The Power of the Little Blue Pill:

Innovations and Implications of Life Style Drugs in an Aging Population[1]

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Abstract

The launch of Viagra in April 1998 led to a historically unprecedented high usage of erectile dysfunction (ED) drugs. We test whether Viagra's introduction significantly influenced outcomes for its target population such as STD rates of older men, as well as its non-target populations, such as divorces, natality, female STDs and sexual assault rates. We find causal evidence that Viagra's introduction increased Gonorrhea rates in older adults by 20-40%. We find no significant evidence of any effects on other variables. We take this as evidence that this lifestyle drug causes significant changes in choices only which affect short term outcomes, while long term planned decisions are unaffected. Overall, we find that the welfare impacts of Viagra with respect to our outcomes of interest are positive and large.

JEL codes: I1, J1, O33, J31

Keywods: Prescription drugs, STD, Aging Population, Viagra, Differences-in-Differences

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I. Introduction

How do innovations in medical technology targeted to the elderly affect the decision making of an aging population? This is an increasingly important question as more resources and R&D are dedicated to the health care of a growing elderly age cohort in the U.S. While the direct health benefits of medical innovations are well studied, the effects of a new class of drug on behavioral decisions of the elderly remains largely unexplored in the literature (Cutler and McClellan 2001 and Cutler 2007).[4]

The 1998 approval of Viagra, informally known as the "little blue pill", offers an ideal natural experiment to identify how one particular medical innovation targeted at the elderly affects their behavior. Before 1998, men suffering from erectile dysfunction (ED) had very limited treatment possibilities. Upon FDA approval in April of 1998 Viagra was rapidly adopted. Sales soared and made the drug a tremendous commercial success for its producer–Pfizer. Since Viagra is targeted to older men, its introduction enables an increased supply of sexually active older men. As a result, the equilibrium decision making of the older population may have been affected leading to several changes in a large set of behavioral outcomes.

We examine Viagra's effect on five different dimensions: adoption of the new class of oral ED drugs and collapse of the traditional ED market, fatherhood decisions by age, the age composition of the marriage/divorce market, sexually transmitted diseases (STDs) and sexual assault and rape rates. Each variable of interest is chosen to highlight different channels through which this lifestyle drug could affect the target population, as well as produce spillover effects on non-target populations. First, we test for Viagra's impact on the number of children fathered by older men. This is a variable of interest because it highlights the drug's capacity to correct a physical disorder and the resulting impact on *planned*

[4] There are at least two channels through which medical innovations could affect decision making of the elderly. First, medical innovations can enable specific behavior that was previously made impossible due to age or disease For example, a hip replacement or medication that ameliorates diabetes can enable exercise. Second, if medical innovations extend the expected lifespan of a population, it can indirectly affect decisions related to financial planning and years worked. We are concerned with the first channel in this paper.

decisions.[5] Second, we test for Viagra's effect on sorting in the marriage market by analyzing divorce rates across age cohorts. This outcome highlights the importance of the drug on the household production function. Third, we test for Viagra' effect on one particular STD, gonorrhea. STDs are of interest because it studies the drug's capacity to impact risky behavior associated with instant gratification. Lastly, we test for Viagra's impact on rape committed by the target population (e.g., older men). This is an important variable due to the magnitude of consequences for victims. It also highlights the drugs capacity to impact unlawful behavior in individuals that previously were not physically able to commit such behavior. In sum, then, we test whether this particular lifestyle drug has an observable effect on four different behavioral channels: newly enabled planned behavior, equilibrium in the marriage market, newly enabled risky behavior associated with instant gratification, and newly enabled criminal behavior.

The USA has the highest Viagra usage per capita of any country in the world. We therefore collected a rich set of both U.S. state and county level data for our outcome variables of interest. For each variable we use a difference-in-difference estimator with differential time trends to test how Viagra differentially affects outcomes in our treatment and control groups. Upon Viagra' approval in the US in April 1998, nearly 90% of Viagra users are over 45 years of age. Therefore, our treatment group is individuals age 45 and above and our control group is individuals age 25-40. In our preferred specification we also employ differential time trends since long run changes in the variables or interest are different across our treatment and control groups. We show convincing evidence, though, that short run fluctuations like macroeconomic conditions affect both the treatment and control groups in similar ways.

We find that Viagra had a positive and significant effect on gonorrhea rates among both men and women in the older population: rates increased by 20-40% in this group relative to the control. This result is robust across a variety of specifications and robustness checks. However, we find no evidence that Viagra's introduction had any significant effect on any other outcome. As a result, we conclude that this lifestyle drug had a significant effect on short term lifestyle decisions (e.g., risky sexual encounters). We

[5] Fatherhood decisions can clearly be unplanned as well, but the majority of child fathering decisions, especially for Viagra's target population are likely to be planned.

find no evidence, though, that it affected deviant (e.g., sexual assault) or long run (e.g., natality, divorce) lifestyle decisions. Overall, in a back of the envelope cost benefit analysis, we find that the welfare impacts of Viagra with respect to our outcomes of interest are positive and large.

These results are important for several reasons. First, the well-being of an aging population is an increasingly important topic given the vast demographic shifts occurring in the U.S., Europe and other industrializing countries.[6] Medical innovations for the elderly increase the feasible choice set for their actions. Specifically, Viagra enabled previously possible choices that were sometimes made impossible with age. Knowing precisely how this increased choice set affects socioeconomic decision making is therefore an important economic problem. The 15 years since Viagra's introduction offer a glimpse as to what economists might observe going forward as medical innovation increase.[7] Second, there could be spillover and indirect effects of medical innovations on non-target groups. It is vital to understand the results for both males and females. Finding effects of Viagra on males demonstrates the existence of a direct effect. However, it important to understand how lifestyle drugs affect the agents who do not take the drugs but rather indirectly enjoy their benefits or suffer from their costs. Third, the "Power of the Pill" articles have shown that innovation in medical technology has substantial impacts on many important economic choices made earlier in life by the targeted group (Goldin and Katz, 2006 and Bailey, 2002). Our paper is different because it the first to look at the effect of medical innovations for decisions made later in life, when individuals have more wealth and experience with decision making. We find that if an individual does not have the ability to engage in a variety of choices and suddenly is given that ability, their decisions tend to be no different except for relatively low cost risky decisions associated with instant gratification. Therefore, we find evidence that self-control can be a challenge, even for experienced decision makers.

[6] In a different context, for example, recent research finds larger concentrations of older populations can cause modest decreases in education spending and/or changes in the political economy equilibrium of difference voting blocks (Harris et. al. 2001 and Levy 2005). The goal of the current paper, then, is to examine how one particular lifestyle drug targeted at the elderly population changes the aging populations socioeconomic decisions.

[7] Artificial organs, for example, are another major medical innovation which are currently being tested which could lead to major changes in the lifestyle decisions of the elderly and even young people.

The remainder of this paper is organized as follows: section two gives historical background on ED medication. Section three presents the econometric model. Section four presents results. Section five offers discussion and concluding remarks.

II. Background and Data

This section provides background about introduction of Viagra and the age composition of its users which are both necessary for discussion of the econometric model in section III. We also discuss the four variables of interest in this section, their relevance and the data used for analysis.

