"I Should Be Pregnant So Many Times By Now":
Risk Perception, Numeracy, and Young Women's Contraceptive Use

by

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Table of Contents

List of Tables

List of Appendices

APPENDIX

Abstract

Conception is probabilistic: any instance of sexual intercourse without contraception may lead to a pregnancy, but whether any one instance of sex results in pregnancy is a matter of chance. The underlying probability of conceiving is not easily inferred from either outcome, and judgments about risk require fairly sophisticated quantitative reasoning skills (numeracy) that many Americans adults do not have. Still, women's deliberations about risk may be tremendously important for their subsequent behavior. In this dissertation, I consider the impact of risk perception and health numeracy on young women's contraceptive use. I use data from the Relationship Dynamics & Social Life study, a longitudinal survey of women aged 18/19 living in a Michigan county. RDSL data include weekly measurement of sex, contraception, pregnancy desire, and pregnancies, and quarterly measurement of women's estimates of their pregnancy risk.

The first empirical chapter finds evidence of a reciprocal relationship between women's pregnancy risk estimates and their actual experiences with sex, contraception, and pregnancy. I find that women's pregnancy risk estimates tend to decrease over time. Women who avoid pregnancy despite having sex without contraception tend to revise their estimates of pregnancy risk downward; in turn, lower estimates of pregnancy risk predict sex without contraception in later weeks.

The second empirical chapter examines a competing set of risk perceptions: women's concerns about side effects and other long-term health consequences of hormonal contraception. Sex without contraception is more likely and more frequent among women expressing greater concerns about side effects. Side effect concerns predict less use of the contraceptive pill/patch/ring, intrauterine devices (IUDs), and contraceptive implants, and more reliance on non-hormonal methods such as condoms and withdrawal.

The final empirical chapter considers whether low numeracy is related to ineffective contraceptive use. In this analysis, I categorize women as low, medium, or high numeracy based on the logical consistency of their answers to survey items about the risk of pregnancy.

Numeracy is not associated with women's sexual behavior, but it does predict contraceptive use among sexually active women. Lower numeracy is associated with a higher likelihood and higher frequency of sex without contraception, more gaps in contraceptive use, and more switches to less effective contraceptive methods. Lower numeracy women also have lower odds of using the pill/patch/ring, IUD, and implant versus condoms as their primary method of contraception.

Collectively, these analyses demonstrate that misunderstandings about the risk and probabilistic nature of pregnancy, concerns about contraceptive side effects, and poor numeracy are barriers to effective contraceptive use among young women who wish to avoid or delay pregnancy.

Chapter 1: Introduction

Conception is probabilistic. That is, any instance of sexual intercourse without contraception *may* lead to a pregnancy, but whether any one instance of intercourse actually results in a pregnancy is a matter of chance. The underlying probability of conceiving is not easily inferred from either outcome (although women's beliefs about the likelihood of pregnancy may be shaped by past experience), and not widely known (Biggs & Foster, 2013; Kaye, Suellentrop, & Sloup, 2009).

Young adults' beliefs about pregnancy risk are complicated and often contradictory. They frequently overestimate the risk of pregnancy from a single instance of sex, underestimate the cumulative risk of pregnancy from many instances of sex, and overestimate their risk of infertility or sub-fecundity. Consequently, young adults' estimates of pregnancy risk depend very much on the phrasing of the question. These internal contradictions reflect confusion about the nature of risk. Experts may be accustomed to thinking of risk at the level of a population, but individuals are concerned with their own personal risk, and this information is often inaccessible or even unknowable. Moreover, judgments of risk require a facility with fractions and ratios that many adults do not have.

This dissertation is concerned with young women's deliberations about risk: their beliefs about the likelihood of pregnancy, their concerns about the likelihood of side effects, and their conceptual understanding of risk itself.

Estimated pregnancy risk

Many theories of health decision-making share the expectation that individuals are less likely to engage in behaviors that carry a high risk of an undesirable outcome (Brewer, Weinstein, Cuite, & Jr, 2004; Lopez, Tolley, Grimes, & Chen-Mok, 2009; Weinstein, 1993; Weinstein et al., 2007). In other words, women who wish to avoid or delay pregnancy should be less likely to have sex without contraception if they believe the risk of conception to be high. Indeed, many studies of contraceptive non-use have identified perceived infertility or a perceived low risk of pregnancy as a contributing factor (Biggs, Karasek, & Foster, 2012; Frohwirth,

Moore, & Maniaci, 2013; Moore, Singh, & Bankole, 2011; M. D. Nettleman, Chung, Brewer, Ayoola, & Reed, 2007). This concern is the foundation of many public health interventions and sexual education curricula emphasizing the possibility of becoming pregnant after even one instance of sex (Lindberg, Santelli, & Singh, 2006; Santelli et al., 2017).

