. However, this does not last long. From equation (5) we see that new infections

[40] That is, I_t represents STD prevalence at time t. This potentially confusing notation is borrowed from the epidemiology literature.

[41] Equation (5) is an approximate for small values of n and/or γ. For large values of either, equation (5) is scaled by an additional term and $N_t = (1-\gamma\mathbf{b})^{n-1} \cdot (1-\gamma)\mathbf{b} \cdot nI_t$. I thank Emily Oster for pointing this out.

[42] For now, γ, and therefore β, is assumed to be constant. I relax this assumption in Appendix 1.

[43] Note also that I have assumed all individuals behave identically. In practice, individuals with different choices of n likely differ in their choice of partner. This determines the distribution of γ's, which in turn determines the number of risky sexual encounters involving an infected and an uninfected individual. Thus, this distribution of γ's determines the number of newly infected individuals in each period, N_t, and can have serious implications for the spread of the disease. I offer one assumption on this distribution which preserves the implications of the model: so long as individuals do not change γ as they change n, the number of newly infected individuals behaves as described. For further discussion, refer to Chapter 10 of Anderson and May (1992).

[44] Recall that gonorrhea and syphilis are both cured on diagnosis.

[45] That is, R_t represents STD incidence at time t.

rise immediately by $\tilde{\beta} I_t \Delta_n$ and from equation (7) we see that this will gradually increase the stock of existing infections. Since STD incidence is proportional to the stock of infected individuals, incidence will also increase gradually. As it does, it will decrease the rate at which the stock of infected individuals grows and therefore the rate at which incidence grows. To summarize, following a discrete jump in n, STD incidence will increase gradually at a decreasing rate.

Now suppose individuals increase r to $r' = r + \Delta_r$. From equation (6), we see that STD incidence will rise immediately by $\Delta_r I_t$. However, this increase will not be permanent. From equation (7) we see that the stock of infected individuals will gradually fall. From equation (5) we see that this will cause the number of new infections to fall as well, exacerbating the fall in the stock of infected individuals. Thus, incidence, though higher at first, will fall along with the stock of infected individuals.

The model suggests two distinct time-paths for STD incidence if individuals increase n or r in response to the legalization of the pill or abortion: an increase in n causes a gradual increase in incidence levels, whereas an increase in r causes a sharp increase in incidence followed by a gradual decline (for convenience, examples of two such time-paths are displayed in Figure 5). Our analysis suggests that individuals will increase both n and r simultaneously, but that men and women might raise n and r by different amounts. In particular we might suspect that women who adopt the pill will increase r more than men since they must go to a doctor to obtain a prescription and are likely to get a check up at the same time. If this were indeed the case, we would observe a spike in female incidence after the legalizations. The spike in incidence might be larger for women than for men.[46] Finally, if women go to the doctor more often than men, $r_f > r_m$, we might observe that increases in female incidence predict reductions in overall incidence after the legalizations, or at least smaller increases in overall incidence than are predicted by increases in male incidence. For further discussion, please see Appendix 2.

Thus far, the analysis does not control for diseases' self-reinforcing dynamics. Since diseases pass from one individual to another, a larger infected population means the disease will actually grow faster–exponentially, if unchecked–and small changes in incidence due to changes in behavior will be amplified over time. Fortunately, the model implies a strict relationship between current and future incidence for which we can control:

Proposition 1. *Percentage changes in STD incidence are a linear function of $\tilde{\beta} n$ and r:*

$$\frac{R_t - R_{t-1}}{R_t} \quad = \quad \tilde{\beta} n - r \tag{8}$$

Proof. See Appendix 3. □

[46] That is, $R_t^F / R_{t-1}^F \approx r'_f / r_f > r'_m / r_m \approx R_t^M / R_{t-1}^M$ immediately following the legalizations.

Equation (8) implies a linear relationship between the growth rate of an STD and individuals' behavioral parameters n and r. These parameters are in no way amplified by the STD's self-reinforcing dynamics. Thus, it is possible to estimate changes in these parameters that are not exaggerated due to the STD's self-reinforcing dynamics. In the empirical section that follows, I employ a more flexible specification when analyzing STD growth rates.[47] There, I regress log of incidence on log of past incidence and the legalizations:

$$\ln R_t \quad = \quad \left(\tilde{\beta} n - r\right) + \alpha \ln R_{t-1} + \epsilon_t \tag{9}$$

If one were to restrict the coefficient on the log of past incidence to one, $\alpha = 1$, this specification would be identical to equation (8).

One shortcoming of both specifications is that changes in n are not identified from changes in r. Thus, it is difficult to formally distinguish changes in sexual behavior from changes in screening rates using data on STD incidence. To distinguish changes in sexual behavior from changes in screening rates, I rely on the model's less formal predictions: changes in sexual behavior will generate a different timepath of STD incidence than changes in screening rates (these differences are described above, summarized in item (2) below, and illustrated in Figures 5a and 5b).

To conclude, the model offers several testable predictions: (1) The legalization of the pill and abortion should cause an increase in risky sexual behavior n and the screening rate r. This should cause STD incidence to rise. (2) An increase in n will cause STD incidence to rise gradually and flatten out at a new, higher level. An increase in r will cause STD incidence to spike immediately, then fall gradually. (3) Increases in r are likely to be larger for women than for men, so incidence will spike more for women. This should cause male incidence to fall faster than it otherwise would. (4) Finally, if r is indeed greater for women than for men, then past male incidence will predict stronger increases in present incidence than past female incidence.

Results

In this section, I attempt to identify changes in sexual behavior and changes in the screening rate in data on STD incidence. The analysis is motivated by the testable predictions of the model in the previous section. First, I demonstrate that STD incidence rose following the legalization of the pill and find that the timepath of STD incidence is consistant with increased risky sexual behavior. Then I control for disease dynamics using specifications based on equation (8). This practically eliminates the estimated effect of the legalizations on STD incidence, suggesting that the effect

[47] The corresponding results are presented in Tables 10-13.

of the legalizations on each individual's behavior was small. Further, the estimated timepath of STD incidence changes and the new timepath is consistent with increased screening. I continue by estimating the timepath separately for men and women. For men, incidence decreased following the legalizations, wheras for women, incidence spiked, then continued to increase. These timepaths are consistent with increased screening rates primarily among women, as we'd expect if women, and not men, went to the doctor to receive a prescription for the pill. Finally, I compare the effect of past male and female incidence on current incidence and find evidence that screening rates are higher among women than men.

I begin by regressing STD incidence on legalization dummies. These equal one when the pill or abortion are introduced in a given state for adults, 18-21 year olds, or minors (depending on the dummy in question). The results are displayed in Table 7 and 8, for gonorrhea and syphilis, respectively. Legalizing the pill for 18-21 year olds had a positive and large effect on gonorrhea incidence; the legalizations led to 35.6 more cases of gonorrhea per 100,00 individuals. This is an over 10% increase in gonorrhea incidence, or, approximately 70,000 more cases of gonorrhea per year nationwide.[48] This result is not statistically significant once I control for state demographics. The results for syphilis are smaller in magnitude and are not statistically significant: lowering the age-of-majority increases syphilis cases by 5%, or 900 cases per year nationwide.