Prior to the launch of Viagra (medical name Sildenafil) in April 1998, ED could only be treated with invasive methods involving injections, penile prosthesis, penis pumps or vascular reconstructive surgeries (Montague et al. 2005). The most common ED drug at the time was Aprostadil. Aprostadil is a penile suppository applied either into the urethra or injected into the penis about ten minutes before the erection is needed. Figure 1 below shows that while in March 1998 more than 900,000 units of Aprodastil were prescribed, one month later, in April 1998 this figure dramatically declined to 462,000 units to then continually decline to insignificant numbers today.[8] The aphrodisiac Yohimbine, a sexual stimulant, experienced even more drastic declines.

This dramatic drop in medication sales can be clearly explained with the approval of Sildenafil by the Food and Drug Administration (FDA), becoming the first oral medication to treat ED, sold under the brand name Viagra starting in April of 1998. The new drug was celebrated in the press and public media as revolutionizing the sexual behavior of the elderly population. The *New York Times*, for example, in the year 1998 featured over 193 articles on Viagra.[9] Viagra was advertised directly to consumers on U.S. on TV, famously being endorsed by sport stars like soccer player Pelé and former U.S. Senator Bob Dole.

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[8] ED medication data were purchased from IMS Health.

[9] Titles for these articles included *The Nation: Thanks a Bunch, Viagra* and *The Pill That Revived Sex, Or at Least Talking About It*.

Viagra was voted the "word of the year" in both Germany and in the USA. Hence, many of the former customers of the drugs Aprodastil or Yohimbine immediately started taking Viagra. Moreover, many *new* patients must have adopted Viagra, as evidenced by Figure 2, which shows shipments to pharmacies for Viagra, Aprodastil and Yohimbine. Figure 2 demonstrates that simultaneously with the drop of the former ED drugs, in April 1998 ED drugs experienced an unprecedented consumption level due to the launch of Viagra selling over 14 million units. The figure shows that Aprodastil and Yohimbine now play an insignificant role whereas Viagra dominates the market.

Data on Viagra Users

An important factor to consider when determining the effects of the release of Viagra are the demographic characteristics of the drug's user. To identify demographic information of Viagra users, we collected data from the Prescribed Medicine File from the Household Component from a U.S. Department of Health and Human Services database called the Medical Expenditure Panel Survey (MEPS).[10] It is a collection of results from nationally representative surveys that are distributed to families, individuals, medical providers, and employers throughout the United States. From 1998-2001, MEPS collected data on various demographic characteristics of a random subsample of 158 Viagra users. We present summary statistics of this survey in this subsection.

Figure 3 shows the age distribution of Viagra users. The average Viagra user is 57 years old. The youngest participant in the survey was at 18 years, while the oldest was at 87 years of age. Overall, the distribution of ages appears fairly normal. Specifically, almost 90% of Viagra users in the survey are 45 years of age and older. Due to this age distribution, we establish the treatment group in our analysis as individuals aged 45 and above and the control individuals 25-40. We drop individuals between the ages 41-44. We view this age category as neither in the treatment nor control as some of these individuals may be prescribed Viagra, but not in the concentrations of males aged 45 or over. For a different reason, we drop the 18-24 age group: sexual activity of the 18-24 age group is in all likelihood a poor control for

[10] These data are stored in the yearly Prescribed Medicine Files at http://www.meps.ahrq.gov/mepsweb/.

people aged 45 and above relative to individuals aged 25-40. For example, the 25-40 age demographic has marriage rates much closer to the above 45 age group than 18-24 year olds.

Data on Variables of Interest

We examine how Viagra's introduction affects four different variables of interest. First we examine how Viagra affected gonorrhea rates in the drug's target population (e.g., males age 45 and above).[11] STDs are of interest because it studies the drug's capacity to impact risky behavior associated with *instant* gratification. If Viagra did affect STDs, it is reasonable to expect that gonorrhea rates would be the clearest example: it is one of the most common STDs as it is a bacterial infection that can easily be transmitted by bodily fluids. We examine gonorrhea rates for men of age 45 and above, but also for women. It important to understand how lifestyle drugs affect the agents who do not take the drug directly but rather indirectly enjoy their benefits or suffer from their costs. We obtained state level gonorrhea infection rate data by age and gender via email exchange from the Center for Disease Control. These data are available from the authors upon request.

Second, we test for how Viagra's introduction affects natality rates in the target population. This is a variable of interest because it highlights the drug's capacity to correct a physical disorder and the resulting impact on *planned* decisions. Viagra makes conceiving a child much less costly for the target population (males with ED). Therefore, natality rates could increase upon Viagra's introduction because couples who previously had physical impediments to conception would now be better enabled to conceive.[12] State level natality data by father's age are drawn from the Center of Disease Control Vital Statistics.

Third, we examine how Viagra's introduction affects criminal sexual activity. This is an important variable due to the magnitude of consequences for victims. It is possible that the publicity in the public

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[11] To transfer the raw data of *levels* into age cohort-by-county *rates*, we use the Intercensal Estimates of the Resident Population by the U.S. Census Bureau, Population Division.
[12] It is important to note that unplanned pregnancy rates—in casual encounters for example-- are also enabled. While this is possible, we view this as unlikely given the age of the average Viagra user.

media about Viagra and sex of elderly changed the sexual crime behavior of the elderly population. Hence, whether there has been an increase in such arrests in the United States since the release of Viagra, and if so amongst what age groups is a relevant question. We collected data for (i) sex offenses arrests (that excludes forcible rapes) and (ii) forcible rape arrests in the U.S. by suspect's sex and age group. Sexual offenses includes the following crime subcategories: adultery/fornication, incest, buggery, indecent exposure, seduction and indecent liberties, sodomy or crimes against nature, statutory rape (not forced), and any attempts of the stated categories.[13] County level arrests for sexual offense and rape statistics are collected from the Uniform Crime Reports of the National Archive of Criminal Justice Data for almost 900 US counties.

Lastly, we test for Viagra's effect on divorce rates. This outcome highlights the importance of this particular medical innovation on the household production function and is also a long run planned decision. Viagra is a lifestyle drug that enables increased coital capacity for its users. If the relative benefit of getting married, staying in a marriage, or getting divorced is asymmetrically affected by Viagra then we would expect a significant effect of Viagra's introduction on marriage market in the treatment group. To test this hypothesis, divorce and marriage data were compiled using the Current Population Survey (CPS) of the Bureau of Census for the Bureau of Labor Statistics. This dataset is a time series of random cross-sectional draws of individuals in the US population.

III. Econometric Model

We estimate several econometric models to identify the causal effect of the introduction of Viagra on several outcomes of interest for men and women middle aged and older. Specifically, we estimate the drug's effect on rates of a sexually transmitted disease (gonorrhea), natality rates and sexual offenses rates including rape, and divorce rate. We use state level data for gonorrhea and natality, county-level data

[13] Sex solicitation rates are also not included in this category but in a "catch all" category that includes many other arrests not prevalent to this research. Solicitation rates may be of interest but are only recorded at the local level and time restraints do not allow us to acquire these rates.

aggregated to the state level for crime and individual level data for divorce. We are forced to use state level data in some cases since, to our knowledge, no more granular level data exists.