Young adults generally do believe that pregnancy is a highly probable outcome of sexual intercourse, although this belief does not necessarily translate to effective contraceptive use. In the nationally representative Fog Zone survey, most young adults report the desire to avoid or delay pregnancy (Kaye et al., 2009), although a substantial proportion reports having sex without contraception in the past and anticipates having sex without contraception in the near future. These data also reveal internal contradictions in young adults' beliefs about pregnancy risk (Kaye et al., 2009). Young women dramatically *overestimate* the probability of conception after one instance of sexual intercourse, but frequently they *underestimate* the cumulative probability of conception after many instances of intercourse, and the prevalence of concerns about infertility is much higher than the actual prevalence of infertility or subfecundity at these ages (Biggs & Foster, 2013; Chandra, Martinez, Mosher, Abma, & Jones, 2005; Foster, Higgins, Karasek, Ma, & Grossman, 2012; Kaye et al., 2009; Polis & Zabin, 2012).

Qualitative evidence may help resolve this apparent contradiction. In multiple studies of women who have had unintended pregnancies, women provide similar narratives: at the time they became pregnant, they considered the risk of pregnancy to be low or nonexistent because they had previously avoided pregnancy despite having sex without contraception (Frohwirth et al., 2013; Moore et al., 2011). The actual risk of pregnancy from one instance of sex is only around 3% (Trussell & Wynn, 2008), and most women who have sex without contraception will *not* immediately become pregnant. Women who overestimate the risk of pregnancy may consider their short-term success in avoiding pregnancy to be evidence of infertility, which may trigger non-use of contraception in the future.

Much of the evidence for a reciprocal relationship or feedback loop of this nature relies on the narratives of women who became pregnant, often at fairly young ages (e.g. Hoggart & Phillips 2016). These accounts may or may not reflect the experiences of young women who have *not* had an early unintended pregnancy. Meanwhile, quantitative evidence linking perceived pregnancy risk to contraceptive non-use originates mainly in cross-sectional surveys; thus, the direction of the association is uncertain.

Side effect concerns

Contraception reduces the risk of pregnancy, but many women consider contraceptive use itself to be a risky endeavor. Contraception is not exempt from the reservations that many Americans express about medications: the belief that medications are not natural, worries about lasting health consequences, and the belief that long-term use medication is inherently undesirable (Benson & Britten, 2002; Pound et al., 2005). For some women, contraception also raises concerns about hormones, the possible disruption of menstruation, and fears about future infertility (Cheung & Free, 2005; Clark, 2001; Clark, Barnes-Harper, Ginsburg, Holmes, & Schwarz, 2006; Gilliam, Davis, Neustadt, & Levey, 2009). The perception that serious side effects or complications are likely when using hormonal contraception may reduce the likelihood of any contraceptive use, discourage use of hormonal methods, and increase reliance on non-hormonal methods with higher failure rates such as condoms and withdrawal.

Side effect concerns may influence several dimensions of contraceptive use, from the initial selection of a contraceptive method to method switching and discontinuation. In nationally representative demographic studies, side effect concerns are associated with a lower likelihood of currently using hormonal methods (Frost, Lindberg, & Finer, 2012; M. Nettleman, Brewer, & Ayoola, 2009) and are a common explanation for discontinuation (Littlejohn, 2012). However, these studies typically measure contraceptive behavior at one point in time, often relying on retrospective reports of lifetime use. Side effect concerns may also be related to method switching or inconsistent contraceptive use, behaviors that unfold over time and are not easily observed without longitudinal measurement of contraceptive behavior.

Numeracy

Numeracy refers to a broad set of numeric skills encompassing basic arithmetic, more complicated mathematical operations, logic, and facility with ratios, fractions, and probability (Reyna & Brainerd, 2008). Health numeracy refers specifically to the ability of lay people to interpret and act on quantitative health information, critical skills in an era emphasizing evidence-based medicine and patient involvement in medical decisions (Barry & Edgman-Levitan, 2012; Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005; Institute of Medicine, 2001; Reyna & Brainerd, 2007). Unfortunately, Americans lag behind citizens of other industrialized nations in mathematical performance (Gonzales et al., 2004; Lemke et al., 2004),

and many adults in the U.S. lack the skills needed to be informed, active participants in their own healthcare.