In the model presented above, discrete changes in risky sexual behavior result in gradual changes in STD incidence. In comparison, increased screening causes STD incidence to jump immediately, then fall gradually. To test for both effects, I regress gonorrhea and syphilis incidence on the legalizations and dummies which indicate whether one, two, three, or four or more years have passed since the age of majority was lowered in a given state. The results are presented in Table 9a. Gonorrhea incidence rose gradually after the legalization, eventually flattening out at roughly 90 additional cases per 100,000, 4 years after age-of-majority was lowered. This is nearly three times as large as the effect on incidence when measured using only a dummy for whether the age-of-majority had been lowered in a given state. Gonorrhea rates rose at roughly the same pace for both men and women, eventually rising to roughly 100 more cases per 100,000 annually for men, and 90 more cases per 100,000 annually for women. Recall, however, that gonorrhea rates are lower for women, so these represent a 24% increase in incidence rates for men and a roughly 39% increase

[48]Note that omitting the pill and abortion for minors may lead one to overstate the effect of legalizing abortion on STD incidence (see column 6). This specification is similar to Stratman and Klick (2003). However, Stratman and Klick use a population-weighted estimator, whereas I use ordinary least squares. Also, some of our demographic controls differ slightly. Our results are otherwise the same.

in rates for women. These results are consistent with increased risky sexual activity.[49][50]

The raw data suggest an increase in risky sexual behavior, and not increased screening. I proceed by testing if this result is due to changes in behavior and is robust to controls for disease dynamics. This is done using specifications motivated by equation (8): I regress the log of gonorrhea and syphilis incidence on all four legalizations and a lag of logged incidence.[51] The lag captures the effect of past STD incidence on future STD incidence. The first set of results are presented in columns (2) and (4) of Table 10. For comparison, these are displayed alongside regressions which do not include a lag. Now, all of the legalizations appear to have no effect on gonorrhea incidence: gonorrhea is estimated to increase only 1/10 of one percent following the legalization of the pill for 18-21 year olds. Furthermore, the upper bound of these estimates falls dramatically in all four cases. Previous estimates suggested that gonorrhea incidence rose by as much as 17.5% after the legalization of the pill for 18-21 year olds. After controlling for disease dynamics, this increase is estimated to be no more than 5.0%. Note that lowering the age-of-majority now appears to have a large effect on syphilis incidence (recall that this effect was small before).

When I expand the specification to include dummies for the number of years which have passed since a state lowered the age-of-majority, I find that gonorrhea incidence increased 5.1% in years zero and one, then fell 1.7% in years two and three. The pattern for syphilis incidence is less clear. See columns (3) and (6) of Table 11.[52] I also regress logged male and female incidence on the legalizations and lags of log overall incidence separately, and find that male incidence eventually fell 2.3% in the four years following the legalizations,[53] whereas female incidence rose immediately by 6.3%, then continued to rise to 115.6% of its pre-legalization level. These results are presented

[49]The estimated increase in gonorrhea incidence is largely driven by early changes in incidence in two states, Idaho and Utah, where the age-of-majority was 18 for women long before 1963. Omitting these states yields very different results: incidence rose for two years after the legalizations, then fell somewhat. The results are displayed in Table 9b. The same result is obtained if the model is estimated using only later years in the sample. Oddly, estimates of the timepath of syphilis incidence follow the opposite pattern. See Tables 9a and 9b.

[50]I also regress incidence on time since the legalization of abortion for comparison with the pill. I find that gonorrhea incidence fell in the years following the legalization of abortion. Incidence fell more for men than women, though none of these results are significantly different from each other or from zero. Syphilis incidence rose in the years after the legalization of abortion. See Table 9c.

[51]In fact, this specification requires that we restrict the coefficient on the lag of logged incidence to one.

[52]Since I include a lag of incidence, columns (2) and (5) are not directly comparable with columns (1) and (4), respectively. This is because, in a model with lags, the effect in early years should be added to the effect in later years to get the 'total' effect of the legalization on incidence. In columns (3) and (6), I add the estimated effect of the legalization in early years to the effect in later years for direct comparison with columns (1) and (4), respectively. I do the same in Table 12.

[53]Note that the upper bound of incidence growth for men is still positive (roughly 2.5%) even four-plus years after the legalizations.

in Table 12.

All three of these results are consistent with the theory that incidence rose following the legalizations as a result of increased screening, and not increased risky sexual activity. To test whether women's screening rate was higher than men's, I regress logged overall incidence on lags of log male and female incidence (see Table 12), a specification motivated in the model above and further in Appendix 2. The coefficient on log lagged male incidence is greater than the coefficient on log lagged female incidence, suggesting that increases in female incidence now do not predict increases in future incidence as well as increases in male incidence. One interpretation of this is that higher rates for women are a result of increased doctors visits, not increased disease prevalence. This suggests that screening was indeed higher among women than among men.

To summarize, when I examine the raw data, I find evidence consistent with increased risky sexual activity. Once I control for disease dynamics, most of the evidence points to higher screening rates, though the results for gonorrhea do not always line up with the results for syphilis. I find that the effect of the legalizations on gonorrhea incidence falls once I control for disease dynamics. I also find that gonorrhea incidence did not rise gradually, but rather spiked gently, if at all, following the legalizations. Additionally, I find that male incidence actually fell following the legalizations, whereas female incidence increased. Finally, I find that past male incidence predicts stronger increases in current incidence than past female incidence. Combined, these four findings support the hypothesis that screening for STDs increased among women following the legalization of the pill for 18-21 year olds. I continue by searching for evidence of increased for other, related diseases in the National Hospital Discharge Survey.

Searching for additional evidence of increased screening

The previous analysis suggests that increases in STD incidence might have been caused by increased screening for STDs, and not just increases in risky sexual behavior. Ideally, one would corroborate this result directly using data on doctors' visits. However, I have thus far failed to obtain such data. Instead, I consider the effect of the legalizations on the diagnoses and treatment of more serious ailments, such as breast cancer. This test is motivated by the following logic: suppose increases in STD incidence were indeed driven by increased diagnoses of STDs as young women sought prescriptions for the pill. Then it is likely that diagnosis rates among 18-21 year old females would rise for a host of ailments–especially those related to reproductive health–and not just STDs.

I use data from the CDC's Hospital Discharge Survey (1970 and 1973-1978) to test the hypothesis that increased screening of young women led to increased diagnoses of serious ailments following the legalization of the pill. The Hospital Discharge Survey is compiled using roughly 270,000

patient files from approximately 500 short stay hospitals throughout the United States. Hospitals are identified by census region, ownership, and size, and patients are identified by gender, age, diagnosis, procedure, length of stay, and a number of other characteristics. Diagnoses are recorded using the International Classification of Diseases (ICD), and are quite detailed. I focus on conditions related to female reproductive health in the survey data (these are classified as "diseases of breast, ovary, Fallopian tube and parametrium" as well as "diseases of uterus and other female genital organs" according to ICD-8). Of course, 18-21 year old women are generally quite healthy. As a result, there are, on average, less than three observations per year per region of 18-21 year olds with conditions related to reproductive health. I proceed nonetheless.[54]

At first glance, the raw data appear to be consistent with the hypothesis presented. The number of 18-21 year old women sampled during this period fell roughly 10%, from approximately 11,000 to approximately 10,000. However, the number of 18-21 year old women diagnosed with conditions related to reproductive health more than doubled during this period, from approximately 17 to approximately 35, nationwide.[55] It is quite likely that these increases were at least partially a result of improvements in screening and diagnosis of conditions related to reproductive health that had nothing to do with the pill and its availability. Indeed, the share of women of any age diagnosed with conditions related to reproductive health also increased during this period, but only by roughly 30%. If improvements in screening and diagnosis affected all age groups equally, then the large increase in diagnoses of 18-21 year olds cannot be explained by systematic changes in screening and diagnosis alone, and might have been driven by demand for the pill.

To formally test the hypothesis that female screening rates rose after the pill was legalized, I regress the number of 18-21 year old females surveyed on the proportion with access to the pill in each census region. I do the same for 18-21 year olds diagnosed with conditions related to reproductive health.[56] I use the proportion with access to the pill in each census region as a proxy for whether individuals surveyed had legal access to the pill.[57] In both specifications, the

[54]I also considered using the SEER cancer database for this analysis. There were only two SEER registries which collected data prior to the legalization of the pill for 18-21 year olds in their state. At these two centers, there were very few cases of cancer among 18-21 year olds. There was a small but statistically insignificant increase in the proportion of young females diagnosed with a number of different types of cancer after the pill was legalized for 18-21 year olds.

[55]There was a large increase in diagnoses in 1978. Still, nationwide diagnoses of 18-21 year olds with conditions related to reproductive health rose over 65% from 1970 to 1977.

[56]The regressions include both yearly and regional dummies.

[57]This is a course measure of pill usage by 18-21 year old females in each region. However, I do not observe the location of the hospital at the state level and thus do not know if the individual in question indeed had legal access to the pill.

estimated relationship between the legalizations and hospital utilization by 18-21 year old women is negative, but not statistically significant at even the 10% level. This negative relationship holds after controlling for the total number of women surveyed and the total number diagnosed with conditions related to reproductive health, respectively, but shrinks in magnitude and remains insignificant. The results are presented in Table 14.

