LEARNING FROM TEEN CHILDBEARING EXPERIENCES OF CLOSE FRIENDS: EVIDENCE USING MISCARRIAGES AS A NATURAL EXPERIMENT[1]

Olga Yakusheva, Jason Fletcher

Abstract**:** This study examines peer effects in teen childbearing among close friends, using miscarriages as a natural experiment. Conditional on a friend's pregnancy, the occurrence of a friend's miscarriage is a quasi-exogenous fertility shock and is conditionally uncorrelated with the unobservable factors. A total of 775 women from the core sample of Add Health had at least one friend with a teen pregnancy, of whom 152 had a friend whose pregnancy ended in a miscarriage. The results suggest the existence of a sizable *negative* local treatment effect – a close friend's teen birth is associated with a 6 percentage point reduction in the likelihood of own teen pregnancy and childbearing. There is evidence that this effect operates through a learning mechanism by changing beliefs regarding early childbearing. Effects of teen pregnancy prevention policies may be partially offset by reductions in the opportunities for social learning.

JEL Codes: I18, J13

Corresponding Author: Yakusheva; Mailing Address: 60 College St., P.O. Box 208034, New Haven, CT 06520; Tel: (262) 901-5186; Fax: (203) 785-6287; Email: olga.yakusheva@yale.edu

Word count: 11,748

[1]Yakusheva thanks AHRQ for funding support from the T-32 Postdoctoral Training Grant in Health Services Research (5 T32 HS 17589-4). Fletcher thanks the Robert Wood Johnson Foundation Health & Society Scholars program and the NICHD (1R21HD066230) for its financial support. We thank Lisa Kahn, Costas Meghir, Stephen Ross, John Cawley, Jody Sindelar, Mark Schlesinger, and seminar participants at the Macmillan Center for International and Area Studies, the Economics Labor Lunch and the Health Policy and Administration Seminar at Yale University, and the Department of Policy Analysis and Management Seminar at Cornell University. This research uses data from Add Health, a program project directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina at Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (http://www.cpc.unc.edu/addhealth). No direct support was received from grant P01-HD31921 for this analysis.

I. Introduction

Teenage childbearing is associated with a host of negative consequences for teen mother and their children. Each year, close to a third of a million US girls age 15 through 19 have a child (Hamilton et al. 2010), and almost three quarters of these births result from pregnancies that were unintended (Harrison et al. 2012). Federal programs aimed at preventing teen pregnancy were projected to cost the US government close to $200 million in 2010 alone (Department of Health and Human Services 2009) – yet the teenage birth rate in the United States remains the highest among all developed countries (United Nations, 2010).

A growing body of empirical literature points to the importance of a teen's social environment as a determinant of a range of health behaviors and outcomes, including teen pregnancy and childbirth. While most of the existing studies find evidence of positive peer influence, meaning that adolescents engage in behaviors similar to those of their peers, there are two reasons why this may be the case. First, theories of the mechanisms underlying peer influence – knowledge externalities (i.e. learning from peers or their experiences), network externalities (e.g. increasing returns to scale in joint childrearing with peers), and social norms (e.g. peer childbearing reducing the social stigma of teen childbirth) – all suggest that behaviors are likely to be positively correlated within peer groups. Second, empirical estimates of peer effects can be biased upward due to, for example, peer selection or shared environmental influences, and few of the existing studies offer research designs capable of credibly isolating the true causal peer effect from these confounding influences.

The key contribution of the present study is the novel finding of a *negative* local treatment effect of teen childbirth of a close friend on own likelihood of teen pregnancy and childbearing. While often not found in empirical research, negative peer correlations in behaviors

have some compelling theoretical motivations, one of which is the knowledge externality generated from learning the consequences of peer behaviors[2]. Indeed, in some behaviors, such as teen childbearing, we might imagine the possibility of a large amount of learning about the difficulties of being a teen mother if a high school friend has a child. This knowledge externality may lead to negative correlations in peer behaviors within peer groups. We present evidence consistent with the notion that the negative effect appears to operate through a learning mechanism by changing beliefs about teen motherhood and reducing pregnancy and childbearing. Our finding is highly policy relevant because it suggests that policies that are successful in reducing teenage childbearing may be partially offset in their overall effects due to the unintended negative spill-over effect of limiting learning opportunities from peer's childbearing experiences (i.e. reducing knowledge externalities).

I. Background Literature

Negative consequences of teen childbearing are well documented and include, among others, lower educational attainment and increased participation in welfare programs (Angrist and Evans 1996; Chevalier and Viitanen 2003; Fletcher and Wolfe 2009; Levine and Painter 2003). The children of teen mothers are at a higher risk of premature birth and low birth weight, reduced educational attainment, and they are more likely to be incarcerated as adults (Martin et al. 2010; Mathews and MacDorman 2010). Furthermore, the daughters of teen mothers are significantly more likely to have a teen childbirth themselves (Manlove et al. 2008; Hoffman and Scher 2008).

Studies found that adolescents may be susceptible to peer influence along multiple margins of fertility choice, from initiation of sexual activity (Fletcher 2007; Richards-Shubick

[2] Network externalities could also generate negative peer correlations in behavior if the behaviors were subject to congestion effects.

2011; Ali and Dwyer 2011), to pregnancy (Evans et al. 1992; Fletcher and Yakusheva 2012), to, ultimately, childbearing (Case and Katz 1991; Kuziemko 2006; Monstad et al. 2011). This tendency toward adoption of peers' fertility-related behaviors was found to exist in a variety of peer group settings including neighborhoods (Case and Katz 1991; Evans et al. 1992), classmates (Fletcher 2007; Richards-Shubick 2011; Fletcher and Yakusheva 2012), co-workers (Hensvik et al. 2011), siblings (Kuziemko 2006; Monstad et al. 2011), and close friends (Ali and Dwyer 2011).

Our understanding of the mechanism of social transmission of adolescent childbearing is rather limited. Empirical evidence of the role of knowledge externalities as a conduit for peer influence in teen pregnancy, the key finding of this study, has been particularly limited in the existing literature. Only one existing study finds some evidence consistent with the notion of knowledge externalities between sisters (Kuziemko 2006). However, there is a significant body of theoretical and conceptual developments outside of the peer effects literature, particularly in the context of contraceptive and other fertility information dissemination and its contribution to declining fertility and other demographic trends (Behrman et al. 2001; Munshi and Myaux 2006; Montgomery and Casterline, 1996). Evidence consistent with network externalities in peer influence (i.e. increase in the net benefit of childbearing when your peer has a child through, for example, economies of scale in joint childrearing) has been documented by a small number of peer effect studies examining, for example, correlation in timing of childbearing among co-workers (Hensvik et al. 2011) and siblings (Kuziemko 2006). Most peer effect studies argue for social norms as the leading mechanism behind social contagion in teen pregnancy, whereby exposure to high rates of adolescent pregnancy reduces the "stigma cost" of being a teenage mother (Case and Katz 1991; Fletcher and Yakusheva 2012). While these mechanisms of peer

influence are likely not mutually exclusive, being able to distinguish between them is key to designing successful teen pregnancy prevention policy.

The sign of the peer effect in fertility depends on the mechanism through which peer influence is transmitted. In particular, when correlation in peer behaviors occurs through the learning mechanism, its sign is theoretically undetermined. Shlag (1998) demonstrates situations where the optimal choice under uncertainty stipulates to not imitate behaviors of individuals whose realized outcomes are worse than oneself and imitate those whose realized outcomes are better (with probability proportional to the difference in realizations). Under this rule, observing a friend have a teen childbirth will increase a woman's likelihood of becoming a teen mother herself if she perceives her friend's fertility experience as being positive and better than her own, and decrease her chances of becoming a teen mother if she views it as having substantial negative consequences. On the other hand, existing theories and empirical finding on social norms and network externalities are characterized by conformity of peer behavior, or increased propensity of an individual to choose behaviors similar to those of their peers, even in the face of a negative payoff (Banerjee 1992; Bikhchandani et al.1998; Case and Katz 1991; Hansvik et al. 2011; Richards-Shubik 2011; Fletcher and Yakusheva 2012).

Difficulties in establishing the mechanism of peer influence aside, estimating the magnitude of reduced-form peer influence presents an significant empirical challenge in itself as the causal peer effect is often muddled by unobserved peer selection, simultaneity of peer influence, and exposure to common contextual effects (Manski 1993). Existing studies use a number of empirical approaches from variations of combined fixed effects and instrumental variable models (Evans et al. 1992; Richards-Shubik 2011; Ali and Dwyer 2011; Fletcher 2007; Fletcher and Yakusheva 2012), to exploiting the timing of outcomes (Kuziemko 2006; Hensvik

et al. 2011). One recent study utilizes a natural experiment, a school-level educational reform in Norway, to measure the impact of the intervention targeting the older sister on the fertility outcomes of the younger sister (Monstad et al. 2011).

This paper relies on a natural experiment, friend's miscarriage, to measure the impact of a quasi-random fertility shock to the peer on the fertility outcomes (pregnancy, childbearing) of the focus individual. Our identifying assumption is that conditional on a friend's pregnancy, the occurrence of a friend's miscarriage is an exogenous fertility shock that is uncorrelated with the unobservable factors. Under this assumption, miscarriage-based estimates of peer effect are free from the selection bias that many earlier peer effects studies struggle with. We deal with the reflection bias by lagging the model and control for school-level fertility measures to account for the shared environment bias. If the assumption of exogeneity of miscarriage is violated, our estimates would most likely reflect a lower-bound effect because selection, reflection and shared environment biases would suggest positive correlations in fertility behaviors.