For every variable of interest, our preferred econometric model uses a difference-in-difference estimator with differential time trends for the treatment and control population. Specifically, we estimate the following model:

$$y_{isgt} = \alpha + \mu_s + f_g(t) + 1\{g \geq 45\}\delta + 1\{t \geq 1999\}\gamma + 1\{g \geq 45\}1\{t \geq 1999\}\beta + \varepsilon_{isgt}. \quad (1)$$

In equation (1), i indexes a location (state or county), g indexes an age group and t the year of observation. We allow for both state fixed effects, μ_s, and an age group specific linear or polynomial time trends represented by $f_g(t)$.[14] We estimate the effect of Viagra's availability on the total population, γ, and the fixed effect of being in the target age group for Viagra over the entire sample period, δ. The coefficient of interest is β which indicates the change in outcome variable of interest for the group intended to be treated by approval and sale of Viagra.

It is important to note that we cannot identify in our data whether a particular individual has consumed Viagra nor how consumption subsequently affects our outcomes of interest. Therefore, even in our CPS data used to analyze divorce rates, our results are market level outcomes. From a policy perspective, though, this is the effect of interest since any public policy targeted toward lifestyle drugs would operate at the market level.

We also estimate equation (1) in both log rates and rates directly for each outcome of interest. While log rates are useful for ease of interpretation, it is problematic for us in some cases: in our data we observe in some low population states or counties some years with zero rates in some age groups for certain variables of interest.[15] Taking the log of these rates leads to dropped observations and severe non-linearity around zero rates. We address this by trimming our datasets in the log rate specification so that

[14] Our differences-in-differences specification with differential time trends is similar in spirit to Blundell et. al. 2004.
[15] For example, in Wyoming there are no recorded sexual assaults for males older than 45.

no state or county with fewer than 10 observed outcomes are ever observed. For example, if a particular state ever has fewer than 10 observed cases of gonorrhea in either the treatment or control group we trim that state from the dataset. We find qualitatively similar results when using other trimming rules.

We also estimate specifications with fewer controls than the full econometric model shown in equation (1). We estimate equation (1) without state fixed effects and time trends in addition to with a common time trend for the control and treatment group. We also estimate versions of the model with both linear and quadratic differential time trends to allow for flexibility in the function $f_g(t)$ for each group. In all cases we use White robust standard errors to correct for potential heteroskedasticity in the error terms. County level regressions are clustered by state and year.

The key identifying assumption in our paper is the timing of treatment. Viagra was first sold commercially in mid-April 1998. We take 1999 to be the starting date of treatment for three reasons. First it is the first complete year that Viagra was legal. Second, our aim is to identify long run effects. Three, any learning about the drug was likely to have occurred in the second half of 1998. In any case, the qualitative results are robust to allowing the treatment date to start in 1998.

IV. Results

Sexually Transmitted Diseases

We estimate the model with state level data for both males and females by age cohort using the CDC dataset. Figure 4 displays the aggregated data for gonorrhea rates by age group and sex. All data are normalized to 100% at the 1999 levels. Panel (a) in Figure 4 shows that gonorrhea rates increased substantially after 1999 for elderly males peaking in 2007 at 70% above of their 1999 levels. In comparison, the control group (age 25 to 40) only increased by 20% by 2007. It is possible that some of the 20% increase in the control group's gonorrhea rates may be transmission of gonorrhea from older to younger cohorts over time. As a result, then, our DD estimates comparing the 70% increase relative to the 20% increase are a lower bound of the effect of Viagra in the elderly population. Female gonorrhea rates are shown in panel (b). While absolute and relative changes in rates across the treatment and control group are smaller in magnitude, they show a qualitatively similar story.

In Figure 4, two additional features are apparent. First, the years 1990 to 1992 experienced a dramatic decline in the STD rates that then leveled off 1993 to 1999. The dramatic decline from 1990-1992 coincides with a time period of large increases in condom usage in the US (Health and Vital Statistics 2010). Starting in 1999, with the introduction of Viagra, the age group trends reverse, with the elderly group showing striking increases of over 70% for males and above 20% for females by 2007. Finally, Figure 4 shows a significant effect of the great recession after 2007. As the recession mainly affected accumulated wealth through the stock market savings, it appears that the elderly group is more responsive to this wealth effect compared to the younger age cohort. We will return to this phenomenon when analyzing the natality data below.

In both panels, changes in treatment and control STD rates track each other over time for both male and female populations. We take this as evidence that using young age cohorts is a valid control for the treatment group. Due to different long run trends, though, in our preferred DD regressions below we control for differential linear and quadratic time trends by age group.

Estimation results are shown in Tables 1 and 2 for males and females respectively. In these and all subsequent tables we present seven versions of the econometric model. While moving left to right specifications (1)-(5) use log of rates as the dependent variable and progressively add more fixed effect controls and/or flexible specifications to control for the time varying effects. Because of using log rates, each of these specifications (1)-(5) trims the sample as described above. Our most flexible specification in log rates is column (4) and (5), which include differential linear and differential polynomial time trends respectively. The last two columns (6) and (7) use rates in levels (and include the entire dataset instead of the trimmed sample). Column (6) shows the results using differential linear time trends and column (7) differential quadratic time trends. Summarizing, columns (4)-(7) are our preferred specifications as they each allow for differential time trends. Our main treatment effect estimate of interest is is the top row corresponding to β of equation (1), here labeled as the Viagra FDA approval treatment variable (in short "VT") in each table.

Table 1 displays the DD regression results for males. Gonorrhea rates in the older population of men unambiguously increases by somewhere between 20-37%. Estimates are larger when the entire dataset is used in specifications (6) and (7). It is also important to note that using quadratic time trends increase the explanatory power of the regressions by over 50% leading us to believe that a linear time trend does a poor job of controlling for variation not explained by the other independent variables. This is also clear from a visual inspection of panel (a) in Figure 4.

Table 2 shows the same estimation results for females. We find a positive effect for both the log rate and the rate specifications that are similar in magnitude to the male specification (28-38%) in our preferred specifications. We also find additional evidence that a uniform or differential linear time trend does a poor job of controlling for the dynamic trends. Specifically, the effect of Viagra on the treatment does not become significant until differential time trends are included

Natality Rates

State level natality data by father's age cohort are drawn from the Center of Disease Control Vital Statistics and are shown in Figure 5. Figure 5 displays the raw aggregated data for natality rates by age group. As before, all data are normalized to the 1999 levels. The data show a long run pre-trend in increased natality rates in the treatment population and no obvious change in that pre-trend. There is a drop in natality rates from 2004-2006 for the treatment group due to missing data for the 55+ age group in some states, but as is clear from the figure, they make up only a small fraction of the natality rate. For the control group, we see a relatively constant natality rate over the sample period. As expected, both groups' natality rates fall with the onset of the great recession in 2008.

Tables (3) and (4) show regression results from a subset of the data displayed in Figure 5. We exclude years 2004 and above due to the missing data problem for the 55+ age cohort, but report the full results in the appendix. They are qualitatively identical to what we report here. Table (3) shows results using data from 1990-2003. In no specification is the variable of interest significant. Furthermore, standard errors are very often twice the size of estimated coefficients. Table (4) shows results from the same regression using data from 1994-2003 to balance the length of the pre-Viagra and post-Viagra periods. We find even larger standard errors in our preferred specifications. We do estimate a significant and negative but small in magnitude coefficient in the simplest specification. We attribute this to noise. Taken together, we view this as there being no evidence that Viagra had any significant effect on natality rates for men in Viagra's target population.