Conclusion

There is no doubt that gonorrhea incidence rose, dramatically even, following the legalization of the pill for 18-21 year olds. The reasons for this rise are less clear. A simple analysis of the timepath of STD incidence following the legalizations shows that gonorrhea rose gradually in the first few years after the legalizations, then flattened out at a new, higher level. The timepath is practically identical for both men and women, and is consistent with increased risky sexual activity, though it does not rule out higher screening rates as an explanation for increases in STD incidence.

A structural approach yields very different results. After I control for disease dynamics, gonorrhea appears to follow two distinct timepaths for men and women. Male incidence fell gradually following the legalizations whereas female incidence rose greatly immediately after the legalizations, then fell somewhat. These timepaths are consistent with higher screening rates among women, though it is important to note that estimates from this specification do not rule out very different timepaths for both men and women, nor do they rule out increased risky sexual behavior. Furthermore, there is no clear positive relationship between access to the pill and screening of other diseases recorded in hospital discharge surveys from the 1970s.

The analysis presented in this paper, though inconclusive, has important policy implications. It suggests that one of the primary benefits of new birth-control methods is that they come packaged with better medical care. Unraveling this package, as would be the case if Plan B were made available over-the-counter, would eliminate this benefit. To the extent that the external costs of contracting an STD are large–and I leave it to the reader to decide for themselves based on the evidence presented–these costs may outweigh the benefits of over-the-counter access.

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Figure 1

Cartoon Promoting Casual Acceptance of the pill, Playboy 1963

FIG. 4. *Playboy* promoted casual acceptance of the pill as early as 1963. (Reproduced by special permission of *Playboy* magazine. Copyright © 1963 by *Playboy*.)

Notes: The popular media reported on, and even promoted casual acceptance of the pill as early as 1963. This cartoon first appeared in Playboy, and was reprinted soon thereafter in Newsweek. Source: Watkins (1998).

Figure 2

Timing of Changes in the Age of Majority, the Adoption of Responsible Minor Laws, and the Legalization of Abortion for Adults and Minors.

Figure 1a. Pill, 18-21

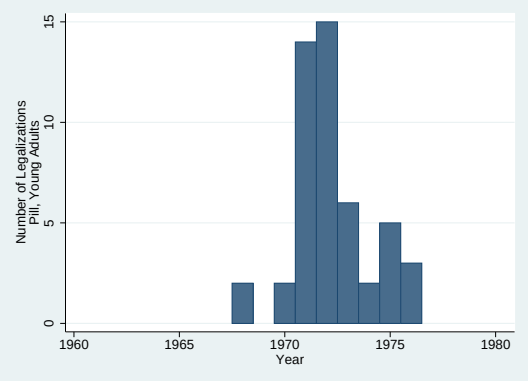


Figure 1b. Pill, Minors

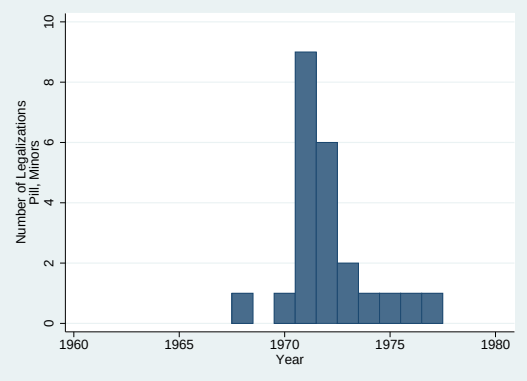


Figure 1c. Abortion, Adults

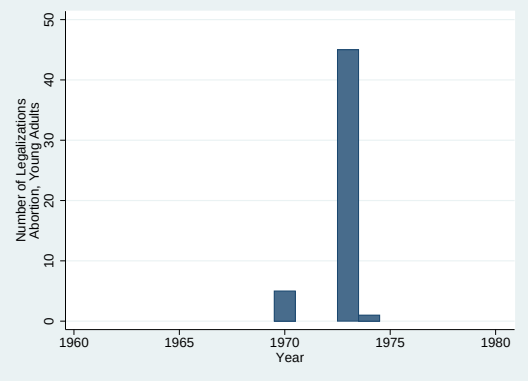
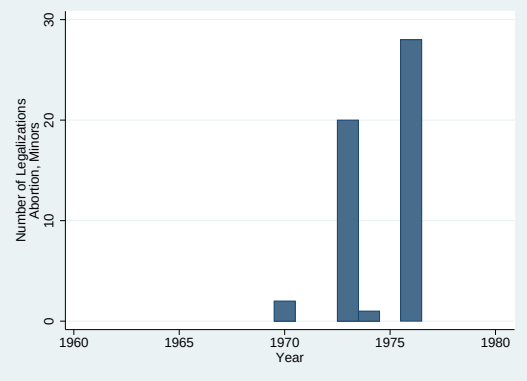


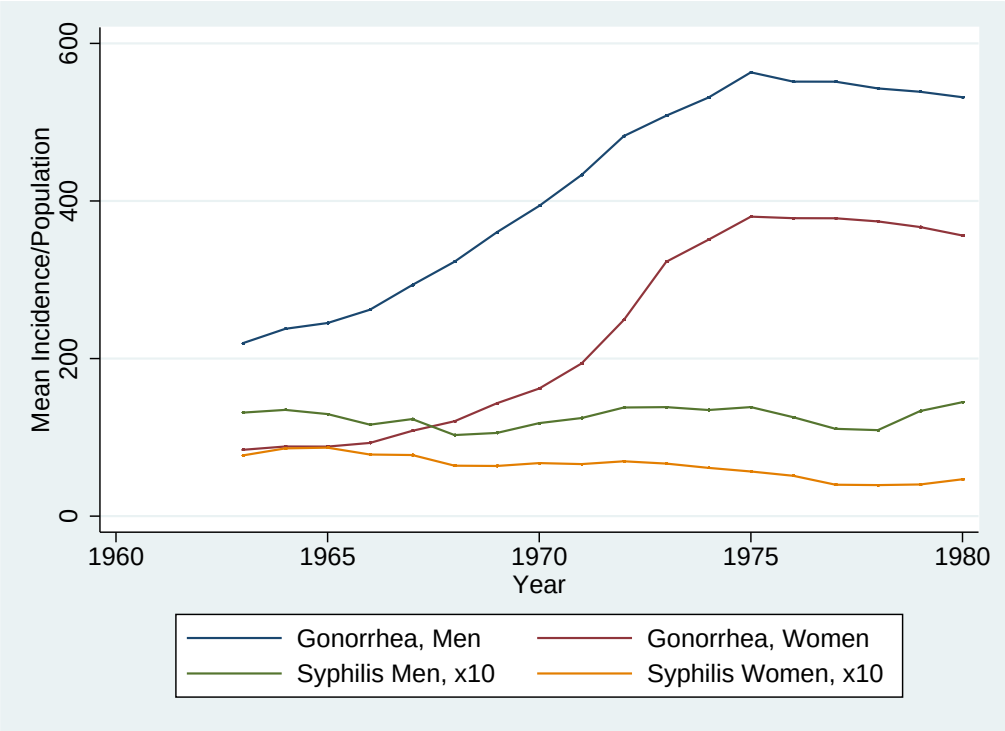
Figure 1d. Abortion, Minors



Notes: Figures 1a. - 1d. display the number of legalizations which occurred in each year. Note that the pill was not legalized for minors in all states, so the number of legalizations will not add to 51 across years in Figure 1b.