Use of miscarriage as a strategy to partition random variation in childbirth from systematic variation due to unobservable factors was pioneered by Hotz et al. (1997, 2005). Since then, this identification strategy has been used to measure the impact of a teen parenthood on a host of mother's subsequent outcomes including educational attainment, earnings, and welfare dependence (Hotz et al. 2005; Ashcraft and Lang 2006; Fletcher and Wolfe 2009)[3]. Although miscarriage has been used in a number of studies to examine the effects of teen childbearing on own and child outcomes, our paper is unique in utilizing the fertility shocks of miscarriage of friends to examine peer effects in fertility decisions.

II. Miscarriage as a natural experiment

[3] Fletcher and Wolfe (2011) utilize miscarriages to examine the impact of a teen birth on the teen father. They compare the outcomes of male adolescents whose partner had a teen childbirth to those whose partner's teen pregnancy ended in a miscarriage and find a modest negative effect on educational attainment.

Miscarriage, also referred to as spontaneous abortion, is defined as loss of the intrauterine product prior to the viability of the fetus, usually before the 24th week of pregnancy (Llewellyn-Jones 1995). According to the American College of Obstetricians and Gynecologists, 10-25% of all known pregnancies end in a miscarriage (American College of Obstetricians and Gynecologists 2011). This number is likely higher because many miscarriages happen very early, before the woman knows she is pregnant.

While the etiology of miscarriage varies, chromosomal abnormalities is the most common factor and studies have found some chromosomal abnormality in 50-80% of all examined first trimester losses (American College of Obstetricians and Gynecologists 2011; Royal College of Obstetricians 1997; Kajii et al. 1980; Eiben et al, 1990; Hogge et al. 2003; Philipp et al. 2003). Other frequent risk factors include anatomical or immunological abnormalities that can cause the mother's body to reject the pregnancy (Christianson 1979; Llewellyn-Jones 1995; Cramer and Wise 2000; Regan and Rai 2000; Lerner 2003). Infections, as well as certain systemic medical illnesses (diabetes, thyroid disease, lupus), are also believed to cause miscarriage, with as many as a half of pregnancies to women with diabetes ending in miscarriage (Llewellyn-Jones 1995; Cramer and Wise 2000; McDonald and Chambers 2000; Lerner 2003; Matovina et al. 2004). There is also a tentative link between certain environmental factors (e.g. pollutants) and miscarriage risk (Green et al. 2009; Sunil 2011). Lastly, substance abuse (cigarette, alcohol, drugs) has been associated with increased miscarriage risk (Baba et al. 2011; Venners et al. 2004; Llewellyn-Jones 1995; Lerner 2003); however the 2004 Surgeon General's report concluded that evidence is insufficient to infer a causal relationship between smoking and miscarriage (USDHHS 2004).

While close to 70 percent of all miscarriages happen before the 12th week of pregnancy, the timing of miscarriage varies (see Figure 1.A). Cytogenetic analysis studies have shown that chromosomal abnormalities can cause spontaneous miscarriage at a range of gestational ages accounting for over 50 percent of all pregnancies lost before week 12 (with the peak prevalence at weeks 10-11) and over 35 percent of all pregnancies lost after week 12 (Kajii et al. 1980; Eiben et al, 1990; Hogge et al. 2003; Philipp et al. 2003). Second trimester losses (after week 12) are less frequent and more likely to be caused by developmental (non-chromosomal) fetal abnormalities (e.g. spina bifida), as well as by maternal anatomic factors, immunologic factors, and infection (Cramer and Wise 2000; McDonald and Chambers 2000; Matovina et al. 2004; Thomas and Tiu, 2007).

Our identification strategy relies on the assumption that miscarriages are correlated with the friend's childbearing status and uncorrelated with unobservable characteristics of the woman. While miscarriages resulting from chromosomal or anatomical abnormalities are plausibly exogenous, some of the other risk factors could violate our identifying assumption. For example, if women and their friends are exposed to the same environmental factor that put all of them at an increased risk of a miscarriage, the miscarriage-based estimate will be biased upward. In fact, Fletcher and Wolfe (2009) found evidence of systematic variation in miscarriage rates across communities and schools and demonstrated that miscarriage-based estimates of the impact of teen childbirth are reduced when this systematic variation is controlled for with community- or school-level fixed effects. Similar to Fletcher and Wolfe (2009), we find systematic variation in miscarriage rates across schools and control for school-level aggregate fertility outcomes (including miscarriage) in our analysis.

In addition to shared environmental factors, women who are at a higher risk of miscarriage due to underlying health issues (or because they engage in substance abuse) may choose friends with similar characteristics, in which case the estimates will also be subject to peer selection bias. Hotz et al. (1997) constructed bounds, presumably containing the true causal effect, based on a proportion of all miscarriages that are believed to be random, and found their estimates to be robust to potential non-randomness. However, this approach has been criticized on the grounds that the width of the bounds depends critically on the untestable assumption regarding the proportion of all miscarriages that are truly random vs. non-random. In this study, we present a series of tests showing that, conditional on pregnancy, miscarriages are uncorrelated with a host of socioeconomic and demographic characteristics of the individual (ego). Additionally, because we examine the impact on a woman's fertility of her friend's miscarriage, we are able to go a step further than the existing studies and explicitly test whether miscarriages are correlated among peers. If peer selection was driving our miscarriage-based results, this test would produce a significant positive correlation in the likelihood of a miscarriage between friends. We will show that conditional on friend's pregnancy and school-level aggregate fertility measures, miscarriages are not correlated among friends.

Another potential issue with using a miscarriage as an exogenous fertility shock is that some of the miscarriages may in fact be either misreported elective abortions or they could have become abortions had they not been spontaneously miscarried. Although the survey was administered in a way that is known to minimize the reporting bias, some women may still misreport abortions as miscarriages. For example, medical abortion, which is an alternative to surgical abortion and uses prescription abortifacient pharmaceutical drugs (commonly referred to as the abortion pill) before 9^{th} week of gestation, is often explained to patients as causing a

miscarriage.[4] Furthermore, the distinction between miscarriages and abortions may not be clear-cut even if all miscarriages were correctly reported and truly random. The reason is that some miscarriages would have been abortions had the pregnancy not been miscarried (Ashcraft and Lang 2006; Fletcher and Wolfe 2009). Because compared to teen moms, women who choose abortion tend to be of a higher socioeconomic status and have better outcomes, this potential contamination of the miscarriage group with abortions could introduce an upward bias in the estimate of the effect of a peer's childbirth on own fertility outcomes (i.e. make it less negative).

We present a test similar to the one described above where we show that miscarriages and abortions are conditionally uncorrelated among friends. Furthermore, following Ashcraft and Lang (2006) and Fletcher and Wolfe (2009) we exploit the timing of miscarriages (by focusing on late miscarriages after the 8^{th}, 10^{th}, and 14^{th} week of pregnancy), with the idea that most elective abortion procedures are conducted before the 10^{th} week of gestation. According to miscarriage and abortion prevalence estimates by week of gestation (Hammerslough 1992), this approach could eliminate half of all abortions and 30 percent of all miscarriages by week 8, over 80 percent of all abortions and 45 percent of all miscarriages by week 10, and virtually all abortions and 75 percent of all miscarriages by week 14 (Figures 1.A&B). Therefore, focusing on later miscarriages allows us to examine loss of pregnancy that is likely due to random chromosomal, developmental, or anatomical abnormalities.

III. Data

The data in this study come from the restricted version of the National Longitudinal Study of Adolescent Health (Add Health). Add Health is a school-based, longitudinal study of health-related behaviors of adolescents and their outcomes in young adulthood, stratified by region, urbanicity, school type, size, and ethnic mix. The survey was conducted in multiple

[4] It has been estimated that about 17% of all abortions in the US are medical abortions. (Jones and Kooistra 2011)

waves. Wave I consists of an in-school questionnaire administered to close to 90,000 students and an in-home component administered to a subsample of about 20,000 students and their parents. The in-home cohort was followed up with a series of in-home surveys, approximately 1 year (Wave II), 6 years (Wave III), and 13 years (Wave IV) later. About 12,000 of Wave I in-home students comprise the main (core) sample that represents a nationally representative sample of adolescents in grades 7 through 12 in the US in 1994-1995 school year, and the rest are special oversamples (well-educated blacks, disabled, siblings, etc.). The present study uses the core sample without oversamples.

One of the distinct features of the Add Health survey is that it is designed to capture friendship data as completely as possible. Each respondent was asked to name their friends during the Wave I in-school and in-home surveys and during the Wave II in-home survey. In addition to the list of friend nominations, the survey is designed to capture the friendship rank, asking about the first friend first, and then asking for up to five male and up to five female friend nominations. The present study pools all three sets of female friend nominations, resulting in up to 15 possible friend nominations per individual. Both the nominating and the nominated individuals are included, regardless of whether or not the nominated individual reciprocated the nomination (i.e. the network ties are undirected). Duplicate nominations are removed after averaging out the within-nomination friendship ranks if they varied. We create three measures based on the three waves of nomination data: number of nominations, friendship rank and whether or not the friendship nomination was reciprocated, to be used as controls for individual-level friend network structure.

Of the 12,105 core sample students surveyed in home at Wave I, approximately half were female and close to 4,500 women were followed at Wave III, when on average they were

22 years old. At Wave III, each participant was asked to complete a pregnancy history questionnaire, including information on the age at which each pregnancy ended and the pregnancy outcome (live birth, abortion, miscarriage, and still birth). To maintain confidentiality and reduce reporting bias, no paper questionnaires were used for this portion of the interview; instead the respondent entered answers on a laptop computer in privacy, after the interviewer had left the room. We use the pregnancy history information to capture a complete set of fertility outcomes that occurred before age 20 for each woman, including all teen pregnancies and pregnancy resolutions (live births, miscarriage, or abortion).