Informed health decisions hinge on comparisons of risk: the probability of experiencing an illness versus the mitigating effect of preventive health behaviors, or the success rate of a treatment versus the risk of an adverse outcome. Comparing probabilities requires fluency with fractions and proportions. These risk comparisons are sophisticated mathematical operations that are prone to systematic cognitive biases (Adam & Reyna, 2005; Lipkus, Samsa, & Rimer, 2001; Wolfe, Fisher, & Reyna, 2013). For instance, many individuals do not immediately register the difference between a risk of 10/1000 and 12/12000; even highly educated adults tend to give undue importance to numerators and neglect denominators (Reyna & Brainerd, 2008). If presented with risks of 3/1000 and 17/10000, many individuals conclude at a glance that 17/10000 is larger. People of all ability levels make these kinds of errors, but people with low numeracy make them more often and are less likely to catch their mistakes. Furthermore, their interpretations of quantitative information are more easily swayed by the presentation format (i.e. "15 in 100" versus "15%"), by mood and affect, and by extraneous information (Peters, 2012; Reyna, Nelson, Han, & Dieckmann, 2009; Rothman et al., 2006).

Few studies have considered the impact of numeracy on contraceptive use in the United States; instead, researchers have typically considered the *accuracy* of women's knowledge. However, Dehlendorf and colleagues (2014) identify the low numeracy of many patients as an obstacle to effective contraceptive counseling and a potential barrier to effective contraceptive use. Furthermore, numeracy is linked to health outcomes in other domains (Dallacker, Hertwig, Peters, & Mata, 2016; Estrada, Martin-Hryniewicz, Collins, Byrd, & Peek, 2004; López-Pérez, Barnes, Frosch, & Hanoch, 2015), including behaviors that are potentially analogous to contraceptive use, such as vaccination (Ball, Evans, & Bostrom, 1998; Brewer et al., 2007) and self-management of HIV medication (Waldrop-Valverde et al., 2009; Waldrop-Valverde, Jones, Gould, Kumar, & Ownby, 2010). This research suggests that people with low numeracy are more likely to engage in risky behavior, and less likely to engage in behaviors that mitigate their health risks. Thus, low numeracy may contribute to ineffective contraceptive use or non-use.

Data

All three chapters use data from the Relationship Dynamics and Social Life study (RDSL), a longitudinal study of young women residing within a racially and economically

diverse Michigan county (Barber, Kusunoki, & Gatny, 2011). Respondents were 18 or 19 years old at the time of recruitment and were randomly selected from the Michigan Department of State's Personal Identification Card and driver's license database.[1] Baseline interviews were conducted on a rolling basis from March 2008 to July 2009; 1,003 women completed a baseline interview, yielding a response rate of 83% and a cooperation rate of 94%. These interviews were conducted in person by a professional interviewer, lasted approximately one hour, and included questions about sociodemographic characteristics, attitudes, relationship characteristics and history, contraceptive use and pregnancy history.

At the end of the baseline interview, participants were invited to participate in a follow-up study that lasted 30 months. Each week, respondents completed a short survey[2] ("journal") about their relationships, sexual behavior, contraceptive use, pregnancy intentions, and pregnancies[3] during the previous week. (If a journal was completed late, these questions referred to the time period since the previous journal.) In addition to the core questions asked every week, the journal included rotating sets of questions on topics that varied from week to week. These measures are updated quarterly (approximately every 12 weeks) for the entire length of the journal study. One set of rotating questions includes women's estimations of their pregnancy risk, which feature heavily in Chapter 2.

The journal took approximately 5 minutes to complete, and could be submitted by telephone or via the internet. Respondents were issued re-loadable debit cards and paid $1 per journal submitted, with a bonus for submitting five consecutive journals on time. Women who did not submit a journal for over 60 days were offered an additional $10 to return to the study. Of the 992 women who enrolled in the journal study, 75% contributed at least 18 months of journal data, and the median time between journals was 8 days.

Over the course of the study, respondents also had three opportunities to participate in longer supplemental surveys dedicated to a particular topic. Chapter 3 uses measures of side

[1] Barber et al. (2011) estimated 96 % agreement between the Michigan Department of State database and the projected number of 18- and 19-year-old women in the county based on the 2000 census.
[2] The original text of all survey items used to construct independent and dependent variables can be found in Appendix A.
[3] The RDSL study also included semi-structured interviews with women who became pregnant during the study period and a matched sample of women who did not become pregnant. Risk perception was not a focus of the qualitative study, but one of these interview participants inspired the title of this dissertation. Describing a friend's experience of avoiding pregnancy despite having sex without contraception several times, she remarked, "*ever since last summer we had like this inside joke, like, it's impossible to get knocked up. Like, she's like, 'I should be pregnant so many times by now…I think it's impossible for me to get pregnant.*'"

effect concerns from the Social Life Journal Supplement (SLJS), which was fielded in May 2010. Of the 982 women still participating in the journal study in May 2010, 590 completed the SLJS for a response rate of 60%.