Figure 3

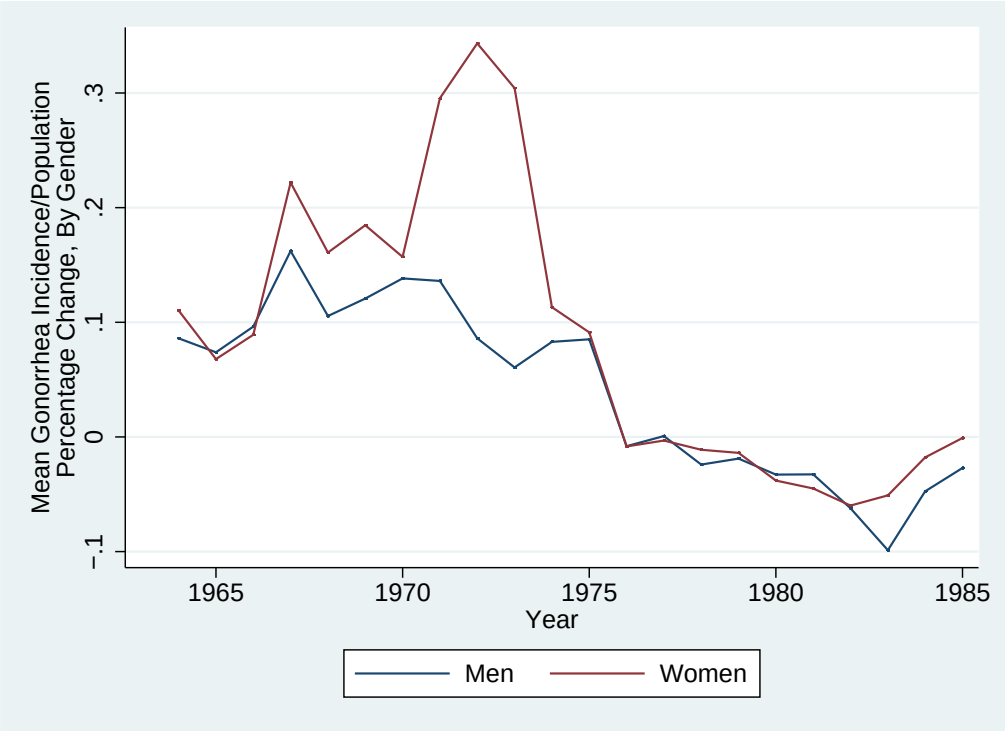
Gonorrhea and Syphilis Incidence, 1963-1980



Notes: Figure 3 displays the mean of gonorrhea and syphilis incidence across states for both men and women. syphilis incidence has been multiplied by 10 to fit on the same axes. The data were obtained from the CDC. I thank Jonathan Klick and Thomas Stratman for sharing these data with me.

Figure 4

Percentage Change in Gonorrhea Incidence, 1963-1980



Notes: Figure 4 displays the mean of percentage changes in gonorrhea incidence across states for both men and women. Notice the high growth rates for women in the early Seventies. This coincides with the legalization of the birth-control pill for 18-21 year olds.

Figure 5

Simulated Time-paths of STD Incidence in the Presence of Changes in Sexual Behavior and Health Care Demand.

Figure 5a. STD Incidence

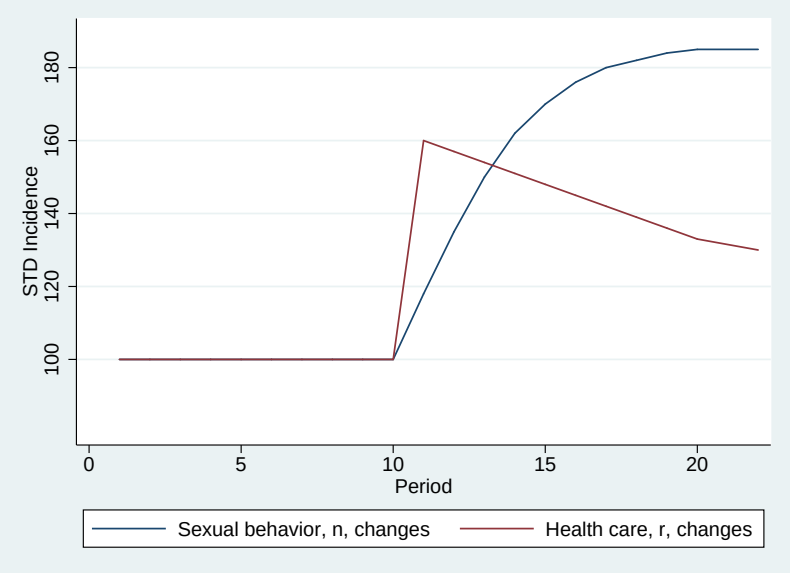
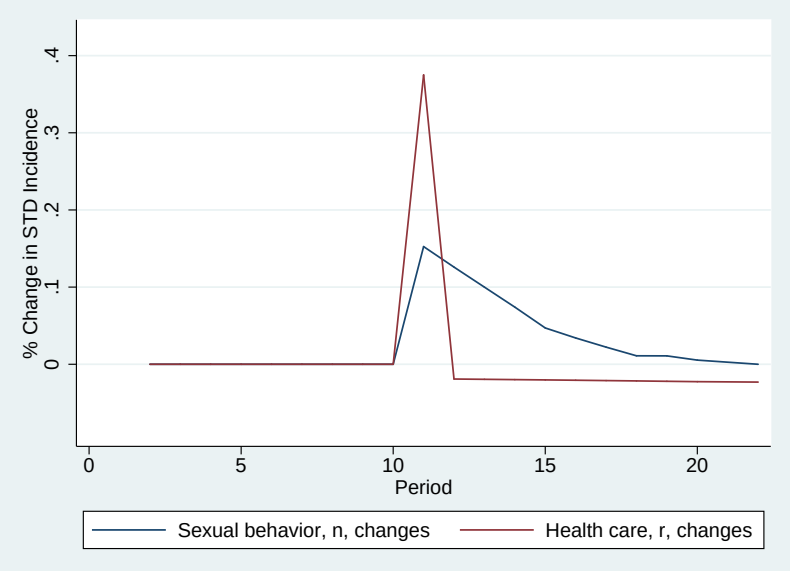


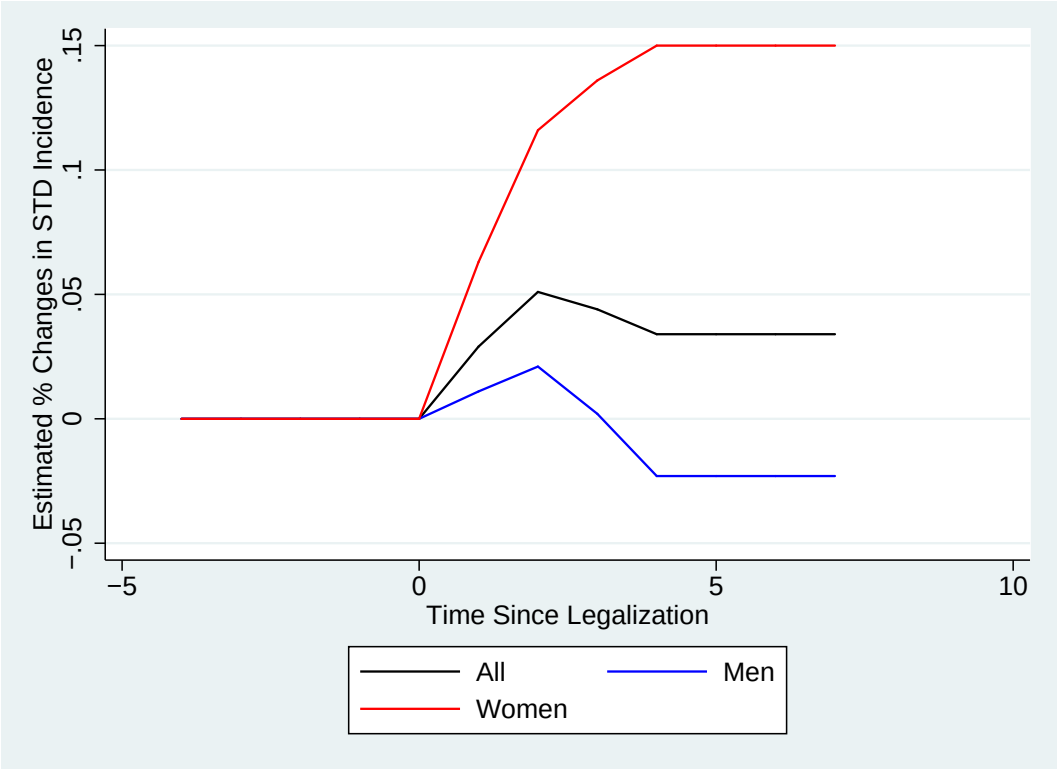
Figure 5b. % Change in STD Incidence



Notes: Figure 5a. depicts simulated time-paths for STD incidence when sexual behavior changes (blue line) and demand for health care changes (red line). Figure 5b. depicts the percentage change in STD incidence in both cases. For comparison with observed changes in STD incidence, see Figures 3 and 4, respectively.