We construct school-level aggregate measures of teen fertility (miscarriage, abortion, and birth) by computing the average prevalence of each outcome by school in the *full* Wave III female sample of over 6,000 observations (or the number of women experiencing a given outcome before age 20 over the total count of female observation for each school). Although using the full survey sample and not just our friendship-linked sample reduces the chance that our estimates will be subject to the negative bias that can arise from including these school-level averages in the regression model (Guryan et al., 2009), we compute these averages after excluding the focus individual and her friends. We also construct a set of other school-level demographic and socioeconomic controls (proportion of African Americans, parental income, education, etc.)[5]. The full list of variables used in our analysis and their descriptions are presented in Appendix A.

A total of 2,430 women had at least one female friend who was also interviewed in Wave III. Because we focus on comparing women whose friends miscarried to those whose friends carried to term, we further restrict our sample by excluding 1,592 women whose friends did not have a teen pregnancy. As we discuss in more detail later, we further restrict our

[5] We do not exclude friends when computing these demographic and socioeconomic averages.

estimation sample by excluding 63 women who became pregnant prior to any of their friends (i.e. chronologically implausible peer effects). The remaining 775 women who had at least one friend with a teen pregnancy comprise our final sample, and 152 of these women had a friend whose teen pregnancy ended in a miscarriage. A total of 136 women had a teen pregnancy themselves, and 90 had a teen birth.

Table 1 presents descriptive statistics stratified by the friend's teen fertility status. Column 1 shows women who will be excluded from our analysis because none of their friends had a teen pregnancy, Column 2 shows women who had at least one friend with a teen pregnancy, and Column 3 shows our final estimation sample that excludes women who became pregnant prior to any of their peers. Note that this exclusion lowers the own fertility rates in Column (3) as compared to Column (2); however, none of the other variables are different between the last two columns. We do however observe large differences between women who did not have a friend with a teen pregnancy and women who did, at both the individual and the school level. Women with pregnant friends are almost 10 percentage points more likely to have a teen pregnancy themselves (24% vs. 15%), and they are 6 percentage points more likely to have a teen birth (16% vs. 10%). However, they are also more likely to be of a minority status, have economically disadvantaged backgrounds, and come from schools with higher overall fertility rates, and these factors may be indicative of a higher propensity toward early childbearing regardless the childbearing experiences of friends. Isolating the causal flow of peer influence requires properly accounting for these potentially confounding influences.

IV. Estimation

The traditional approach to estimating peer effect utilizes a so called linear-in-means model that regresses the outcome of the focus individual on the average of the corresponding

peer characteristic, aggregated at some group-level. Pioneered by Case and Katz (1991), and further developed by Manski (1993, 1995, 2000), this approach has been used in a large number of peer effects studies (see for example Ali and Dwyer 2011, Bifulco et al. 2011; Fletcher and Yakusheva 2012). However, because traditional linear-in-means model would not allow us to adequately model situations where the ego or the alter has multiple pregnancies with different outcomes (e.g. a miscarriage and an abortion), we adopt a conceptually similar but notably more granular approach. We link each individual in the data to each of her nominated friends (alters) who reports a teen pregnancy. We further expand this analysis to allow each alter's pregnancy outcome to affect the ego's outcome by linking pairs of ego and alter outcomes. For example, an ego with two alters who each have two pregnancies number four observations in our data. To avoid giving undue influence to egos with many alters with many pregnancies, we weight the data[6]. We also do not estimate effects of future-alter pregnancies (but instead use these results as a falsification exercise). The transformed sample has a total of 1,490 "own fertility outcome × friend's fertility outcome" observations.[7]

The study estimates the following modification of the peer effects model:

$$Y^{E}_{ijmn} = aMISC^{A}_{ijmn} + \beta ABRT^{A}_{ijmn} + EF_{im}\gamma + AF_{ijn}\delta + AF^{-j}_{ijm}\rho + \phi K_{i} + R_{ij}\varphi + X_{i}\theta + S_{i}\lambda + \varepsilon_{ijmn} \quad (1)$$

where *i* is the individual (ego) index (1-775), *j* is the friend (alter) nomination index (1-15), and *m* and *n* are the own and friend's fertility outcome index (range of 1 to 6 fertility outcomes). Y^{E} is own (ego) fertility outcome (no pregnancy/ miscarriage/ abortion/ birth). Variables $MISC^{A}$ and

[6] We create frequency weights equal to the inverse of the product of the number of individual own fertility observations for each individual, M_i, times the number of friend links for every own fertility observation, J_{im}, times the number of friend's fertility observations for each own fertility observation- friend link, N_{imj}: $\left[\frac{1}{(M_i J_{im} N_{imj})}\right]$. We use these weights, in conjunction with the Core 1 Add Health survey design weight, in all our models

[7] 1,490 = 775 women × 1.156 own fertility outcomes (on average) × 1.262 pregnant friend links (on average) × 1.317 friend's fertility outcomes (on average).

$ABRT^A$ represent the friend's (alter's) prior fertility resolutions (birth is omitted), with the alter's miscarriage term, $MISC^A$, being our primary variable of interest.

Because our model links each of the own fertility event *m* to each of the friend's fertility events *n* individually, internal consistency of the model requires properly accounting for own fertility history (excluding event *m*) and friend j's fertility history (excluding event *n*). Therefore, we control for own fertility history prior to event *m* (ego's number of miscarriages, abortions, and births), *EF*, as well as for the friend/alter j's complete fertility history prior to ego's event *m* and excluding the alter's focus event n *AF*. We also control for a vector of average fertility outcomes of *i*'s friends excluding the focus friend *j* (average number of miscarriages, abortions, and births), AF^{-j}. Other controls include ego *i*'s number of friendship links (*K)*, a vector of friendship specific variables (friendship rank of alter *j* as nominated by ego *i* and a 0/1 indicator for reciprocated nomination, *R*), ego *i*'s observable characteristics, (age, African American, Hispanic, other non-white, age, parental income, two-parent family, mother's education *X*), and school-level controls (percent African American, average parental income, average mother's education, percent two-parent families, percent teen miscarriage, percent teen abortion, percent teen birth, *S*). We weight all models using a product of the Add Health survey design weights and our contracted inverse frequency weights, and cluster standard errors at the individual level. We use a multinomial logistic regression and compute average marginal effects.

Our coefficient of interest in model (1) is α. If α is negatively related to ego's likelihood of having a live birth, this would be consistent with a positive childbearing peer effect, or conformity with peer behavior among friends, accounting for confounding due to selection, reflection, and common environmental influences. A positive significant coefficient of friend's miscarriage, on the other hand, would suggest that women with friends who had a teen childbirth

are less likely to experience a teen pregnancy and childbirth themselves. Note that due to the use of inverse frequency weights, the magnitude of the coefficient represents the change in own probability of having a teen birth as the proportion of pregnant friends who give birth (as opposed to miscarry) changes from 0 to 1, and is conceptually equivalent to the peer effect coefficient in the conventional linear-in-means model.

We also conduct two tests of the validity of our identifying assumption of exogeneity of miscarriages. Specifically, if miscarriages were non-random but rather caused by common environmental factors or correlated through friend selection, we would expect a positive significant coefficient of the friend's miscarriage variable in the own miscarriage equation. Additionally, if miscarriages were contaminated with abortions, we would expect a positive and significant cross-outcome effects, i.e. a positive association between a friend's abortion and own miscarriage.

Lastly, we attempt to examine a bit further the extent to which potential contamination of miscarriages with misreported and "would-be" abortions may be confounding our results, by restricting our sample to only include pregnancies that lasted longer than 8, 10, and 14 weeks. Epidemiological studies show that more than a half of all elective abortions happen by week 8, three quarters happen by week 10, and virtually all abortions happen by week 14 (Figure 1.B). In our sample, 90% of all abortions were reported on or before the 14^{th} week of pregnancy. Restricting the sample in this way is likely to significantly reduce any confounding due to misreported abortions and spontaneous miscarriage of pregnancies that would have otherwise been electively terminated.

V. Results

Table 2 shows the results of the balancing tests where we regress an extensive set of socioeconomic and demographic characteristics of the ego on the miscarriage status of the alter. The balancing tests are consistent with the idea that women whose friends miscarried are very similar to women whose friends carried to term. Only one of the balancing tests produced a significant coefficient, which is expected for one out of every 20 tests at a .05 level. Additionally, the significant difference is in the network characteristic of the friendship link that has little impact on any of our results.

Table 3 shows our main set of results, using miscarriage to identify the impact of a friend's teen childbirth on own teen fertility. The results show a significant negative relationship between friend's teen birth and own childbirth. Specifically, friend's teen miscarriage is associated with a 5.8 ($p<.10$) percentage point reduction in own probability of a not becoming pregnant as a teen (i.e. friend's miscarriages are related to additional ego pregnancies) and a 6.2 ($p<.01$) percentage point increase in the probability of having a teen birth. This means that women whose friends had a teen birth were significantly less likely to have a teen pregnancy and childbirth themselves, as compared to women whose friend's pregnancy ended in a miscarriage. Note that this negative effect of a friend's teen birth on own teen fertility arises only after we condition on the friend's pregnancy status in Table 3, while the naïve examination of fertility outcomes in Table 1 shows a significant and positive correlation.

Some of the other important determinants of teen pregnancy and childbearing are the own past fertility history, race, mother's education, and school-level environment measures. African American women are significantly more likely to have a teen pregnancy and childbirth, as well as women with less educated mothers. Women exposed to high rates of teen childbearing at the school are, not surprisingly, more likely to have a teen pregnancy and childbirth. Lastly, there is

a positive association between the likelihood of having a miscarriage and school-level socio-demographic and fertility measures, suggesting that unobserved socioeconomic or environmental factors common at the school level may systematically impact miscarriage rates. [8]

Our main set of results in Table 3 provide little evidence that, conditional on aggregate school-level fertility measures and other controls, miscarriages may be caused by exposure to shared environment or otherwise positively correlated among friends through unobserved selection. In particular, if friends' miscarriages were correlated with the error term in the fertility equation (either through unobserved environmental factors or due to friend selection), we would expect a significant association between own and friend's likelihood of miscarriage. Furthermore, we find the association between own miscarriage and a friend's abortion, which could arise if friend's miscarriages were contaminated with abortions, to be non-significant. However, we will continue to examine this issue of potential contamination of miscarriages with abortions when we exploit the timing of friend's pregnancy resolution below.