Sexual Offenses and Rape

We collected county level rape and sexual assault arrest data for male perpetrators by age group from the Uniform Crime Reports of the National Archive of Criminal Justice Data. Figure 6 shows the trends in rape and sexual assault normalized to 1999 levels. Both panels show a significant downward trend in criminal activity for both age groups. It is not immediately apparent from the figure that Viagra's approval and sale caused significantly higher sexually related reported criminal activity by the target population.

Table (5) shows the regression results for county level rape arrests over the entire dataset. The three simplest regression specifications find a significantly positive effect of Viagra and rape arrests. These effects, though, are eliminated when more flexible specifications are performed. In the two most flexible specifications, (5) and (7), we find insignificant effects of Viagra on rape arrests. We show in the appendix the same qualitative results when we balance the dataset around years Viagra's introduction.

Table (6) shows the regression results for county level sexual offense arrests over the entire dataset. We find similar results to those from rape: in the simplest specifications we find a positive and significant effect of Viagra on sexual offenses that is eliminated in more flexible specifications. Indeed, we even find a significantly negative effect in specification (5). We attribute this to noise though: as shown in the appendix, when using a balanced dataset around Viagra's introduction this effect goes away. In sum, we find no strong evidence that Viagra affected rates of rape or sexual offenses for the target population of the drug.

Divorce Rates

If Viagra were to have an effect on any major socioeconomic decision, we expect it to be on divorce rates. It is plausible that men who have ED and were in a troubled marriage would have sought out Viagra in an attempt to improve the quality of their married life. To test if Viagra had an effect on divorce rates we collected divorce data from the Current Population Survey (CPS) of the Bureau of Census for the Bureau of Labor Statistics. This data is somewhat different than our other data in that the CPS is collected as a random subsample of the US population each year. The dataset we collected has age and marital status for that year. The average sample size per year for males is 50,879 and for females is 35,242.

Data showing divorce rates by age are displayed in Figure 7. The graph shows divorces per 1000 married households. For both age groups, there is a strong pre-trend before Viagra's approval in 1998. The average number of divorced households is roughly 135 and 123 for the treatment and control respectively over the sample period. It is not clear from a visual inspection that there is any significant break in this pre-trend due to Viagra's introduction. There is a discrete drop in the divorce rate between 2000 and 2001 in the treatment group, but that drop is both more than two full years after Viagra's introduction and coincides with a US recession in that year.

We performed regressions for both male and female divorce rates by age cohort as before. We don't report the results in table form for conciseness. Using a differential linear time trend with divorce rate as the left hand side variable (e.g., column 6 in the tables) we estimate the effect of Viagra on male divorce to be 2.014 but that estimate is insignificant (robust standard error is 2.332). Noting that the divorce rate for men in the treatment group in 1999 is 140 per 1000, this represents a statistically insignificant change of roughly 1.4%. Similarly, we perform the same specification for women and estimate a coefficient of .059 and that estimate is also insignificant (robust standard error is .053). Taken together, these estimates indicate that Viagra had no statistically significant effect in the marriage market.

The results can inform a rudimentary welfare calculation of the effect of Viagra on the target population. For three variables of interest- natality, divorce and rape- we find no evidence that Viagra had a statistically significant effect on the target population. We find that Viagra's introduction increased gonorrhea rates 20-40% for both men and women older than 45. According to the CDC, the average gonorrhea rate in the 45-55 age group ranged from 20.8-30.3 per 100,000 and 6.0-9.7 for 55-65 with negligible rates for ages 65+.[16] Taking the upper bounds for both, our estimates of the gonorrhea rate increases due to Viagra, average gonorrhea rates by age from the CDC and population by age data from the census from 2011, it implies that Viagra is responsible for at most an additional 4,830 cases of gonorrhea per year in the target population.[17] Gonorrhea is commonly treated with Cefixime, which has inexpensive generic versions for no more than $40. Therefore, this yearly negative cost due to Viagra's introduction is on the order of $200,000. This number is dwarfed by annual sales of Viagra, which is a lower bound for consumer surplus associated with its use. As a result, we conclude that Viagra's introduction led to a massive welfare increase accounting for any costs associated with the variables of interest studied here.

V. Conclusion

We use the introduction of a well-publicized and heavily prescribed lifestyle drug, Viagra, to test for how that drug affects outcomes for the target age cohort. We are studying four types of lifestyle choices of economic importance: enabled risky behavior associated with instant gratification (STD rates), enabled

[16] http://www.cdc.gov/std/stats11/tables/21.htm. Last retrieved October 17, 2013.
[17] http://www.census.gov/population/age/data/2011comp.html. Last retrieved October 17, 2013.

planned behavior (natality and divorce), and enabled criminal behavior (sexual assault and rape). We find evidence that the drug increased STDs in the target population but that no other variable of interest was affected. As a result, we find that this particular medical innovation targeted toward older age cohorts only led to changes in short term decision making rather than long run decision making. Overall, in a back of the envelope cost benefit analysis, we find that the welfare impacts of Viagra with respect to our outcomes of interest are positive and large.

These results have important implications for the economics literature. First, as the population ages, more resources will be invested in improving the elderly's quality of life by the development of medical innovations. As other new groundbreaking medical innovations are introduced, such as artificial organs, our results imply that there might not be substantial changes in some long run planned economic decisions of the elderly. Second, these results contribute to a large economic literature on how endowments and choice sets influence decision making (Kahneman et. al. 1991 and Rabin 1998). If an individual does not have the ability to engage in a variety of choices and suddenly is given that ability, we find their decisions tend to be no different except for relatively low cost risky decisions associated with instant gratification. It could be that self-control problems are a major challenge, even for experienced decision makers. These questions could be important avenues for future research to better understand decisions in an aging population.

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TABLE 1: Impact of Viagra on Rate of Gonorrhea Cases 1990-2011: US Males

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	log rate	log rate	log rate	log rate	log rate	rate	rate
VT	0.281	0.281	0.281	0.210	0.281	0.369	0.319
	(0.075)***	(0.048)***	(0.047)***	(0.064)***	(0.075)***	(4.776)	(0.071)***
45+	-3.887	-3.887	-3.887	-3.932	-4.100	-131.240	-3.684
	(0.066)***	(0.042)***	(0.040)***	(0.054)***	(0.090)***	(7.197)***	(0.088)***
t > 1998	-0.182	-0.182	-0.013				
	(0.055)***	(0.031)***	(0.044)				
Linear trend			-0.015				
			(0.003)***				
Linear $\text{trend}_{25\text{-}40}$				-0.018	-0.093	-2.199	-0.076
				(0.002)***	(0.009)***	(0.434)***	(0.008)***
Linear trend_{45+}				-0.010	-0.045	-0.033	-0.078
				(0.005)**	(0.017)***	(0.369)	(0.016)***
Quad. $\text{Trend}_{25\text{-}40}$					0.003		0.003
					(0.000)***		(0.000)***
Quad. Trend_{45+}					0.001		0.003
					(0.001)**		(0.001)***
Constant	5.045	4.738	4.815	4.833	5.135	153.567	2.960
	(0.047)***	(0.055)***	(0.055)***	(0.056)***	(0.070)***	(10.704)***	(0.172)***
R^2	0.93	0.97	0.97	0.97	0.98	0.60	0.94
N	836	836	836	836	836	2,242	2,133

Unit of observation is STD rate in a state by year by age group from 1990 to 2011. Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate.