Figure 6

Estimated Time-paths of STD Incidence, Controlling for Disease Dynamics.



Notes: Figure 6 displays the estimated timepaths of gonorrhea incidence following the legalization of the birth control pill. Estimates for the entire population are displayed in black, estimates for men in blue, and for women in red. I control for STD disease dynamics. For point estimates and standard errors, see Tables 11 and 12.

Table 1

State Demographics, Definitions

Variable	Definition
pop	State population in thousands
per1534	Percentage of population between the ages 15 and 34
pop1534	Interaction of *pop* and *per1534*
blackper	Percentage of population that is African American
blackpop	Interaction of *pop* and *blackper*
cpipc	CPI per capita
alpci	Annual alcohol sales per capita (units?)
seced	Percentage of population with high school diploma
dlaw	Indicates whether unilateral divorce was available in a given state
dlawblack	Interaction of *blackper* and *dlaw*
dlaw1534	Interaction of *per1534* and *dlaw*

Table 2

State Demographics, Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
pop	4071.56	4330.28	256.00	23800.00
per1534	.314	.033	.246	.429
pop1534	1272.56	1372.63	90.79	8794.26
blackper	.099	.122	.001	.712
blackpop	454.89	536.39	.59	2402.00
cpipc	10351.90	2209.72	4866.88	21062.94
alpci	2.54	.995	.2700033	6.92
seced	55.48	10.31	30.5	82.5
dlaw	.338	.473	0	1
dlawblack	.019	.046	0	.267
dlaw1534	.114	.161	0	.429

Notes: For variable definitions, please see Table 1.

Table 3

Year of Legalization on State Demographics in 1970

	Pill, 18-21	**Pill, Minors**	**Abortion, Adults**	**Abortion, Minors**
pop	$-1.72 \cdot 10^{-3}$	$-6.41 \cdot 10^{-4}$	$5.18 \cdot 10^{-5}$	$4.80 \cdot 10^{-5}$
	$(2.38 \cdot 10^{-3})$	$(3.33 \cdot 10^{-3})$	$(3.78 \cdot 10^{-4})$	$(1.49 \cdot 10^{-3})$
per1534	-53.37	-54.35	$-.27$	-11.90
	(45.90)	(51.93)	(7.29)	(28.71)
pop1534	$4.44 \cdot 10^{-3}$	$7.76 \cdot 10^{-4}$	$-5.09 \cdot 10^{-4}$	$-7.85 \cdot 10^{-4}$
	$(7.62 \cdot 10^{-3})$	(.0000116)	$(1.21 \cdot 10^{-3})$	$(4.77 \cdot 10^{-3})$
blackper	-6.12	10.50	$-.049$	-1.21
	(6.18)	(8.27)	(.982)	(3.86)
blackpop	$1.87 \cdot 10^{-3}$	$-1.05 \cdot 10^{-3}$	$5.91 \cdot 10^{-5}$	$2.16 \cdot 10^{-4}$
	$(2.50 \cdot 10^{-3})$	$(2.48 \cdot 10^{-3})$	$(3.97 \cdot 10^{-4})$	$(1.56 \cdot 10^{-3})$
cpipc	.0011*	.0020*	$-.0000137$	.0001
	(.0004)	(.0005)	(.0000753)	(.0002)
alpci	.3717	$-.9617$	$-.0310$	$-.2662$
	(.6785)	(.5965)	(.1078)	(.4244)
seced	-22.42*	-12.26	$-.3820$	-2.82
	(9.54)	(8.40)	(1.516)	(5.97)
dlaw	-8.11	-67.26	9.944	-4.21*
	(16.43)	(118.10)	(2.611)	(10.28)
dlawblack	-19.88	.157	6.46	5.89
	(24.46)	(39.03)	(3.88)	(15.30)
dlaw1534	37.21	217.80	-35.09	15.44*
	(53.46)	(403.34)	(8.49)	(33.44)
Constant	1988.20*	1978.28*	1973.80	1979.25*
Adjusted R^2	0.09	0.57	0.61	-0.06
F-test: $Pr > F =$	0.226	0.006	0.000	0.202

Notes: The dependent variables are the dates of the legal changes in question: lowering the age of majority, adoption of responsible minor laws, legalizing abortion for adults, and legalizing abortion for minors. The means of the dependent variables are 1971.74, 1972.04, 1972.84, and 1974.54, respectively. I include only observations from 1970 in the regressions. Coefficients that are significant at the 5% level are denoted with an asterisk. The F-test tests joint significance of all demographics included in the regressions. The demographics included in these regressions are described in Tables 1 and 2; for variable definitions, please see Table 1.

Table 4

Gonorrhea and Syphilis Incidence, 1963-1980

		Gonnorhea				Syphilis			
Population	**Observations**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
All, 1963-1980	918	325.0	320.1	18.8	2776	9.3	13.0	0	117.5
Men, 1963-1980	918	420.5	469.8	25.8	4407.1	12.6	18.2	0	174.2
Women, 1963-1980	918	235.4	213.5	9.1	1486.2	6.3	9.0	0	77.8
All, 1965	51	164.5	183.8	33.5	1313.9	10.8	12.6	.2	65.2
All, 1975	51	468.5	358.3	84.6	2491.8	9.6	14.1	.7	94.3

Source: The Center for Disease Control.

Table 5

Age Distribution of Gonorrhea and Syphilis Cases, 1995

	Gonorrhea			Syphilis		
Age	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
10-14	6,995	1,072	5,893	106	11	95
15-19	104,753	40,311	64,442	1,796	604	1,192
20-24	100,107	52,577	47,350	3,067	1,476	1,591
25-29	51,167	29,789	21,378	2,853	1,390	1,463
30-34	33,761	21,411	12,350	2,919	1,482	1,437
35-39	22,045	15,479	6,566	2,412	1,369	1,043
40-44	11,528	9,164	2,364	1,472	980	492
45-54	7,778	6,726	1,052	1,272	939	333
55-64	1,990	1,810	180	385	311	74
65+	920	754	166	186	149	37
TOTAL	343,127	179,985	163,142	16,503	8,729	7,774

Source: Watstein and Jovanovic (2003).

Table 6

Gonorrhea and Syphilis Incidence and Percentage Change in Gonorrhea Incidence on State Demographics

	Incidence		% Change in Incidence	
	Gonorrhea	**Syphilis**	**Gonorrhea**	**Syphilis**
pop	.0226	$-2.53 \cdot 10^{-04}$	$1.05 \cdot 10^{-06}$	$-2.41 \cdot 10^{-05}$
	(.0209)	$(9.48 \cdot 10^{-04})$	$(6.78 \cdot 10^{-06})$	$(2.26 \cdot 10^{-05})$
per1534	2242.99	-15.10	.432	1.29
	(1204.56)	(49.43)	(.317)	(1.07)
pop1534	-.0165	$2.51 \cdot 10^{-03}$	$-1.04 \cdot 10^{-06}$	$3.02 \cdot 10^{-05}$
	(.0607)	$(3.01 \cdot 10^{-06})$	$(1.94 \cdot 10^{-05})$	$(6.62 \cdot 10^{-05})$
blackper	2316.08*	99.86*	−.073*	−.53*
	(328.87)	(15.68)	(.040)	(.16)
blackpop	−.2329*	$-2.52 \cdot 10^{-03}$	$-1.96 \cdot 10^{-05}$	$3.34 \cdot 10^{-05}$
	(.0942)	$(4.21 \cdot 10^{-03})$	$(1.57 \cdot 10^{-05})$	$(5.75 \cdot 10^{-05})$
cpipc	.0252	-.0003036	.00001*	$5.75 \cdot 10^{-06}$
	(.0190)	(.0005154)	$(2.75 \cdot 10^{-06})$	(.0000155)
alpci	27.52	2.91*	-.00256	.016
	(20.74)	(1.04)	(.00397)	(.019)
seced	297.48	27.27	−.151*	.253
	(266.91)	(14.83)	(.070)	(.358)
dlaw	-84.75	8.64	.0959	.145
	(426.99)	(12.85)	(.118)	(.433)
dlawblack	804.92	-15.79	.293*	.521
	(399.65)	(23.03)	(.081)	(.386)
dlaw1534	161.83	-17.18	-.384	-.816
	(1334.98)	(38.90)	(.347)	(1.26)
Constant	-1042.7	-11.38	-.042	-.394
Year Dummies	yes	yes	yes	yes
R^2	50.81	0.79	0.24	0.05
F-test: $Pr > F =$	0.000	0.000	0.000	0.033

Notes: The dependent variables are gonorrhea and syphilis incidence and percentage change

in incidence. The means of the dependent variables are 325.04, 9.34, .081, and .095, respectively. I include years 1963 through 1980 in the regressions. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. The demographics included in these regressions are described in Tables 1 and 2; for variable definitions, please see Table 1.