Given that the overall prevalence of teen childbirth in the full sample is 13%, the magnitude of the estimate in Table 3, 6.2 percentage points, represents a non-trivial peer effect. Recall that our identification strategy requires that we focus on peer influences received only from a relatively small proportion of an individual's full reference peer group, i.e. only pregnant friends who either gave birth or miscarried. This slightly complicates traditional estimates of social multiplier effects, as not everyone in the peer group is captured in our estimated peer effect. In typical linear-in-means models the assumption of large groups allows the straightforward calculation of the social multiplier as $1/(1-\alpha)$ (Glaeser et al. 2003). In our case, we need to scale the α parameter by the proportion of pregnancies in our data (~20%). This

[8] We also estimate our models without controls for school level aggregate fertility measures and after dropping schools with less than 100 in-sample observations. Our results are robust in both cases.

produces a scaled-up peer effect of -0.31 and implies that if one friend's teen childbirth were removed from the peer group, the overall reduction in teen childbearing would be 0.76 cases, thus suggesting a non-trivial policy dampening effect.

The above computation of the social multiplier assumes that our peer influence estimate from the pregnant peer sample is generalizable to the full sample of all women, which may not be the case if our sample selection restriction of having a friend with a teen pregnancy was correlated with the underlying unobserved susceptibility to peer influence. For example, if women who did not have any pregnant friend are less likely to be influenced by their friend, we expect that the peer effect will be smaller in the non-pregnant friend group. In Table 4, we test whether some of the variables that may be indicative of susceptibility to peer influence differ between our sample of women with a pregnant friend and women who were excluded from the analysis because none of their friends had a teen pregnancy.[9] We find little evidence that women in our sample may be more likely to be influenced by the peers. On the contrary, they are significantly less likely to feel that their friends care about them, and their parents are significantly less likely to report that these women are influenced by their friends. Although there are no differences in the amount of friend interactions, women in our sample are also slightly less likely to discuss problems with their friends. These results provide some suggestive evidence that peer influence in the full reference peer group may be at least as large as what we find in our sample, suggesting that our social multiplier estimate may be a lower bound.

Robustness

In order to further examine to further examine the robustness of the results from our preferred specifications in Table 3, we also examine two variations of our model. We first apply a "falsification test" to ask whether *future* peer actions predict own behaviors and then we focus

[9] See Appendix B for the list of Add Health questions and description of the variables.

on the issue of potential contamination of miscarriages with abortions. In Table 5, we present estimation results for a chronologically incorrect model, where we regress own fertility outcomes on friend's subsequent pregnancy resolutions. We find that none of the own fertility outcomes are significantly associated with the friend's future fertility events.[10] In Table 6, we examine the issue that an unknown portion of miscarriages are either misreported abortions, or, even if they are truly random, may not have resulted in childbirth but would instead become elective abortions. As we discuss earlier, the presence of abortions in the friend's miscarriage group could bias the estimated peer effect upward, or in our case because the coefficient estimate is negative, it may be biased toward zero. We attempt to test this by restricting our miscarriage instrument to include only miscarriages that occurred after the 8^{th}, 10^{th}, and 14^{th} week of pregnancy. We find that the estimates are robust and consistent with a negative effect of peer childbirth on own teen childbearing.

Mechanisms

We attempt to explore the mechanism of peer influence by examining whether the magnitude of the effect varies depending on school-level fertility rates. If the negative effect arises through the learning mechanism, we would expect it to be larger in schools with low teen childbearing rates because the incremental amount of information learned from a friend's childbirth should increase with less exposure to teen childbirth at the school level. In Table 7, we interact friend's fertility variables with an indicator for above-average school-level teen childbearing rates (>20%). Consistent with the learning mechanism, we find that the reduction in own chances of teen pregnancy and childbirth following a friend's childbirth is indeed larger in schools with high rates of teen childbearing (10.3 percentage points, $p<.05$). This finding that the

[10] The findings are also robust to eliminating all pregnancies that occurred prior to friendship nominations. Results are available upon request.

learning effect may be diminished with greater exposure to peer fertility also suggests that the magnitude of the effect of a friend's teen childbirth in the full reference peer group (i.e. including those not in our analysis sample) may be larger than is suggested by our estimates obtained on a pregnant friend sample. This is because the full reference group includes women who are not exposed to teen childbirth among their friends and who, therefore, may stand to learn the most from a peer's teen childbearing experience.

To further explore learning as the potential mechanism of peer influence, we examine whether the magnitude of the effect changes depending on the characteristics of the friend's partner. We expect that if learning is the mechanism behind the negative peer effect, then the negative impact of a friend's teen childbirth should be smaller when the friend's partner is ready to assume the parenting role and thus alleviate the burden of childbearing compared to situation where the full burden falls on the teen mother herself with little or no involvement from the partner. We use two survey questions in an attempt to gauge the propensity of the friend's partner toward participating in childrearing: one asks whether or not the respondent wanted their partner to be their child's parent, and the other one asks whether or not the partner accompanied the responded to pregnancy-related doctor/midwife/nurse appointments. The results are shown in Table 8, and they are consistent with the idea that the negative peer effect in teen childbearing is larger when the childbearing experience of the friend is associated with more hardship. In particular, childbearing of peers who answered "no" to the questions about their partners has a large negative effect on own likelihood of teen pregnancy and childbearing, 12-14 percentage points ($p<.05$), as compared to women whose friends have a child with a partner who is ready to take on parenting responsibilities, 2 percentage points ($p>.50$). The differences between these estimates are statistically significant at the .10 level.

Lastly, in Table 9 we utilize attitudes toward teen pregnancy and childbearing data provided in the Add Health data (Appendix C).[11] The questions were asked during the in-home Wave I interview of respondents who were at least 15 years old at the time of the interview.[12] The responses were recorded on a scale from "strongly disagree" to "strongly agree" and we define all attitude variables as indicators for agreeing with a statement portraying pregnancy in a negative way. The results suggest that women whose friend had a teen birth are more likely to have a negative attitude toward pregnancy. They are significantly more likely to feel that pregnancy would be the worst thing to happen to them, that it would embarrass them, and could lead them to marry a wrong person. These findings also support the knowledge externalities model and the optimal behavioral rule under uncertainty. In particular, the estimates suggest that being friends with a teen mom is associated with increased perceptions of teen childbearing as being a negative outcome, and a tendency toward not repeating the friend's behavior.

Lastly, we would like to point out several limitations to our methods and findings. The focus of the study was peer influences in childbirth, and the study design did not allow examination of how a woman's fertility may be influenced by other behaviors of friends (i.e. sexual behaviors and pregnancy). Because we use pregnancy histories collected retrospectively several years after many of the reported pregnancies occurred, recall bias may be an issue. Due to the fact that less than 20% of the original in-school sample were followed through to Wave III resulted in incomplete capture of friendship networks[13]. Lastly, by selecting only individuals

[11] "Motivations for Risky Behaviors" and "Attitudes toward Pregnancy, STD, and HIV" sections of the Wave I in-home questionnaire.
[12] The age restriction reduces the sample size in this sub-analysis by about one-third. Our main results are robust and in fact the magnitudes are larger in this older sub-sample.
[13] Recall that Add Health by design only collected longitudinal data on 20,000 of the original 90,000 individuals who participated in the in-school survey. However, those followed were a random subset of the original 90,000 sampling frame.

with friends who experienced a teen pregnancy, our sample may not be representative of the full high school population and the results may not generalize to other populations.

VI. Conclusion

Our findings support the presence of a sizable negative local treatment effect on teen childbearing among best friends. Multinomial logistic regression with controls for own and friend's fertility history, extensive set of socio-demographic controls, local peer network structure, and school-level fertility measures suggest that a friend's teen birth is associated with a 6 percentage point reduction in the likelihood of own teen pregnancy and childbirth. There is also evidence that this effect operates through a learning mechanism by changing attitudes toward early childbearing and reducing unwanted pregnancies.

The findings suggest that lowering the rates of teen motherhood could have an unintended spill-over effect of reducing a teen's exposure to peer childbearing and therefore limiting opportunities to learn from peer's experiences. If similar learning mechanisms are operative in other teen decisions (e.g. alcohol use, drug use), our results may point to a general phenomenon that should be considered when designing policies to reduce certain teen behaviors. As effective targeted policies lower rates of teenage childbearing, reductions in the opportunities for social learning within networks may partially counteract the effects of the policy. More comprehensive approaches may be able to both reduce individual teen childbearing outcomes as well as provide information to peers about the consequences of teen childbearing in order to further reduce this outcome among teens.