* p<0.1; ** p<0.05; *** p<0.01. All columns have robust SEs.

Columns (2)-(7) include State FEs

Columns (4) and (6) include differential linear time trends

Columns (5) and (7) include differential quadratic time trends

Columns (1)-(5) drop 32 states that ever have less than 10 cases in a given age category in a given year.

Note that in 1999 there were 30,687 reported cases of gonorrhea in males 25-40 and 1,326 in males 45+.

TABLE 2: Impact of Viagra on Rate of Gonorrhea Cases 1990-2011: US Females

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	0.077	0.077	0.077	0.286	0.285	2.297	0.372
	(0.074)	(0.047)	(0.039)*	(0.052)***	(0.058)***	(9.746)	(0.059)***
45 +	-2.306	-2.306	-2.306	-2.264	-2.461	-252.726	-2.353
	(0.063)***	(0.040)***	(0.033)***	(0.046)***	(0.075)***	(18.473)***	(0.080)***
t > 1998	-0.388	-0.388	0.196				
	(0.053)***	(0.033)***	(0.040)***				
Linear trend			-0.053				
			(0.003)***				
Linear trend$_{25\text{-}40}$				-0.040	-0.089	-8.838	-0.075
				(0.002)***	(0.008)***	(1.141)***	(0.008)***
Linear trend$_{45+}$				-0.054	-0.054	-0.981	-0.074
				(0.005)***	(0.014)***	(0.766)	(0.014)***
Quad. Trend$_{25\text{-}40}$					0.002		0.002
					(0.000)***		(0.000)***
Quad. Trend$_{45+}$					-0.000		0.001
					(0.000)		(0.000)***
Constant	5.641	5.258	5.524	5.487	5.683	347.397	2.746
	(0.048)***	(0.045)***	(0.038)***	(0.040)***	(0.051)***	(28.895)***	(0.090)***
R^2	0.84	0.93	0.95	0.95	0.96	0.52	0.93
Number of observations	836	836	836	836	836	2,242	2,203

* p<0.1; ** p<0.05; *** p<0.01, all columns have robust SEs
Columns (2)-(7) include State FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate
Columns (1)-(5) drop 32 states that ever have less than 10 cases in a given age category in a given year

Note that in 1999 there were 55,071 reported cases of gonorrhea in females 25-40 and 8,169 in females 45+

TABLE 3: Impact of Viagra on Rate of Births 1990-2003:
2 Age categories- by age of Father, State level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	-0.011	-0.011	-0.011	-0.013	-0.007	-0.704	-0.678
	(0.026)	(0.019)	(0.019)	(0.024)	(0.029)	(70.385)	(85.097)
45+	-3.745	-3.745	-3.745	-3.776	-3.880	-6,890.327	-7,613.520
	(0.016)***	(0.012)***	(0.012)***	(0.023)***	(0.033)***	(70.396)***	(97.892)***
t > 1998	0.070	0.070	0.043				
	(0.011)***	(0.014)***	(0.020)**				
Linear trend			0.004				
			(0.002)*				
Linear $\text{trend}_{25\text{-}40}$				0.006	-0.030	45.348	-225.840
				(0.002)***	(0.007)***	(6.168)***	(22.488)***
Linear trend_{45+}				0.010	0.013	1.477	1.487
				(0.003)***	(0.008)*	(8.358)	(20.593)
Quad. $\text{Trend}_{25\text{-}40}$					0.002		18.079
					(0.000)***		(1.485)***
Quad. Trend_{45+}					-0.000		-0.001
					(0.001)		(1.569)
Constant	8.874	8.794	8.775	8.773	8.871	7,578.390	8,301.558
	(0.007)***	(0.046)***	(0.048)***	(0.047)***	(0.050)***	(128.340)***	(133.289)***
R^2	0.98	0.99	0.99	0.99	0.99	0.98	0.98
N	1,428	1,428	1,428	1,428	1,428	1,428	1,428

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All columns have robust SEs
Columns (2)-(7) include State FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate

TABLE 4: Impact of Viagra on Rate of Births 1994-2003:
2 Age categories- by age of Father, State level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	-0.049	-0.049	-0.049	-0.007	-0.007	-0.564	-0.564
	(0.029)*	(0.022)**	(0.022)**	(0.031)	(0.031)	(92.083)	(92.179)
45+	-3.707	-3.707	-3.707	-3.653	-3.760	-6,078.075	-6,838.021
	(0.021)***	(0.015)***	(0.015)***	(0.049)***	(0.133)***	(144.294)***	(399.835)***
t > 1998	0.086	0.086	0.027				
	(0.013)***	(0.015)***	(0.025)				
Linear trend			0.012				
			(0.004)***				
Linear $trend_{25-40}$				0.017	-0.005	122.952	-53.538
				(0.003)***	(0.020)	(8.832)***	(64.162)
Linear $trend_{45+}$				0.009	0.012	1.463	1.059
				(0.006)	(0.022)	(16.040)	(61.475)
Quad. $Trend_{25-40}$					0.001		9.289
					(0.001)		(3.397)***
Quad. $Trend_{45+}$					-0.000		0.021
					(0.001)		(3.126)
Constant	8.858	8.798	8.715	8.683	8.775	6,810.856	7,572.548
	(0.009)***	(0.052)***	(0.058)***	(0.056)***	(0.101)***	(163.269)***	(318.607)***
R^2	0.98	0.99	0.99	0.99	0.99	0.98	0.98
N	1,020	1,020	1,020	1,020	1,020	1,020	1,020

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All columns have robust SEs
Columns (2)-(7) include State FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate

TABLE 5: Impact of Viagra on Rate of Rape Arrests 1994-2010:
2 Age categories, US Males, County level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	0.186	0.186	0.186	-0.046	-0.079	0.070	-0.103
	(0.064)***	(0.040)***	(0.040)***	(0.052)	(0.072)	(0.450)	(0.639)
45+	-1.734	-1.734	-1.734	-1.807	-1.819	-35.899	-35.591
	(0.053)***	(0.034)***	(0.034)***	(0.039)***	(0.075)***	(0.723)***	(1.252)***
t > 1998	-0.382	-0.382	-0.126				
	(0.042)***	(0.024)***	(0.033)***				
Linear trend			-0.030				
			(0.003)***				
Linear $trend_{25-40}$				-0.044	-0.037	-0.890	-0.736
				(0.002)***	(0.010)***	(0.063)***	(0.274)***
Linear $trend_{45+}$				-0.018	-0.004	-0.033	0.039
				(0.005)***	(0.022)	(0.041)	(0.190)
Quad. $Trend_{25-40}$					-0.000		-0.009
					(0.001)		(0.014)
Quad. $Trend_{45+}$					-0.001		-0.003
					(0.001)		(0.008)
Constant	3.643	3.650	3.741	3.777	3.755	44.051	43.564
	(0.034)***	(0.062)***	(0.067)***	(0.068)***	(0.074)***	(2.726)***	(2.872)***
R^2	0.54	0.83	0.84	0.84	0.84	0.43	0.43
N	2,550	2,550	2,550	2,550	2,550	18,258	18,258