The RDSL data are well suited to this research for several reasons. First, RDSL is unique among fertility surveys in its inclusion of longitudinal measures of perceived pregnancy risk. These measures permit not only comparisons *between* women, but also analysis of change *within* women over time and in response to their experiences with sex, contraception, and pregnancy. Second, women's sexual behavior, contraceptive use, pregnancy status, and pregnancy desire are measured weekly. Thus, analyses of sex and contraception can be restricted to the specific weeks in which women are at risk of unintended pregnancy: weeks in which they are not currently pregnant and do not desire a pregnancy. Journal questions about contraception include several dimensions of contraceptive behavior, including any contraceptive use, specific method use, and consistency (using some form of contraception at each instance of intercourse), and intensive measurement allows for the detection of behavioral changes from week to week, such as method switching and gaps in contraceptive use. Weekly measurement also limits recall bias and reduces the risk of short-term changes in contraceptive behavior (such as a short period of experimentation with a new method) going unnoticed between survey waves.

Implications for Policy and Practice

Women between the ages of 18 and 24 experience the majority of unintended pregnancies in the United States (Finer & Henshaw, 2006; Finer & Zolna, 2011, 2013, 2016) and have done so for multiple decades. Although the rate of unintended pregnancy has decreased (Finer & Zolna, 2016), the prevalence of unintended pregnancy remains highest in this age group. Identifying factors that increase the risk of poor contraceptive use or non-use among young women who do not wish to conceive is therefore an urgent public health and policy concern. Moreover, nearly half of all unintended pregnancies in the United States occur to recent contraceptive users (Finer & Henshaw, 2006), which suggests that many couples of all ages use contraception inconsistently, or do not use highly effective methods. Although caution is required when generalizing research conducted on 18- and 19-year-olds to people of other ages, the findings of this research may also have important implications beyond this age group.

Structure of the Dissertation

In the following chapters, I consider three topics which may influence young women's sexual behavior and use of contraception. In Chapter 2, I use longitudinal measures of estimated pregnancy risk, sex, contraception, and pregnancy to demonstrate reciprocal relationships between risk perception and behavior. I consider the impact of recent sex, contraception, and pregnancy experiences on women's estimates of their pregnancy risk, and the consequences of change in these risk estimates for subsequent behavior. I test whether women who avoid pregnancy (despite having sex without contraception) reduce their estimates of their pregnancy risk, and whether these reductions trigger additional risky behavior. In Chapter 3, I investigate whether concerns about contraceptive side effects discourage use of highly effective contraceptive methods. Additionally, I investigate whether reduced use of these hormonal methods results in greater reliance on non-hormonal methods or less contraceptive use altogether. In Chapter 4, I evaluate numeracy as a predictor of poor contraceptive use among young women who do not wish to become pregnant. I compare women of different numeracy levels in terms of their sexual behavior and contraceptive use over a period of 30 months. Finally, in Chapter 5, I discuss the results of all three analyses and their contributions to scholarship on risk, numeracy, contraceptive use, and health behaviors more generally. I close with a discussion of the implications of this research for policy and practice, including possible avenues for intervention.

Chapter 2: Reciprocal Relationships between Estimated Pregnancy Risk and Young Women's Contraceptive Use

Introduction

Risk perceptions have a central role in many influential theories of medical decision-making (Weinstein, 1993). However, accurate risk information is not always widely available or accessible to lay people, and individuals' risk perceptions may be shaped by their social environment. For instance, young adults' beliefs about pregnancy risk are likely influenced by sexual education, healthcare providers, members of their social networks, and their own experiences with sex, contraception, and pregnancy.

Most adolescents in the U.S. receive some information about pregnancy risk from sexual education (Vanderberg et al., 2016). In many states, formal sexual education legally must emphasize negative consequences of adolescent or non-marital sex, such as the risk of becoming pregnant after even one instance of sex (Lindberg et al., 2006; Santelli et al., 2017). In this setting, adolescents are likely to receive the message that the risk of pregnancy is high. Some young adults receive information about pregnancy risk from healthcare providers, although access to reproductive healthcare is certainly not universal (Ralph & Brindis, 2010). Young adults frequently turn to family members and peers as a substitute for or complement to contraceptive information provided by educators and medical professionals (Gilliam et al., 2009; Hodgson, Collier, Hayes, Curry, & Fraenkel, 2013; Kaye et al., 2009; L. Yee & Simon, 2010). These social networks may amplify a mix of accurate and inaccurate information, depending on the sources of contraceptive information available to other members of the network. Young adults' own experiences with sex, contraception, and pregnancy may also inform their beliefs about pregnancy risk.