Olga Yakusheva, Marquette University, Yale University

Jason Fletcher, Yale Univeristy, Columbia University

Appendix A. Variables description and sample range

Variable	Variable Description	Sample Range	
Age	Age in months divided by 12, at Wave I	12.7	20.5
African American	=1 if African American	0	1
Other Race	=1 if other non-white	0	1
Hispanic	=1 if Hispanic ethnicity	0	1
Held back in grades 1-5	=1 if was held back at least once in grades 1 through 5		
Urban residence	=1 if lives in an urban area		
Suburban residence	=1 if lives in a suburban area		
Two-parent family	=1 if two-parent family	0	1
Family income	Annual income at wave I, x10,000	0	87
Number of siblings	Number of siblings living in same household at Wave I	0	11
Birth order	Birth order	1	9
Mother's age	Age in years of the mother at Wave I	20	89
Mother born in the USA	=1 if mother born in the USA	0	1
Mother smoked	=1 if mother ever smoked at Wave I	0	1
Maternal Education	=8 if less than 9th grade; =10 if 9-12 grades, no HS diploma; =12 if HS diploma; =13 some college, no degree; =14 if less than 4-year degree; =16 if college degree; =20 if graduate or other professional degree	8	20
Number of friend nominations	Total count of non-duplicate friend links	1	13
Reciprocal nomination	=1 if nominated peer also nominated the respondent	0	1

Nomination Rank	Friendship nomination rank	1	5
School-level Teen Misc. Rate	School-level average teen miscarriage rate excluding the focus individual and her friends, based on full Wave III sample	0	0.15
School-level Teen Abort. Rate	School-level average teen abortion rate excluding the focus individual and her friends, based on full Wave III sample	0	0.25
School-level Teen Birth Rate	School-level average teen birth rate excluding the focus individual and her friends, based on full Wave III sample	0	0.6
School-level %Af. American	School-level percentage of African Americans based on full Wave III sample	0	0.98
School-level Avg. Fam. Inc.	School-level average annual parental family income based on full Wave III sample and Wave I income data, x10,000	1.38	17.55
School-level Avg. Maternal Educ	School-level average maternal education level based on full Wave III sample and Wave I income data	10.83	17.44
School-level % Two-parent family	School-level percent two-parent households based on full Wave III sample and Wave I income data	0.33	1

Appendix B. Add Health questions used as measures of susceptibility to peer influence, Wave I.

- *How much do you feel that your friends care about you?* (Section 35; 1-Not at all, 2-Very Little, 3-Somewhat, 4-Quite a bit, 5-Very much)
- *What kind of influence is {NAME}'s best friend—good, bad, or neither?* (Parent questionnaire; 1-Good influence, 2-Bad influence, 3-Neither a good or a bad influence; recoded 3 to 0 and 1, 2 to 1)
- *During the past week, how many times did you just hang out with friends?* (Section 2, 0-Not at all, 1-1 or 2 times, 2-3 or 4 times, 3-5 or more times)
- *Did you go to {Name}'s house during the past seven days?* (Section 20; 0-No, 1-Yes)
- *Did you meet {NAME} after school to hang out or go somewhere during the past seven days?* (Section 20; 0-No, 1-Yes)
- *Did you spend time with {NAME} during the past weekend?* (Section 20; 0-No, 1-Yes)
- *Did you talk to {NAME} about a problem during the past seven days?* (Section 20; 0-No, 1-Yes)

Appendix C. Add Health questions used as measures of beliefs and attitudes about pregnancy, Wave I.

- *Getting pregnant at this time in your life is one of the worst things that could happen to you.* (Section 8; 1-Strongly Agree; 2-Agree, 3-Neither agree nor disagree; 4-Disagree, 5-Stongly disagree; recoded 3-5 to 0 and 1-2 to 1)
- *Imagine that sometime soon you were to have sexual intercourse with someone just once, but were unable to use any method of birth control for some reason. What is the chance*

that you would get pregnant? (Section 8; 1-Almost no chance, 2-Some chance, but probably not, 3-A 50/50 chance, 4-A good chance, 5-Almost certain; recoded 4-5 to 1, 1-3 to 0)

- *If you got pregnant, it would be embarrassing for your family.* (Section 17, 1-Strongly Agree, 2-Agree, 3-Neither agree nor disagree, 4-Disagree, 5-Strogly disagree; recoded 1-2 to 1, 3-5 to 0)
- *If you got pregnant, it would be embarrassing for you.* (Section 17, 1-Strongly Agree, 2-Agree, 3-Neither agree nor disagree, 4-Disagree, 5-Strogly disagree; recoded 1-2 to 1, 3-5 to 0)
- *If you got pregnant, you would have to quit school.* (Section 17, 1-Strongly Agree, 2-Agree, 3-Neither agree nor disagree, 4-Disagree, 5-Strogly disagree; recoded 1-2 to 1, 3-5 to 0)
- *If you got pregnant, you might marry the wrong person, just to get married.* (Section 17, 1-Strongly Agree, 2-Agree, 3-Neither agree nor disagree, 4-Disagree, 5-Strogly disagree; recoded 1-2 to 1, 3-5 to 0)
- *If you got pregnant, you would be forced to grow up too fast.* (Section 17, 1-Strongly Agree, 2-Agree, 3-Neither agree nor disagree, 4-Disagree, 5-Strogly disagree; recoded 1-2 to 1, 3-5 to 0)

References

- Ali, Mir and Debra S. Dwyer (2011). "Estimating Peer Effects in Sexual Behavior Among Adolescents." Journal of Adolescence, 34: 183-190
- American College of Obstetricians and Gynecologists (ACOG). (2011) Early Pregnancy Loss: Miscarriage and Molar Pregnancy. In FAQ090 Pregnancy. http://www.acog.org/~/media/For%20Patients/faq090.pdf?dmc=1&ts=20120228T1110043046. Accessed on Nov 10 2011.
- Angrist, Joshua and William Evans. 1996. "Schooling and Labor Market Consequences of the 1970 State Abortion Reforms," paper presented at the 1997 Population Association of American meetings,Washington, D.C.
- Ashcraft, A. and K. Lang (2006): "The Consequences of Teenage Childbearing," National Bureau of Economic Research, Working Paper No. 12485.
- Sachiko Baba, Hiroyuki Noda, Masahiro Nakayama, Masako Waguri, Nobuaki Mitsuda and Hiroyasu Iso (2011) Risk factors of early spontaneous abortions among Japanese: a matched case–control study. *Human Reproduction* 26(2): 466-472
- Banerjee, Abhijit V. (1992). "A Simple Model of Herd Behavior". Quarterly Journal of Economics 107 (3): 797–817. doi:10.2307/2118364.
- Behrman, J. R., H-P. Kohler and S.C. Watkins (2001), "The Density of Social Net-works and Fertility Decisions: Evidence from South Nyanza District, Kenya", Demography, vol. 38, pp. 43-58.
- Bikhchandani, S., D. Hirshleifer and I. Welch (1992), "A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades", Journal of Political Economy. vol 100, No. 5, pp. 992-1026.

- Bifulco, Robert, Jason M. Fletcher, and Stephen L. Ross (2011). “The Effect of Classmate Characteristics on Post-Secondary Outcomes: Evidence from the Add Health.” American Economic Journal: Economic Policy, 3(1): 25–53
- Case A, Katz L. (1991) The company you keep: the effects of family and neighborhood on disadvantaged youth. NBER Working Paper 3705.
- Chevalier, Arnaud and Tarja K. Viitanen. (2003) "The long-run labour market consequences of teenage motherhood in Britain," Journal of Population Economics, Springer, vol. 16(2), pages 323-343.
- Cramer DW, Wise LA. (2000) The epidemiology of recurrent pregnancy loss. Seminars in Reproductive Medicine 2000; 18(4):331–9.
- Department of Health and Human Services. 2009. Fiscal Year 2010 Budget in Brief. Report available at http://www.hhs.gov/asrt/ob/docbudget/2010BudgetInBrief.pdf
- Eiben B., Bartels I., Bahr-Porsch S., Borgmann S., Gatz G., Gellert G., Goebel R., Hammans W., Hentemann M., Osmers R., Rauskolb R., and I. Hansmann. (1990) Cytogenetic Analysis of 750 Spontaneous Abortions with the Direct-Preparation Method of Chorionic Villi and Its Implications for Studying Genetic Causes of Pregnancy Wastage. American Journal of Human Genetics, 47: 656-663
- Evans, William N., Wallace E. Oates, and Robert M. Schwab. (1992). Measuring Peer Group Effects: A Study of Teenage Behavior. Journal of Political Economy, 100(5): 966-991
- Fletcher, Jason M. (2007) “Social Multipliers in Sexual Initiation Decisions among U.S. High School Students.” Demography, 44 (2): 373-388

- Fletcher, Jason M. and Barbara L. Wolfe. (2009) "Education and Labor Market Consequences of Teenage Childbearing: Evidence Using the Timing of Pregnancy Outcomes and Community Fixed Effects." Journal of Human Resources, 44: 303-325
- Fletcher, Jason M. and Barbara L. Wolfe . (in press). "The Effects of Teenage Fatherhood on Early Outcomes." Economic Inquiry
- Fletcher, Jason M. and Olga Yakusheva. (2012) "Peer Effects on Teenage Fertility: Social Transmission Mechanisms and Policy Recommendations" (Working paper)
- Glaeser, Edward L., Bruce I. Sacerdote, Jose A. Scheinkman, (2003). "The Social Multiplier," Journal of the European Economic Association, 1(2-3):345-353
- Guryan, Jonathan, Kroft, Kory and Matthew J. Notowidigdo (2009) Peer Effects in the Workplace: Evidence from Random Groupings in Professional Golf Tournaments. Am Econ J Appl Econ. 2009 October 1; 1(4): 34–68.
- Green RS, Malig B, Windham GC, Fenster L, Ostro B, et al. (2009) Residential Exposure to Traffic and Spontaneous Abortion. Environ Health Perspect 117(12): 1939-1944.
- doi:10.1289/ehp.0900943
- Hammerslough C. R. (1992) Estimating the probability of spontaneous abortion in the presence or induced abortion and vice versa. Public Health Perspectives, 107(3): 269-277
- Hamilton BE, Martin JA, Ventura SJ. (2010) Births: preliminary data for 2009. Natl Vital Stat Rep 2010; 59(3).
- Harrison AT, Gavin L, Hastings PA. (2012) Pregnancy Contraceptive Use Among Teens with Unintended pregnancies Resulting in Live Births – Pregnancy Risk Assessment Monitoring System (PRAMS), 2004-2008. January 20, 2012. 61(02); 25-29