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All columns have robust SEs
Columns (2)-(7) include County FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate
Columns (1)-(5) drop 462 counties that ever have 0 arrests in a given age category in a given year

TABLE 6: Impact of Viagra on Rate of Sexual Offense Arrests 1994-2010: 2 Age categories, US Males, County level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	0.104	0.104	0.104	-0.018	-0.078	0.029	0.633
	(0.038)***	(0.023)***	(0.023)***	(0.028)	(0.040)*	(0.898)	(1.270)
45+	-1.089	-1.089	-1.089	-1.144	-1.148	-60.625	-54.481
	(0.032)***	(0.020)***	(0.020)***	(0.023)***	(0.043)***	(1.276)***	(2.243)***
t > 1998	-0.230	-0.230	-0.047				
	(0.026)***	(0.015)***	(0.021)**				
Linear trend			-0.022				
			(0.002)***				
Linear $\text{trend}_{25\text{-}40}$				-0.028	-0.010	-1.233	0.510
				(0.001)***	(0.006)*	(0.109)***	(0.482)
Linear trend_{45+}				-0.013	0.012	-0.250	-0.500
				(0.003)***	(0.012)	(0.084)***	(0.385)
Quad. $\text{Trend}_{25\text{-}40}$					-0.001		-0.097
					(0.000)***		(0.025)***
Quad. Trend_{45+}					-0.001		0.011
					(0.001)**		(0.017)
Constant	4.283	4.001	4.066	4.094	4.036	92.164	86.645
	(0.022)***	(0.107)***	(0.103)***	(0.104)***	(0.106)***	(3.642)***	(4.064)***
R^2	0.26	0.75	0.76	0.76	0.76	0.45	0.45
N	9,690	9,690	9,690	9,690	9,690	29,614	29,614

* p<0.1; ** p<0.05; *** p<0.01
All columns have robust SEs
Columns (2)-(7) include County FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate
Columns (1)-(5) drop 586 counties that ever have 0 arrests in a given age category in a given year

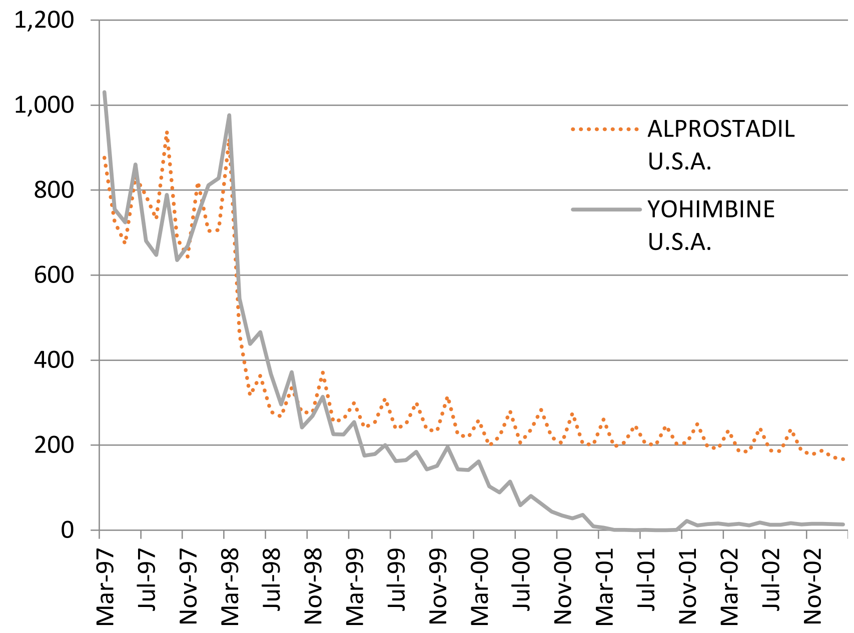


Figure 1: Prescribed units (in thousands) sold of Aprodastil and Yohimbine March 1997 to February 2003 in the U.S.A.

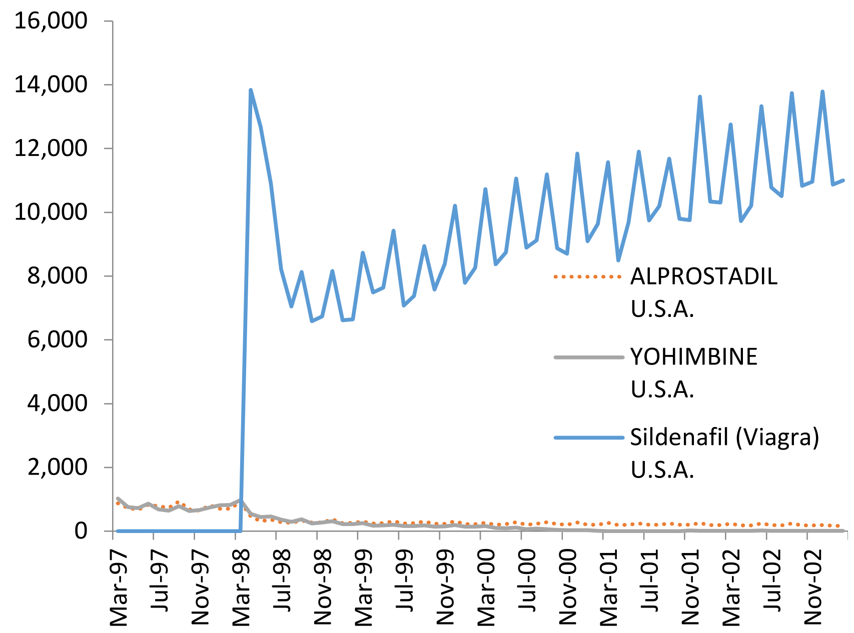


Figure 2: Prescribed Units (in Thousands) sold of all ED related medications, Mar 1997 to Feb 2005, USA