Table 7

Gonorrhea Incidence Rates on the Legalization of the Pill and Abortion

	(1)	(2)	(3)	(4)	(5)	(6)
Pill, 18-21	208.67**	57.49	109.39**	39.8**	35.62	
	(29.48)	(61.95)	(20.83)	(23.33)	(24.36)	
Pill, Minors		57.07**	42.56**	29.79**	77.15**	
		(99.31)	(41.64)	(43.69)	(26.38)	
Abortion, Adults		142.09**	112.82**	11.51	22.67	44.50
		(68.11)	(17.66)	(13.67)	(29.26)	(32.05)
Abortion, Minors		22.55	10.43	23.44	21.23	
		(68.64)	(18.01)	(36.25)	(29.28)	
Constant	219.11**	209.65**	204.36**	148.71**	1995.58**	1831.01
State Dummies			yes	yes	yes	yes
Year Dummies				yes	yes	yes
Demographics					yes	yes
R^2	0.11	0.13	0.13	0.15	0.30	0.29

Notes: The dependent variable is gonorrhea incidence divided by state population ($\cdot 10^5$). The mean of the dependent variable is 325.04. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list adjusted R^2 in the first two columns, and cumalative R^2 in columns (3) - (5).

Table 8

Syphilis Incidence Rates on the Legalization of the Pill and Abortion

	(1)	(2)	(3)	(4)	(5)
Pill, 18-21	−.51	−.72	.27	.55	.45
	(.85)	(2.69)	(.81)	(.84)	(.83)
Pill, Minors		1.93	−.87	−1.07**	−.94
		(3.69)	(1.11)	(1.14)	(1.09)
Abortion, Adults		−2.29	−.23	.035	.01
		(2.63)	(.73)	(1.37)	(1.44)
Abortion, Minors		1.68	−.62	1.37	1.38
		(2.37)	(.59)	(1.06)	(1.05)
Constant	9.60**	9.72**	9.73**	10.34**	−56.74
State Dummies			yes	yes	yes
Year Dummies				yes	yes
Demographics					yes
R^2	−0.00	0.00	0.00	0.00	0.17

Notes: The dependent variable is syphilis incidence divided by state population ($\cdot 10^5$). The mean of the dependent variable is 9.34. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list adjusted R^2 in the first two columns, and cumalative R^2 in columns (3) - (5).

Table 9a

Gonorrhea and Syphilis Incidence Rates on Time Since the Legalization of the Pill for 18-21 Year Olds

		Gonorrhea		Syphilis
		Male	Female	
Year 0	2.03	3.37	1.16	−.151
	(19.28)	(23.53)	(17.33)	(.585)
Year 1	41.81	44.24	40.74	1.07
	(21.86)	(22.82)	(24.48)	(1.21)
Year 2	85.68**	94.11**	79.34**	.743
	(29.85)	(35.62)	(29.32)	(1.26)
Year 3	91.91**	101.38**	84.58**	.867
	(35.12)	(40.05)	(34.69)	(1.37)
Year 4+	94.63**	100.45**	91.30**	.840
	(44.61)	(47.05)	(45.80)	(1.69)
Constant	2551.85**	3425.49**	1767.62**	−35.91**
Other Legalizations	yes	yes	yes	yes
State/Year Dummies	yes	yes	yes	yes
Demographics	yes	yes	yes	yes
R^2	0.24	0.29	0.13	0.18

Notes: The dependent variables are gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 325.04, 420.51, 235.44, and 9.34, respectively. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list cumulative R^2.

Table 9b

Gonorrhea and Syphilis Incidence Rates on Time Since the Legalization of the Pill for 18-21 Year Olds, Omitting Idaho and Utah

		Gonorrhea		**Syphilis**
		Male	**Female**	
Year 0	-23.381	-23.416	-23.085	0.489
	(16.013)	(20.324)	(14.981)	(0.552)
Year 1	5.496	6.738	5.294	1.983
	(17.587)	(18.196)	(21.951)	(1.341)
Year 2	38.046	45.499	32.249	1.910
	(21.586)	(27.996)	(23.068)	(1.432)
Year 3	32.355	40.146	26.064	2.392
	(24.068)	(29.605)	(26.264)	(1.553)
Year 4+	14.557	20.057	10.962	2.854
	(28.858)	(33.426)	(32.160)	(1.973)
Constant	$2,746.96^{**}$	$3,622.41^{**}$	$1,959.40^{**}$	-61.450
Other Legalizations	yes	yes	yes	yes
State/Year Dummies	yes	yes	yes	yes
Demographics	yes	yes	yes	yes
R^2	0.24	0.29	0.13	0.18

Notes: The dependent variables are gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 332.10, 430.86, 239.45, and 9.66, respectively. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list cumulative R^2.

Table 9c

Gonorrhea and Syphilis Incidence Rates on Time Since the Legalization of the Abortion for Adults

		Gonorrhea		**Syphilis**
		Male	**Female**	
Year 0	-	-	-	-
Year 1	-8.939	-15.993	-3.205	2.223**
	(17.048)	(15.085)	(21.342)	(0.725)
Year 2	-27.862	-35.335	-23.727	1.362
	(23.070)	(23.727)	(36.663)	(1.059)
Year 3	-10.933	-24.898	-0.071	0.402
	(26.980)	(37.667)	(34.511)	(1.415)
Year 4+	-61.131	-75.330	-50.738	3.006
	(54.051)	(43.824)	(72.712)	(1.795)
Constant	2,765.977**	3,643.016**	1,977.820**	−61.651**
Other Legalizations	yes	yes	yes	yes
State/Year Dummies	yes	yes	yes	yes
Demographics	yes	yes	yes	yes
R^2	0.24	0.29	0.13	0.18

Notes: The dependent variables are gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 325.04, 420.51, 235.44, and 9.34, respectively. Year 0 is omitted to prevent colinearity with yearly dummies. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list cumulative R^2.

Table 10

Log of Incidence on the Legalizations, Controlling for a Lag of Logged Incidence

	Gonorrhea		Syphilis	
Pill, Adults	0.061	0.001	0.084	0.149
	(0.058)	(0.025)	(0.119)	(0.067)
Pill, Minors	-0.061	0.003	-0.015	-0.017
	(0.067)	(0.020)	(0.151)	(0.072)
Abortion, Adults	0.049	-0.015	0.043	0.075
	(0.054)	(0.025)	(0.133)	(0.049)
Abortion, Minors	0.071	-0.026	0.045	0.039
	(0.044)	(0.022)	(0.117)	(0.064)
Lag of Log Incidence		0.759**		0.584**
		(0.022)		(0.050)
Constant	3.506	1.364	0.437	0.101
State Dummies	yes	yes	yes	yes
Year Dummies	yes	yes	yes	yes
Demographics	yes	yes	yes	yes
R^2	0.87	0.95	0.10	0.41

Notes: The dependent variables are log of gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 5.468, and 1.598, respectively. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list cumulative R^2.