- Hensvik, Lena, Krogstad Asphjell, Magne and J Peter Nilsson (2011) Businesses, Buddies and Babies: Fertility and Social Interactions at Work (Working Paper)
- Hoffman S, Scher L. (2008) Consequences of teen childbearing for the life chances of children, 1979-2002. In: Hoffman S, Maynard R, eds. Kids having kids: economic costs and social consequences of teen pregnancy. Washington, DC: The Urban Institute Press; 2008.
- Hogge WA, Byrnes AL, Lanasa MC, Surti U. (2003) The clinical use of karyotyping spontaneous abortions. American Journal of Obstetrics and Gynecology, 189(2):397–402.
- Hotz, V. Joseph, Charles Mullin, and Seth Sanders. 1997. "Bounding Causal Effects Using Data from a Contaminated Natural Experiment: Analyzing the Effects of Teenage Childbearing." Review of Economic Studies 64(4):575-603.
- Hotz, V. Joseph, McElroy, Susan Williams, and Seth G. Sanders. (2005) "Teenage Childbearing and Its Life Cycle Consequences." Journal of Human Resources 40(3): 683-715
- Jones, Rachel K.; Kooistra, Kathryn (2011). "Abortion incidence and access to services in the United States, 2008". Perspect Sex Reprod Health. 43 (1): 41–50.
- Kajii T, Ferrier A, Niikawa N, Takahara H, Ohama K, Avirachan S. (1980) Anatomic and chromosomal anomalies in 639 spontaneous abortuses. Human Genetics,
- 55(1):87–98.
- Kumar, Sunil (2011) Occupational, Environmental and Lifestyle Factors Associated With Spontaneous Abortion. *Reproductive Sciences* October 2011 vol. 18 no. 10 915-930
- Kuziemko, Ilyana. (2006). "Is Having Babies Contagious? Estimating Fertility Peer Effects between Siblings." Working Paper

- Lerner, Henry M. (2003) Miscarriage: Why it happens and how best to reduce your risks. Perseus Publishing, 11 Cambridge Center, Cambridge, MA 02142.
- Levine, D.I. and Painter, G. (2003). The schooling costs of teenage out-of-wedlock childbearing: Analysis with a within-school propensity-score-matching estimator. Review of Economics and Statistics 85(4): 884-900.
- Llewellyn-Jones D. (1995) Abortion. In: Llewellyn-Jones D, editor. Fundamentals of obstetrics and gynecology. London: Mosby; 1995. pp. 99–103.
- Manlove J, Terry-Humen E, Mincieli L, Moore K. (2008) Outcomes for children of teen mothers from kindergarten through adolescence. In: Hoffman S, Maynard R, eds. Kids having kids: economic costs and social consequences of teen pregnancy. Washington, DC: The Urban Institute Press; 2008.
- Manski C. 1993. Identification of endogenous social effects: the reflection problem. Review of Economic Studies 60(3): 531–542.
- Manski C. 1995. Identification Problems in the Social Sciences. Harvard University Press: Cambridge, MA.
- Manski C. 2000. Economic analysis of social interactions. Journal of Economic Perspectives. 14: 3.
- Martin JA, Hamilton BE, Sutton PD, et al. (2010) Births: Final data for 2008. National vital statistics reports; vol 59 no 1. Hyattsville, MD: National Center for Health Statistics. 2010.
- Mathews TJ, MacDorman MF. (2010) Infant mortality statistics from the 2006 period linked birth/infant death data set. National vital statistics reports; vol 58 no 17. Hyattsville, MD: National Center for Health Statistics. 2010.

- Matovina M, Husnjak K, Milutin N, Ciglar S, Grce M. (2004) Possible role of bacterial and viral infections in miscarriages. Fertility and Sterility;81(3):662–9.
- McDonald HM, Chambers HM. (2000) Intrauterine infection and spontaneous midgestation abortion: is the spectrum of microorganisms similar to that in preterm labor? Infectious Diseases in Obstetrics and Gynecology; 8(5–6):220–7.
- Monstad, Karin, Propper, Carol and Salvanes, Kjell G. (2011) "Is teenage motherhood contagious? Evidence from a Natural Experiment," CEPR Discussion Papers 8505, C.E.P.R. Discussion Papers.
- Montgomery, M. and J. Casterline (1996), "Social Networks and the Diffusion of Fertility Control." Policy Research Division Working Paper no. 119, New York: The Population Council.
- Munshi, K, and J. Myaux (2006), "Social Norms and the Fertility Transition, Journal of Development Economics 80, pp. 1-38.
- Philipp T, Philipp K, Reiner A, Beer F, Kalousek DK. (2003) Embryoscopic and cytogenetic analysis of 233 missed abortions: factors involved in the pathogenesis of developmental defects of early failed pregnancies. Human Reproduction, 18(8):1724–32.
- Regan L, Rai R. (2000) Epidemiology and the medical causes of miscarriage. Bailliere's Best Practice & Research Clinical Obstetrics & Gynaecology 2000;14(5):839–54.
- Richards-Shubik, Seth. (2011). "Peer Effects in Sexual Initiation: Separating Demand and Supply Mechanisms." Working Paper
- Royal College of Obstetricians; Gynecologists Study Group on Early Pregnancy Loss. (1997) Recommendations arising from the 33rd RCOG study group on early pregnancy

loss. In: Grudzinskas JG, O'Brien PMS, editors. Problems in early pregnancy: advances in diagnosis and treatment. London: RCOG Press; 1997.

- Schlag, Karl H. (1998) "Why Imitate, and If So, How? A Boundedly Rational Approach to Multi-armed Bandits" *Journal of Economic Theory* 78, 130-156
- Thomas C.M. and A. Y. Tiu. (2007) Second Trimester Pregnancy Loss. American Family Physician. 76(9): 1341-1346.
- United Nations. (2010) 2008 demographic yearbook. New York, NY: United Nations; 2010.
- U.S. Department of Health and Human Services. (2004) The Health Consequences of Smoking: A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.
- Venners S, Wang X, Chen C, Wang L, Chen D, Guang W, Huang A, Ryan L, O'Connor J, Lasley B, Overstreet J, Wilcox A, Xu X (2004). "Paternal smoking and pregnancy loss: a prospective study using a biomarker of pregnancy". Am J Epidemiol 159 (10): 993–1001.

Tables

Table 1. Descriptive statistics, by exposure to friend pregnancy

	Pregnant Friend = No, N=1592	Pregnant Friend = Yes, N=838	Final sample: Pregnant Friend = Yes, N=775
Had a teen pregnancy	0.15***	0.24	0.18
Had a teen miscarriage	0.02***	0.03	0.03
Had a teen abortion	0.03	0.04	0.03
Had a teen birth	0.10***	0.16	0.12
Age	16.13	16.08	16.08
African American	0.14***	0.27	0.26
White	0.78***	0.66	0.67
Asian	0.03***	0.02	0.02
Hispanic Ethnicity	0.04	0.05	0.05
Held back in grades 1-5	0.09***	0.14	0.14
Suburban residence	0.34***	0.25	0.25
Rural residence	0.37***	0.44	0.45
Two-parent household	0.77***	0.70	0.70
Annual family income, $10,000	5.10***	3.52	3.53
Number of siblings	1.34	1.32	1.32
Birth order	1.80	1.81	1.83
Mother's age	44.51	44.59	45.02

Mother born in USA	0.92	0.95	0.95
Mother ever smoked	0.44	0.48	0.48
Mother's education	14.11***	13.25	13.30
Number of friend nominations	4.52***	4.79	4.78
Average friendship rank	2.66	2.73	2.75
Reciprocal nomination	0.53*	0.50	0.50
Sch. avg. teen pregnancy rate	0.20***	0.27	0.26
Sch. avg. teen miscarriage rate	0.04***	0.05	0.05
Sch. avg. teen abortion rate	0.04***	0.05	0.05
Sch. avg. teen live birth rate	0.15***	0.20	0.20
Sch. avg. African Americans	0.18***	0.26	0.26
Sch. avg. Mother's Education	13.93***	13.51	13.53
Sch. avg. family income	5.36***	4.22	4.27
Sch. avg. two-parent household	0.75***	0.70	0.70

***p<.01, **p<.05, *p<.10 between columns (1) and (2). Column (2) includes 63 egos pregnant before any of the friends; Column (3) excludes such egos. Ego fertility rates in column (3) are lower because of this exclusion. None of the other characteristics in Column (3) are significantly different from Column (2).

Table 2. Balancing tests, pregnant friend sample, N=1490

	Coefficient of friend's teen miscarriage	Std. Error
Age	-0.244	(0.233)
African American	-0.0384	(0.0475)
White	0.0285	(0.0482)
Asian	0.00751	(0.0163)
Other race	0.0223	(0.0229)
Hispanic ethnicity	0.0544	(0.0446)
Held back in grades 1-5	-0.0177	(0.0370)
Urban residence	0.0352	(0.0500)
Suburban residence	-0.0421	(0.0412)
Two-parent family	-0.00157	(0.0507)
Family income	0.448	(0.489)
Number of siblings	-0.125	(0.0998)
Birth order	1.177	(3.584)
Mother's age	0.639	(3.079)
Mother born in USA	0.0338	(0.0435)
Mother smoked	0.0313	(0.0466)
Mother's education	0.642	(0.537)
Number of friend nominations	-0.123	(0.161)
Average friendship rank	0.118	(0.132)
Reciprocated nomination	-0.137**	(0.0369)
Sch. Avg. teen pregnancy rate	-0.0131	(0.0119)
Sch. Avg. teen miscarriage rate	-0.00458	(0.00352)
Sch. Avg. teen abortion rate	0.00908	(0.00650)
Sch. Avg. teen live birth rate	-0.0188	(0.0119)
Sch. Avg. African Americans	0.0116	(0.0319)

Sch. Avg. family income	0.119	(0.200)
Sch. Avg. mother's Education	0.128	(0.140)
Sch. Avg. two-parent household	0.00860	(0.0178)