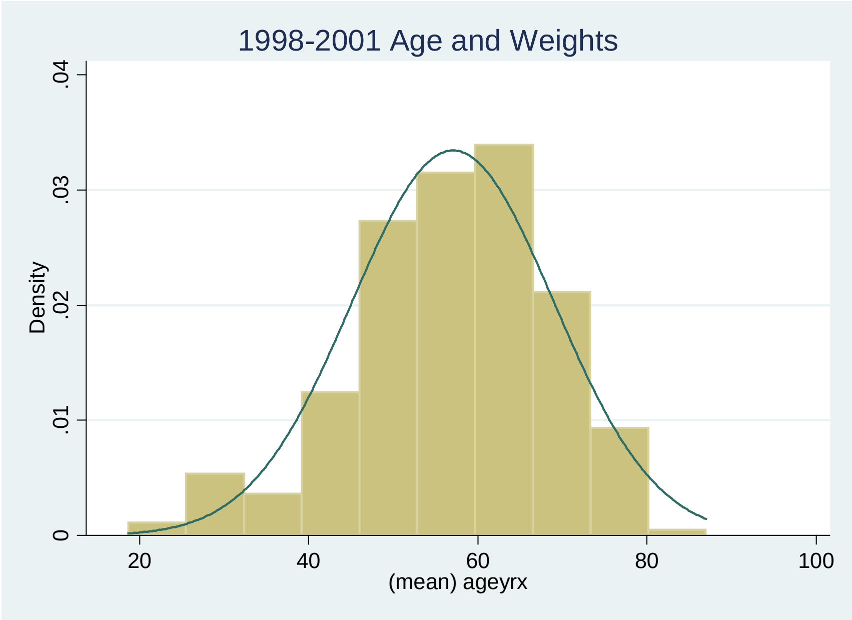
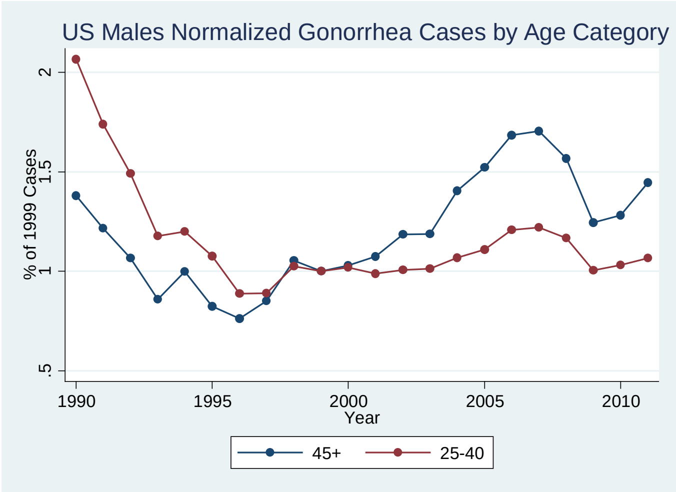
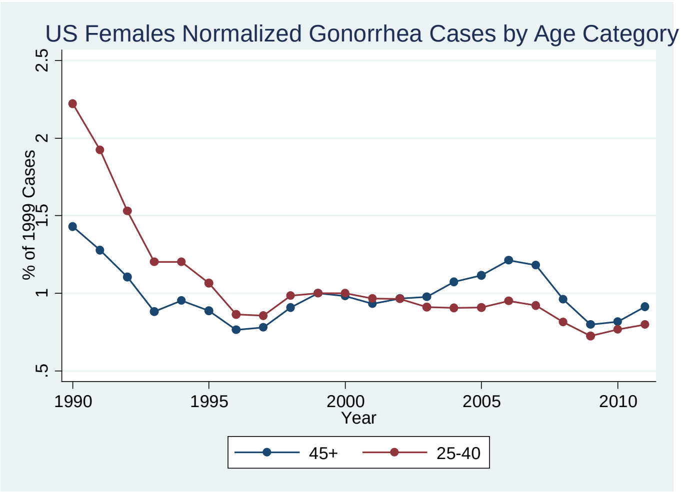


Figure 3: Histogram of US Viagra users by age. Data from MEPS survey of Viagra users from 1998-2001.



(a) Male gonorrhea rates by age group



(a) Male gonorrhea rates by age group

Figure 4: Gonorrhea rates by age and sex. State level population weighted data shown. Data obtained from CDC. Data normalized to 1999, the first full year Viagra available for sale.

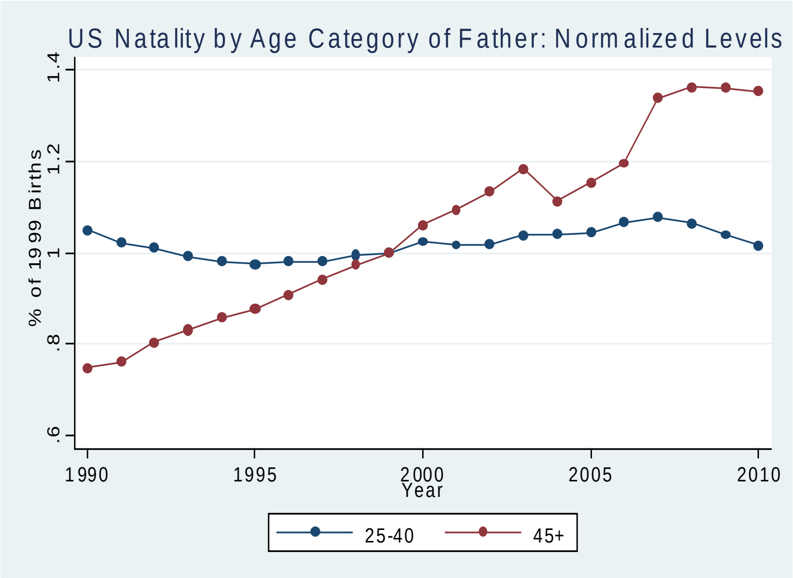
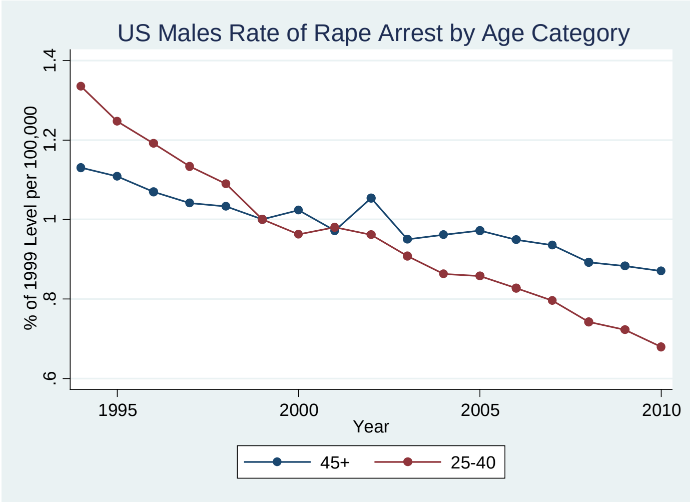
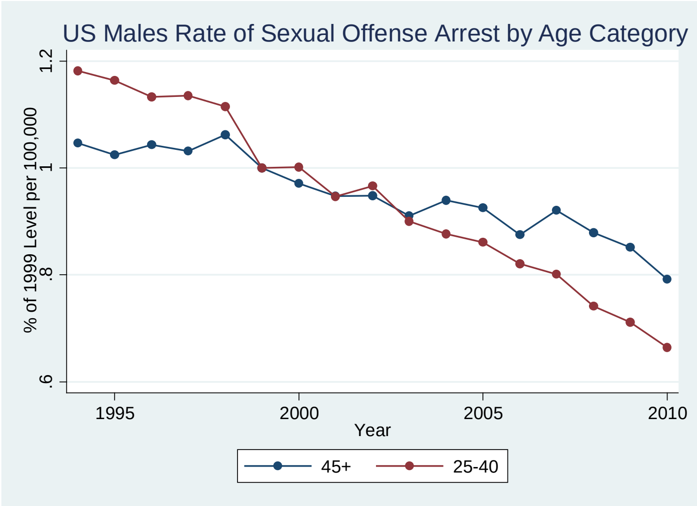


Figure 5: Natality rates by father's age. Data normalized to 1999, the first full year Viagra available for sale. State level natality data are drawn from the Center of Disease Control Vital Statistics.



(a) County level data normalized to 1999 level.



(b) County level data normalized to 1999 level.

Figure 6: Rape and sexual assault data. Data normalized to 1999, the first full year Viagra available for sale. The data are collected from the Uniform Crime Reports of the National Archive of Criminal Justice Data.