Table 11

Log of Incidence on Time Since the Legalization of the Pill for 18-21 Year Olds, Controlling for a Lag of Logged Incidence

	Gonorrhea			Syphilis		
	(1)	(2)	(3)	(4)	(5)	(6)
Year 0	0.035	-0.024	-0.024	0.045	0.165**	0.165**
	(0.048)	(0.024)	(0.024)	(0.114)	(0.079)	(0.079)
Year 1	0.070	0.023	0.005	0.147	0.178**	0.274
	(0.065)	(0.035)	(0.048)	(0.136)	(0.079)	(0.115)
Year 2	0.088	0.023	0.027	0.066	0.044	0.205
	(0.080)	(0.033)	(0.065)	(0.153)	(0.086)	(0.138)
Year 3	0.079	-0.001	0.020	0.176	0.218**	0.338
	(0.095)	(0.034)	(0.081)	(0.175)	(0.102)	(0.170)
Year 4+	0.056	-0.005	0.010	0.207	0.178	0.376
	(0.125)	(0.043)	(0.102)	(0.208)	(0.112)	(0.206)
Log of Lagged Incidence		0.760**			0.587**	
		(0.022)			(0.049)	
Constant	3.506	1.360**	1.360**	0.523	0.126	0.126
State Dummies	yes	yes		yes	yes	
Year Dummies	yes	yes		yes	yes	
Demographics	yes	yes		yes	yes	
R^2	0.87	0.95		0.11	0.41	

Notes: The dependent variables in columns (1), (2), (4), and (5) are log of gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 5.468, and 1.598, respectively. I include years 1963 through 1980 in the regressions. Standard errors are

clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these regressions are described in Tables 1 and 2. I list cumulative R^2.

Columns (3) and (6) are included for comparison with columns (1) and (4), respectively. Since the specification in columns (2) and (5) includes a lag, events in past years affect incidence in later years. However, the coefficients in later years do not reflect changes in earlier years and thus are not comparable to coefficients in columns (1) and (4). To correct for this, I add the effect of past years into current years, scaling them by the coefficient on the lag. For example the coefficient on Year 2 of column (3) is calculated as the coefficient on Year 2 in column (2), plus 0.76 times the coefficient on Year 1 in column (2), plus 0.76^2 times the coefficient on Year 0 in column (2). Standard errors are calculated using the delta method.

Table 12

Log of Incidence on Time Since the Legalization of the Pill for 18-21 Year Olds, Controlling for a Lag of Logged Incidence, Separately for Men and Women

	Male			Female		
	(1)	(2)	(3)	(4)	(5)	(6)
Year 0	0.017	-0.034	-0.034	0.078	0.006	0.006
	(0.041)	(0.022)	(0.022)	(0.071)	(0.041)	(0.041)
Year 1	0.039	-0.001	-0.023	0.123	0.064	0.069
	(0.053)	(0.028)	(0.038)	(0.095)	(0.059)	(0.090)
Year 2	0.059	0.003	-0.013	0.141	0.060	0.122
	(0.065)	(0.028)	(0.050)	(0.115)	(0.061)	(0.137)
Year 3	0.046	-0.023	-0.032	0.130	0.032	0.142
	(0.074)	(0.026)	(0.057)	(0.139)	(0.071)	(0.190)
Year 4+	0.014	-0.036	-0.057	0.111	0.030	0.156
	(0.097)	(0.030)	(0.066)	(0.182)	(0.092)	(0.260)
Log of Lagged Incidence		0.676**	0.676**		0.893**	0.893**
		(0.030)	(0.030)		(0.049)	(0.049)
Constant	4.128**	2.300**	2.300**	2.907	0.255	0.255
Other Legalizations	yes	yes		yes	yes	
State/Year Dummies	yes	yes		yes	yes	
Demographics	yes	yes		yes	yes	
R^2	0.84	0.92		0.87	0.92	

Notes: The dependent variables are log of gonorrhea and syphilis incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 5.468, and 1.598, respectively. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in

these regressions are described in Tables 1 and 2. I list cumulative R^2.

Columns (3) and (6) are included for comparison with columns (1) and (4), respectively. Since the specification in columns (2) and (5) includes a lag, events in past years affect incidence in later years. However, the coefficients in later years do not reflect changes in earlier years and thus are not comparable to coefficients in columns (1) and (4). To correct for this, I add the effect of past years into current years, scaling them by the coefficient on the lag. For example the coefficient on Year 2 of column (3) is calculated as the coefficient on Year 2 in column (2), plus 0.67 times the coefficient on Year 1 in column (2), plus 0.67^2 times the coefficient on Year 0 in column (2). Standard errors are calculated using the delta method.

Table 13

Log of Incidence on Time Since the Legalization of the Pill for 18-21 Year Olds, Controlling for a Lag of Male and Female Incidence

	Gonorrhea	**Syphilis**
Pill, Adults	-0.003	0.158**
	(0.025)	(0.074)
Pill, Minors	0.004	-0.020
	(0.021)	(0.070)
Abortion, Adults	-0.016	0.107
	(0.023)	(0.061)
Abortion, Minors	-0.021	0.034
	(0.023)	(0.067)
Log Lagged Incidence	0.504**	0.408**
(Male)	(0.033)	(0.063)
Log Lagged Incidence	0.255**	0.201**
(Female)	(0.024)	(0.052)
Constant	1.183**	-0.750
State Dummies	yes	yes
Year Dummies	yes	yes
Demographics	yes	yes
R^2	0.95	0.41

Notes: The dependent variables are log of gonorrhea incidence divided by state population ($\cdot 10^5$). The means of the dependent variables are 5.468, and 1.598, respectively. I include years 1963 through 1980 in the regressions. Standard errors are clustered by state. Coefficients that are significant at the 5% level are denoted with an asterisk. The demographics included in these

regressions are described in Tables 1 and 2. I list cumulative R^2.

Table 14

Number of 18-21 Year Old Females Treated at Hospitals on Measures of Pill Use and Availability

	Total Number of 18-21 Females Treated		**18-21 Females Treated for Conditions Related to Reproductive Health (CRRH)**	
Proportion of Population with Access to the Pill	-193.604	-100.580	-1.418	-1.207
	(140.262)	(81.509)	(2.696)	(2.054)
Total Females Treated		0.072**		
		(0.017)		
Total Females Treated for CRRH				0.009
				(0.003)*
Constant	1,494.042**	271.217**	3.462	0.727
	(127.368)	(109.301)	(2.687)	(2.954)
Yearly Dummies	yes	yes	yes	yes
Regional Dummies	yes	yes	yes	yes
R-squared	0.98	0.99	0.57	0.62

Notes: The dependent variables are the total number of 18-21 year old females surveyed in the NHDS, and the number of 18-21 year olds diagnosed with conditions related to reproductive health. The means of the dependent variables are 1169.71, and 2.78, respectively. I include years 1970 and 1973 through 1978 in the regressions. Standard errors are clustered by census region. Coefficients that are significant at the 5% level are denoted with an asterisk.

Appendix 1 - Some long term considerations

In the model presented above, I held the probability of acquiring an STD, $\beta = \gamma \mathbf{b}$, fixed. In practice, γ, and therefore β, rises as more individuals acquire the STD, and this will have behavioral implications.[58] For simplicity, suppose that γ is just the proportion of the population that is infected, I_t/P_t.[59] As I_t gradually increases, so will β. From equation (2), we see that individuals will respond by reducing n. However, we also see that this response is likely to be small relative to the response to the pill or abortion, mostly since the cost of pregnancy is probably much greater than the cost of acquiring either gonorrhea or syphilis, $c_p >> c_{STD}$. From equation (4), we see that individuals will respond to increases in β by increasing r, further slowing the growth of the disease. Thus, to the extent that increases in β are important, these would dampen growth in STD incidence.

[58] The self-inhibiting characteristics of STDs are discussed at length by Philipson and Posner (1994).

[59] This assumes the population is homogenous. For further discussion, see Chapter 10 of Anderson and May (1991).