Shown are regression estimates of own characteristics on friend's miscarriage indicator (baseline is friend's teen birth, friend's abortions excluded), using the final sample of 1490 "own fertility outcome × friend's fertility outcome" observations. No other controls included, estimates adjusted for survey design and weighted; standard errors adjusted for clustering. ***p<.01, **p<.05, *p<.1

Table 3. Multinomial logistic regression results, pregnant friend sample, N=1490

	(1)	(2)	(3)	(4)
	No Teen Pregnancy	Teen Pregnancy Resolution		
VARIABLES		Teen Miscarriage	Teen Abortion	Teen Birth
Friend Teen Miscarriage	-0.0577*	0.00714	-0.0118	0.0624**
	(0.0324)	(0.0110)	(0.0252)	(0.0245)
Friend Teen Abortion	0.0134	0.00487	0.00166	-0.0199
	(0.0332)	(0.0101)	(0.0190)	(0.0252)
Past Miscarriages	-0.124***	0.0231*	0.0280	0.0724**
	(0.0418)	(0.0131)	(0.0171)	(0.0321)
Past Abortions	-0.0578	0.0284	0.0112	0.0182
	(0.0528)	(0.0290)	(0.0115)	(0.0439)
Past Births	-0.102***	0.0151*	0.0185	0.0680***
	(0.0259)	(0.00845)	(0.0147)	(0.0205)
Friend Past Miscarriages	0.0805*	-0.0283*	-0.0197	-0.0325
	(0.0466)	(0.0150)	(0.0303)	(0.0280)
Friend Past Abortions	-0.00844	0.00397	0.00911**	-0.00464
	(0.0363)	(0.00887)	(0.00441)	(0.0356)
Friend Past Births	-0.0463***	0.0117**	0.0126	0.0220
	(0.0160)	(0.00581)	(0.0126)	(0.0137)
Friend Subseq Miscarriages	0.230***	0.0207**	-0.304***	0.0536***
	(0.0498)	(0.00957)	(0.0505)	(0.0186)
Friend Subseq Abortions	-0.00981	-0.0351*	0.0129	0.0320
	(0.0396)	(0.0211)	(0.00828)	(0.0398)
Friend Subseq Births	-0.00396	0.00485	-0.0189	0.0180
	(0.0241)	(0.00648)	(0.0173)	(0.0191)

Other Friends' Miscarriages	-0.101	-0.0348	0.0998***	0.0363
	(0.0691)	(0.0284)	(0.0201)	(0.0557)
Other Friends' Abortions	0.0420	-0.0206	-0.0145	-0.00683
	(0.0717)	(0.0213)	(0.0309)	(0.0550)
Other Friends' Births	-0.0496	0.000938	-0.0507	0.0994***
	(0.0467)	(0.0177)	(0.0398)	(0.0265)
Friend Nomination Rank: #2	0.0106	-0.00846	-0.0296	0.0274
	(0.0297)	(0.0100)	(0.0203)	(0.0249)
Friend Nomination Rank: #3	0.00372	-0.0142	-0.0234	0.0338
	(0.0318)	(0.0115)	(0.0165)	(0.0258)
Friend Nomination Rank: #4	0.0449	-0.0214	-0.0266	0.00306
	(0.0403)	(0.0145)	(0.0212)	(0.0279)
Friend Nomination Rank: #5	0.0689*	-0.0298**	-0.0226	-0.0165
	(0.0374)	(0.0143)	(0.0174)	(0.0292)
Number of nominations	-0.0141**	0.00219	0.00716**	0.00478
	(0.00635)	(0.00316)	(0.00298)	(0.00586)
Reciprocated nomination	0.0437*	-0.0139**	-0.00832	-0.0215
	(0.0235)	(0.00701)	(0.0135)	(0.0203)
African American	-0.0306	0.0270**	-0.00643	0.00998
	(0.0384)	(0.0129)	(0.0249)	(0.0254)
Asian	0.177*	-0.283***	0.0440*	0.0620
	(0.0970)	(0.0907)	(0.0253)	(0.0412)
Other Race	-0.0362	-0.00426	0.0216	0.0189
	(0.0475)	(0.0277)	(0.0194)	(0.0449)
Hispanic	-0.0452	-0.00738	0.0116	0.0410
	(0.0492)	(0.0213)	(0.0281)	(0.0322)
Age in years	0.0246***	-0.00478**	-0.00532	-0.0145**
	(0.00829)	(0.00234)	(0.00428)	(0.00644)

Held back in grades 1-5	-0.0250	0.0104	-0.0245	0.0392
	(0.0287)	(0.0116)	(0.0184)	(0.0241)
Two-parent family	-0.00694	0.00734	-0.0147	0.0143
	(0.0275)	(0.0161)	(0.0117)	(0.0266)
Family income	-0.000449	-5.22e-06	0.00122*	-0.000762
	(0.00139)	(0.000675)	(0.000633)	(0.00118)
Number of siblings	0.0146	0.00421	-0.00665	-0.0122
	(0.00961)	(0.00409)	(0.00501)	(0.00852)
Birth order	-0.00701	-0.00204	0.000239	0.00880
	(0.0108)	(0.00565)	(0.00621)	(0.00886)
Mother's age	0.00321*	-0.000423	-0.000910**	-0.00188
	(0.00171)	(0.000628)	(0.000451)	(0.00119)
Mother's education	0.000142	0.000220	0.00169	-0.00205
	(0.00370)	(0.00171)	(0.00169)	(0.00288)
Mother smoked	-0.0175	0.00289	-0.00718	0.0218
	(0.0223)	(0.0100)	(0.0147)	(0.0202)
Mother born in USA	-0.129**	0.0215*	0.00847	0.0994*
	(0.0643)	(0.0126)	(0.0181)	(0.0549)
Suburban residence	-0.00603	-0.00799	-0.00422	0.0182
	(0.0343)	(0.0144)	(0.0135)	(0.0310)
Rural residence	0.0143	0.00661	-0.0269	0.00602
	(0.0301)	(0.0110)	(0.0199)	(0.0273)
Sch. Avg. mother educ.	0.0402	-0.0465**	-0.00438	0.0107
	(0.0534)	(0.0222)	(0.0387)	(0.0397)
Sch. Avg. family income	0.0117	-0.00535**	-0.00328	-0.00305
	(0.00719)	(0.00272)	(0.00344)	(0.00764)
Sch. Avg. %Black	-0.0392***	0.0176***	0.00196	0.0196*
	(0.0131)	(0.00563)	(0.00767)	(0.0102)

Urban School	-0.0181	0.0103	-0.00777	0.0156
	(0.0449)	(0.0292)	(0.0220)	(0.0426)
Sch. Avg. %Teen Misc	-0.431	0.224	0.0707	0.137
	(0.415)	(0.141)	(0.215)	(0.338)
Sch. Avg. %Teen Abort	-0.270	-0.0601	0.354**	-0.0248
	(0.291)	(0.0842)	(0.150)	(0.244)
Sch. Avg. %Teen Birth	-0.448**	0.118*	-0.0792	0.409***
	(0.187)	(0.0614)	(0.113)	(0.145)

Shown are average marginal effects from a multinomial logistic regression of own fertility outcome on prior friend's fertility outcome for the pregnant friend sample (Model 1). Estimates adjusted for survey design and weighted; standard errors adjusted for clustering. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. Differences in measures of susceptibility to peer influence by exposure to friends' fertility, N=2,430

VARIABLES	Coefficient of INSAMPLE	Std. Error
Friends care about me	-0.0815**	(0.0318)
Influenced by friends	-0.0696***	(0.0205)
Hang out with friends	0.0297	(0.0426)
Go to friend's house	0.0263	(0.0214)
See friend after school	0.0252	(0.0210)
See friend on weekends	0.00337	(0.0212)
Discuss problems with friend	-0.0155*	(0.0092)

Shown are regression estimates of friendship characteristics on an indicator for having at least one friend with a teen pregnancy (INSAMPLE=1, if in the pregnant friend sample; =0 otherwise). Included are all 2,430 women matched with a friend, omitted category are women with no pregnant friends. No other controls included, estimates adjusted for survey design and weighted; standard errors adjusted for clustering. ***p<.01, **p<.05, *p<.1

Table 5. Results for chronologically incorrect peer effects, N=1551

	(1)	(2)	(3)	(4)
	No Teen Pregnancy	Teen Pregnancy Resolution		
VARIABLES		Teen Miscarriage	Teen Abortion	Teen Birth
Friend Teen Miscarriage	-0.000822	-0.0283	0.0214	0.00778
	(0.0386)	(0.0186)	(0.0170)	(0.02290)

Shown are average marginal effects from a multinomial logistic regression of own fertility outcome on *subsequent* friend's fertility outcome for the pregnant friend sample. Other controls (not shown) are same as in table 3. Estimates adjusted for survey design and weighted; standard errors adjusted for clustering. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Results after excluding all friend's abortions and early miscarriages

	>8 weeks				>10 weeks				>14 weeks			
VARIABLES	No teen pregnancy	Teen Misc	Teen Abort	Teen Birth	No teen pregnancy	Teen Misc	Teen Abort	Teen Birth	No teen pregnancy	Teen Misc	Teen Abort	Teen Birth
Friend Teen	-0.0683**	0.0138	0.00111	0.0533*	-0.0900**	-0.00262	0.0225	0.0701**	-0.0955**	0.000290	0.0226	0.0726**
Miscarriage	(0.0291)	(0.0140)	(0.0155)	(0.0288)	(0.0435)	(0.0228)	(0.0318)	(0.0342)	(0.0433)	(0.0221)	(0.0321)	(0.0335)
Observations	1,097				1,073				1,014			

Shown are average marginal effects from a multinomial logistic regression of own fertility outcome on prior friend's fertility outcome for the pregnant friend sample, *excluding all friends abortions and early miscarriages.* Other controls (not shown) are same as in table 3. Estimates adjusted for survey design and weighted; standard errors adjusted for clustering. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7. Differences in predicted probabilities of own fertility by friend's miscarriage status and school-level exposure to teen childbearing, N=1,409.