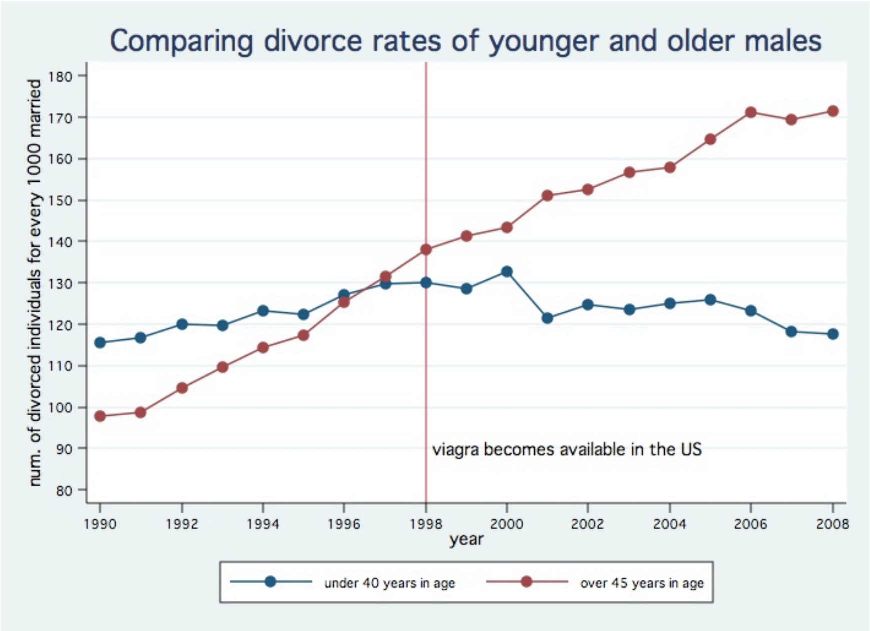


Figure 7: Divorces per 1000 married households for males. Red vertical line is 1998 when Viagra first approved. The data are from the Current Population Survey (CPS) of the Bureau of Census for the Bureau of Labor Statistics.

IV. Appendix

TABLE 1A: Estimating the Impact of Viagra on Rate of Births 1990-2010:
(2004-2006 omitted due to missing data for age 55+)
2 Age categories by age of Father, State level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	-0.028	-0.028	-0.028	0.016	0.001	2.991	1.135
	(0.022)	(0.017)*	(0.016)*	(0.021)	(0.021)	(59.924)	(62.529)
agetreat	-3.745	-3.745	-3.745	-3.741	-3.816	-6,814.934	-7,087.157
	(0.016)***	(0.012)***	(0.012)***	(0.017)***	(0.029)***	(53.421)***	(86.459)***
timetreat	0.098	0.098	0.052				
	(0.009)***	(0.011)***	(0.017)***				
time			0.004				
			(0.001)***				
trend_y				0.008	-0.002	58.270	-11.732
				(0.001)***	(0.004)	(3.515)***	(13.937)
trend_o				0.005	0.016	0.868	2.104
				(0.002)***	(0.005)***	(4.897)	(13.019)
trend2_y					0.000		3.146
					(0.000)***		(0.607)***
trend2_o					-0.000		-0.050
					(0.000)**		(0.489)
Constant	8.874	8.741	8.719	8.711	8.747	7,048.809	7,316.433
	(0.007)***	(0.029)***	(0.030)***	(0.030)***	(0.033)***	(51.683)***	(72.281)***
R^2	0.98	0.99	0.99	0.99	0.99	0.98	0.98
N	1,836	1,836	1,836	1,836	1,836	1,836	1,836

* p<0.1; ** p<0.05; *** p<0.01
All columns have robust SEs
Columns (2)-(7) include State FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate

TABLE 2A: Impact of Viagra on Rate of Rape Arrests 1994-2003: 2 Age categories, US Males, State level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	0.155	0.155	0.155	-0.036	-0.036	0.313	0.313
	(0.083)*	(0.044)***	(0.044)***	(0.070)	(0.069)	(0.901)	(0.902)
agetreat	-1.815	-1.815	-1.815	-1.902	-1.901	-25.642	-27.042
	(0.061)***	(0.029)***	(0.028)***	(0.054)***	(0.086)***	(1.168)***	(2.051)***
timetreat	-0.263	-0.263	-0.146				
	(0.054)***	(0.027)***	(0.042)***				
time			-0.023				
			(0.008)***				
trend_y				-0.048	-0.080	-0.830	-1.609
				(0.005)***	(0.021)***	(0.149)***	(0.691)**
trend_o				-0.014	-0.047	-0.082	-0.161
				(0.013)	(0.029)	(0.163)	(0.383)
trend2_y					0.003		0.071
					(0.002)		(0.057)
trend2_o					0.003		0.007
					(0.003)		(0.032)
Constant	3.464	3.554	3.624	3.684	3.748	31.204	32.761
	(0.040)***	(0.029)***	(0.037)***	(0.036)***	(0.052)***	(1.004)***	(1.811)***
R^2	0.80	0.95	0.95	0.95	0.95	0.79	0.79
N	440	440	440	440	440	840	840

* p<0.1; ** p<0.05; *** p<0.01
All columns have robust SEs
Columns (2)-(7) include State FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate
Columns (1)-(5) drop 20 states that ever have 10 or fewer arrests in a given age category in a given year

TABLE 3A: Impact of Viagra on Rate of Sexual Offense Arrests 1994-2003: 2 Age categories, US Males, County level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VT	0.039	0.039	0.039	-0.055	-0.055	0.997	0.997
	(0.046)	(0.026)	(0.026)	(0.041)	(0.041)	(1.442)	(1.442)
agetreat	-1.089	-1.089	-1.089	-1.135	-1.161	-56.476	-56.581
	(0.032)***	(0.019)***	(0.019)***	(0.032)***	(0.054)***	(1.797)***	(3.175)***
timetreat	-0.135	-0.135	-0.065				
	(0.032)***	(0.017)***	(0.028)**				
time			-0.014				
			(0.005)***				
trend_y				-0.025	-0.027	-0.590	-1.293
				(0.003)***	(0.014)**	(0.246)**	(1.139)
trend_o				-0.008	0.002	-0.523	-1.174
				(0.007)	(0.018)	(0.253)**	(0.613)*
trend2_y					0.000		0.064
					(0.001)		(0.099)
trend2_o					-0.001		0.059
					(0.001)		(0.049)
Constant	4.283	4.163	4.205	4.234	4.238	73.443	74.850
	(0.022)***	(0.148)***	(0.148)***	(0.147)***	(0.149)***	(8.651)***	(8.985)***
R^2	0.28	0.78	0.78	0.78	0.78	0.49	0.49
N	5,700	5,700	5,700	5,700	5,700	17,420	17,420

* $p<0.1$; ** $p<0.05$; *** $p<0.01$
All columns have robust SEs
Columns (2)-(7) include County FEs
Column (3) includes a time trend
Columns (4) and (6) include differential linear time trends
Columns (5) and (7) include differential quadratic time trends
Columns (1)-(5) have lograte as the dependent variable and columns (6)-(7) use rate
Columns (1)-(5) drop 586 counties that ever have 0 arrests in a given age category in a given year