Appendix 2 - Differing health care patterns and STD incidence

In this section, I attempt to further distinguish the effect of increased demand for healthcare from increased disease. To do this, I consider a regression of incidence on lags of male and female incidence. Let R_t^G represent incidence for gender G at time t so that $R_t = R_t^M + R_t^F$, where M and F indicate male and female, respectively. Differentiating equation (6) with respect to past incidence, we get,

$$\begin{aligned}
\frac{\partial I_t}{\partial R_{t-1}^G} &= \frac{\partial I_{t-1}}{\partial R_{t-1}^G} + \frac{\partial N_t}{\partial R_{t-1}^G} + \frac{\partial I_{t-1}}{\partial R_{t-1}^G} \\
&= -1 + \frac{\partial N_t}{\partial I_t}\frac{\partial I_t}{\partial I_{t-1}}\frac{\partial I_{t-1}}{\partial R_{t-1}^G} - r^G\frac{\partial I_t}{\partial R_{t-1}^G} \\
&= -1 + \tilde{\beta}n \cdot 1 \cdot (-1) - r^G\frac{\partial I_t}{\partial R_{t-1}^G}
\end{aligned}$$

Collecting terms, we get that,

$$\frac{\partial I_t}{\partial R_{t-1}^G} = -\frac{\tilde{\beta}n + 1}{r^G}$$

and since $R_t = rI_t$,

$$\frac{\partial R_t}{\partial R_{t-1}^G} = -r \cdot \frac{\tilde{\beta}n + 1}{r^G}$$

Thus, if $r^F > r^M$ then $\frac{\partial R_t}{\partial R_{t-1}^F} < \frac{\partial R_t}{\partial R_{t-1}^M}$, and female incidence now will predict smaller increases in future incidence than male incidence.

Appendix 3 - Proof of Proposition 1

In this section, I derive the relationship between incidence and the behavioral parameters, n and r. The resulting specification focuses on STD growth rates, rather than levels. Recall that of all the components in this model, we observe only the recovered population, R_t. To estimate n, $\tilde{\beta}$, and r we must somehow relate R_t to these parameters. I take first differences and manipulate equations (5) - (7). It then turns out that percentage changes in incidence are a linear function of $\tilde{\beta}n$ and r,

$$\begin{aligned}
R_t - R_{t-1} &= r\left(I_t - I_{t-1}\right) \\
&= r\left(N_t - R_t\right) \\
&= r\left(\tilde{\beta}nI_t - R_t\right) \\
&= r\left(\tilde{\beta}n\frac{1}{r}R_t - R_t\right) \\
&= (\tilde{\beta}n - r)R_t \\
\frac{R_t - R_{t-1}}{R_t} &= \tilde{\beta}n - r
\end{aligned}$$

From equation (8), it is clear that incidence growth rates will change with n and r, the behavioral parameters in the model. Note that n and r determine the long-run equilibrium level of the disease, which occurs when $\tilde{\beta}n - r = 0$.

Appendix 4: Additional models of disease spread

The model explored above and in Appendix 3, is based on one simple model of disease spread, in which all newly infected individuals seek treatment after exactly one period. In this section, I explore additional models with different assumptions on the relationship between the recovered population, R_{it}, and the infected populations, N_{it} and I_{it}.

Assumption 1: All infected individuals seek treatment.

Suppose we actually do observe the newly infected population, except after some fixed period of time. During this time, individuals may infect others with the disease. Once they seek treatment, individuals are cured of the disease and may become infected again. Suppose further that individuals seek treatment after exactly one period. Then the recovered population perfectly tracks the newly infected population, growing at the same rate, except at a lag. Formally, this translates as follows: since $\tilde{\beta} = 1$, new and existing infections are one and the same. That is,

$$N_{it} \quad = \quad I_{it} \tag{10}$$

Also, the recovered population is just the newly infected population one period ago:

$$R_{it} \quad = \quad N_{i,t-1} \tag{11}$$

From equations (1) - (3), it follows that $R_{it} = \tilde{\beta} R_{i,t-1}$.[60] Allow $\tilde{\beta}$ to change with the legalizations, so that $\tilde{\beta} = \tilde{\beta}_0 \cdot \Delta_{\tilde{\beta}}^{a_{it}}$, where a_{it} indicates if the birth-control method in question was legal in state i at time t and $\Delta_{\tilde{\beta}} - 1$ is the percent change in $\tilde{\beta}$ following the legalization. Then we may estimate changes in $\tilde{\beta}$ using the following specification:

$$\ln R_{it} - \ln R_{i,t-1} \quad = \quad \ln \tilde{\beta}_0 + a_{it} \ln \Delta_{\tilde{\beta}} + \epsilon_{it} \tag{12}$$

Assumption 2: Complex Recovery Rates[61]

In practice, many newly infected individuals seek treatment for an STD upon noticing symptoms, even if they are not aware of the nature of the infection. Others ignore initial symptoms or have none, only to have the disease diagnosed at a later date. As mentioned above, individuals who acquire gonorrhea are likely to notice symptoms in the first three weeks following infection whereas

[60] Start with equation (3). Substituting for $N_{i,t-1}$ from equation (1) yields $R_{it} = \tilde{\beta} I_{i,t-2}$. Substituting for $I_{i,t-2}$ from equation (2) yields $R_{it} = \tilde{\beta} N_{i,t-2}$. Finally, substituting for $N_{i,t-2}$ from equation (3) yields $R_{it} = \tilde{\beta} R_{i,t-1}$.

[61] I thank Kevin Murphy for suggesting this approach.

individuals who acquire syphilis may take up to three months to develop a chancre (if at all). For gonorrhea this implies,

$$R_{it} = \alpha_i N_{it} + (1-\alpha_i)\sum_{k=1}^{K} r(1-r)^{k-1} N_{i,t-k} \tag{13}$$

where $K \to \infty$. That is, α_i of newly infected individuals in state i seek treatment in the first month. The rest are equally likely to be diagnosed with gonorrhea in any given period.[62]

In matrix notation, equation (7) translates to the following,

$$R = AN$$

where N is the vector $[\cdots N_t \cdots]$. Solving for N and substituting equations (2) and (3) yields,

$$R = A\left[I \; a'I\right]\begin{bmatrix} \tilde{\beta}_0 \\ \left(\Delta\tilde{\beta}\right) \end{bmatrix}$$

where a is a vector denoting whether the birth-control method in question is legal, and I is the vector $[\cdots I_t \cdots]'$. Let the subscript L denote lags in R and I. Then,

$$R - R_L = A\left[I - I_L \; a'I - a_L' I_L\right]\begin{bmatrix} \tilde{\beta}_0 \\ \Delta\tilde{\beta} \end{bmatrix}$$

Since $a_t = a_{t-1}$ except at the time of legalization, $t = T_i$, in each state i, $a'I - a_L' I_L = a'(R - AR)$ for $t \neq T_i$ for $i = \{1, 2, \ldots, 51\}$. Thus,

$$R - R_L = \left[R - AR \; a'\left(R - AR\right)\right]\begin{bmatrix} \tilde{\beta}_0 \\ \Delta\tilde{\beta} \end{bmatrix}$$

If we allow r to change with the legalization, this implies,

$$\begin{aligned} R_{it} - R_{i,t-1} &= \tilde{\beta}_0 R_{it} - \tilde{\beta}_0\left[\alpha_i R_{it} + (1-\alpha_i)\sum_{k=1}^{K} r_0(1-r_0)^{k-1} R_{i,t-k}\right] \\ &\quad + \Delta\tilde{\beta} a_t R_{it} - \Delta\tilde{\beta}\left[\alpha_i a_{it} R_{it} + (1-\alpha_i)\sum_{k=1}^{K} \Delta r(1-\Delta r)^{k-1} a_{i,t-k} R_{i,t-k}\right] \\ &= \left(\tilde{\beta}_0 - \alpha_i\right) R_{it} - \tilde{\beta}_0\left[(1-\alpha_i)\sum_{k=1}^{K} r_0(1-r_0)^{k-1} R_{i,t-k}\right] \\ &\quad + \left(\Delta\tilde{\beta} - \alpha_i\right) a_t R_{it} - \Delta\tilde{\beta}\left[(1-\alpha_i)\sum_{k=1}^{K} \Delta r(1-\Delta r)^{k-1} a_{i,t-k} R_{i,t-k}\right] \end{aligned}$$

except when $t = T_i$ for $i \in \{1, 2, \ldots, 51\}$. As before, we cannot identify changes in $\tilde{\beta}$ due to simultaneous changes in r.

[62] This further implies, $I_{it} = (1-\alpha_i)N_{it} + \alpha_i \sum_{k=1}^{K}(1-r)^k N_{i,t-k}$ and again, $K \to \infty$.