	School with high teen birth rate				School with low teen birth rate			
	No teen pregnancy	Teen Miscarriage	Teen Abortion	Teen Birth	No teen pregnancy	Teen Miscarriage	Teen Abortion	Teen Birth
P(Y| Friend Teen Misc. = No)	0.852	0.0226	0.0415	0.0837	0.859	0.0220	0.0285	0.0909
P(Y| Friend Teen Misc. = Yes)	0.823	0.0408	7.10e-08	0.136	0.758	0.0200	0.0275	0.195
Δ = P(Y|Yes) - P(Y|No)	-0.0290	0.0182	-0.0415*	0.0523	-0.1010*	-0.0020	-0.0010	0.1041**
F-statistic of Δ	0.31	0.50	2.78	0.27	3.45	0.03	0.00	4.02

Predicted probabilities are obtained from an extension of model (1) that includes an interaction term between friend's miscarriage indicator and an indicator for being from a school with above average (>20%) rate of teen births, and a stand-alone term for being from such school. Estimates adjusted for survey design, weighted and clustered. The bottom two rows show the difference between the predicted probabilities of the corresponding own fertility outcome by friend's miscarriage status (relative to friend's teen birth), and the F-statistics of the significance test of the difference being equal to zero. *** p<0.01, ** p<0.05, * p<0.1

Table 8. Differences in predicted probabilities of won fertility by friend's miscarriage status and friend's view of their partner

	Bad partner = 0				Bad partner = 1			
	No teen pregnancy	Teen Miscarriage	Teen Abortion	Teen Birth	No teen pregnancy	Teen Miscarriage	Teen Abortion	Teen Birth
Did friend want partner to be their child's parent?(Bad Partner = 1, if "No")								
P(Y| Friend Teen Misc. = No)	0.869	0.0198	0.0242	0.0870	0.847	0.0259	0.0415	0.0858
P(Y| Friend Teen Misc. = Yes)	0.855	0.0366	7.24e-08	0.108	0.724	0.0237	0.0313	0.221
Δ = P(Y|Yes) - P(Y|No)	-0.0140	0.0168	-0.024	0.0210	-0.123**†	-0.0022	-0.0102	0.135***†
F-statistic	0.12	0.51	2.96	0.29	5.35	0.02	0.15	7.87
Did friend's partner go along to pregnancy-related doctor's visits? (Bad Partner = 1, if "No")								
P(Y| Friend Teen Misc. = No)	0.864	0.0174	0.0266	0.0918	0.853	0.0295	0.0395	0.0778
P(Y| Friend Teen Misc. = Yes)	0.849	0.0380	8.09e-08	0.113	0.742	0.0233	0.0325	0.202
Δ = P(Y|Yes) - P(Y|No)	-0.0150	0.0206	-0.027	0.0212	-0.111*	-0.0062	-□.0070	0.124**†
F-statistic	0.71	0.45	2.38	0.27	3.56	0.20	0.06	5.92

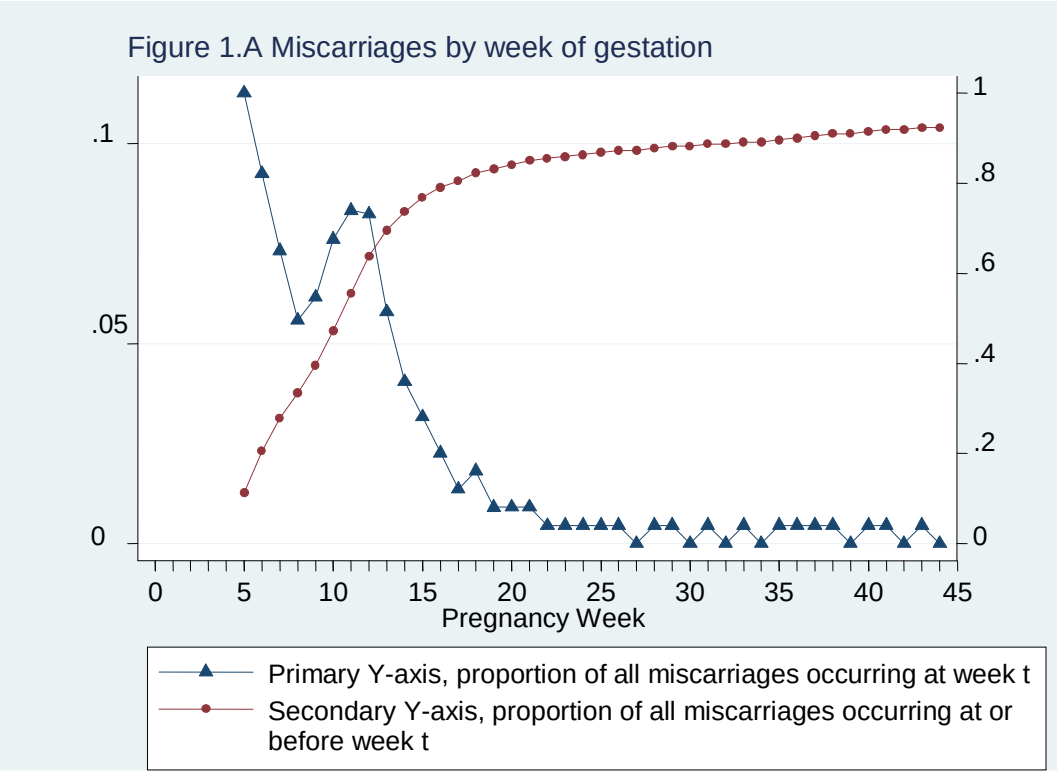
Predicted probabilities are obtained from an extension of model (1) that includes an interaction term between friend's miscarriage indicator and an indicator for friend saying "no" to the questions about their partner, and a stand-alone term for saying "no." Estimates adjusted for survey design, weighted and clustered. The bottom two rows show the difference between the predicted probabilities of the corresponding own fertility outcome by friend's miscarriage status (relative to friend's teen birth), and the F-statistics of the significance test of the difference being equal to zero. *** p<0.01, ** p<0.05, * p<0.1; † p<.10 show a significant second difference, ($\Delta^{\text{Bad Partner = 1}} - \Delta^{\text{Bad Partner = 0}}$).

Table 9. Own beliefs about pregnancy on friend's miscarriage

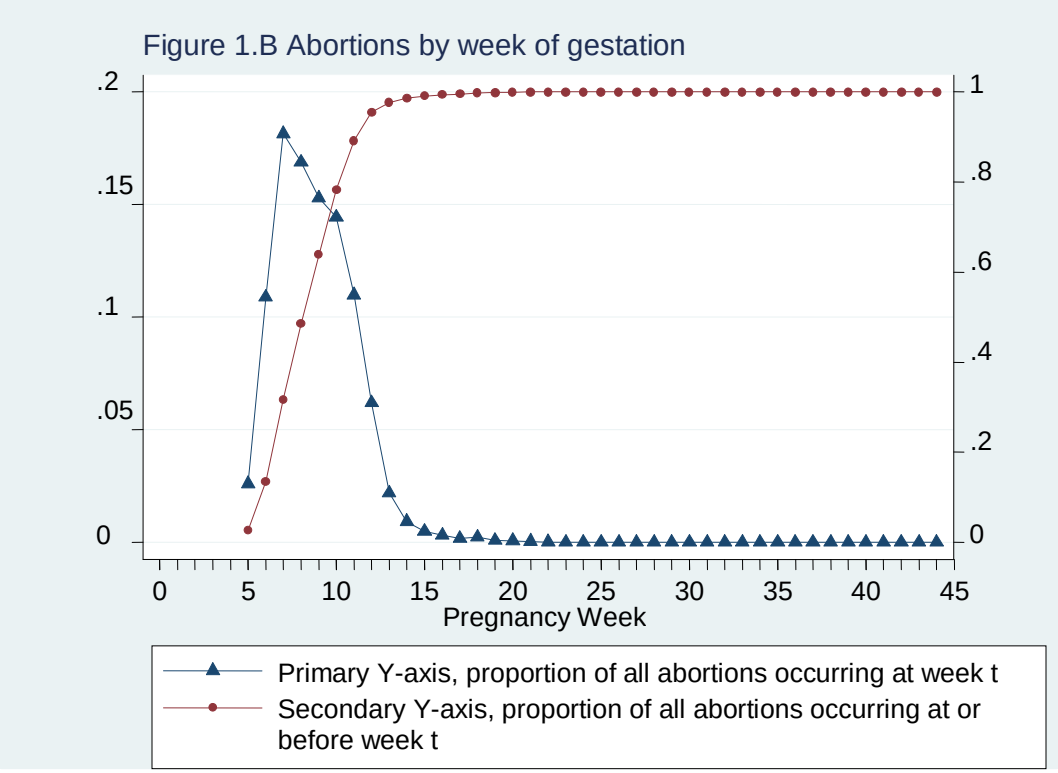
VARIABLES	(1) Worst Thing	(2) Preg. Risk	(3) Embar. Family	(4) Embar. Sef	(5) Quit School	(6) Marry Wrong	(7) Grow Up Fast
Friends Teen Miscarriage	-0.0705**	-0.0204	0.0133	-0.0436*	0.00886	-0.0711*	-0.0339
	(0.0342)	(0.0460)	(0.0571)	(0.0263)	(0.0453)	(0.0416)	(0.0547)
Observations	844	870	828	858	853	857	858

Estimates are marginal effects from a binomial logistic model of the indicator for agreeing with a negative statement about pregnancy on friend's teen pregnancy resolution modeled as in (1). Other controls (not shown) are same as in table 3. Estimates adjusted for survey design, weighted and clustered. Standard errors in parentheses. *** p<.01, ** p<.05, * p<.10.

Figures



Adapted from Hammerslough (1992)



Adapted from Hammerslough (1992)