Given these diverse sources of information, it is not surprising that many young adults' estimates of their pregnancy risk diverge from the estimates derived from clinical trials and surveys. The risk of pregnancy from one instance of sexual intercourse depends on the timing of sex relative to the menstrual cycle: the likelihood of conceiving is nearly zero during the first

three days of the menstrual cycle, increases in the days preceding ovulation, peaks around 9%, and decreases thereafter (Wilcox, Dunson, Weinberg, Trussell, & Baird, 2001). Averaging over the menstrual cycle, Wilcox and colleagues (2001) estimate that the risk of conceiving from one instance of sex on a randomly selected day is about 3%. Among couples having sex without contraception approximately once per week, 85% will conceive within one year (Trussell, 2011). These probabilities are descriptions of the fertility of a typical or average woman in a study population, not predictions about one specific woman. These probabilities are not necessarily accessible to lay people, and they are not common knowledge. Previous surveys indicate that young adults frequently overestimate the risk of pregnancy from one instance of sex, underestimate the cumulative risk of pregnancy from many instances of sex, and overestimate the likelihood of infertility or sub-fecundity (Kaye et al., 2009; Polis & Zabin, 2012).

Low estimates of pregnancy risk may contribute to non-use of contraception among women who wish to avoid pregnancy (Biggs et al., 2012; Frohwirth et al., 2013; Moore et al., 2011; M. D. Nettleman et al., 2007). Alternatively, low estimates of pregnancy risk may result from women's success in avoiding pregnancy, particularly among women who frequently have sex without contraception. The relationship between estimated pregnancy risk and women's behavior may even be reciprocal. However, the direction(s) of this relationship cannot be discerned from previous research: the temporal ordering of risk perceptions and behavior is uncertain due to cross-sectional design and retrospective reporting.

In this chapter, I use longitudinal survey data to examine the relationships between young women's estimated pregnancy risk, sexual behavior, and contraceptive use. I investigate whether women's estimates of their pregnancy risk predict sex and contraceptive use in later weeks. I also test whether women's recent experiences with sex, contraception, and pregnancy influence their subsequent estimates of pregnancy risk.

Background

Lay estimates of pregnancy risk

The only recent, nationally representative data on young adults' beliefs about their pregnancy risk are collected in the 2009 National Survey of Reproductive and Contraceptive Knowledge, commonly referred to as the Fog Zone study. Two additional surveys of reproductive-age women conducted within family planning clinics have measured pregnancy risk estimates among women seeking abortions (Foster et al., 2012) and women with no abortion

history (Biggs & Foster, 2013), although these results may be less representative of young adults. These studies indicate a common set of errors in pregnancy risk estimation.

Almost universally, women *overestimate* the risk of pregnancy from one instance of sex without contraception. Among women aged 18-29 in the Fog Zone study, the mean estimate of pregnancy risk from one instance of sex is 65.4%,[4] much higher than the true risk of pregnancy from one instance of sex. In a survey of 1,472 family planning clients with no abortion history (Biggs & Foster, 2013), 92% of women estimate the risk of pregnancy from one instance of sex without contraception to be greater than 20%. Among 562 reproductive-age women seeking abortions (Foster et al., 2012), 63% estimated the risk of pregnancy from one instance of sex to be greater than 50%.[5]

Meanwhile, women frequently *underestimate* the cumulative risk of pregnancy from having sex without contraception repeatedly. This mistake is less universal than the overestimation of the risk of pregnancy from one instance of sex, but it occurs among a sizeable minority of respondents in each of the studies described above. Among family planning clients with no history of abortion (Biggs & Foster, 2013), almost a quarter (24%) estimate the risk of pregnancy from having sex without contraception for one year to be less than 70%. Among women seeking abortions, 37% estimate the risk of pregnancy from having sex without contraception regularly for one year to be less than 75% (Foster et al., 2012).[6] Within the Fog Zone sample, the *mean* pregnancy risk estimate is accurate (85.5%), but this mean obscures overestimates *and* underestimates of pregnancy risk from having sex without contraception repeatedly. Among Fog Zone participants, 17% provide an estimate under 75%, whereas 52% provide an estimate over 95%. This is the only study to find any systematic overestimation of pregnancy risk from having sex without contraception repeatedly.

Based on this prior research, I hypothesize that young women in the RDSL sample will tend to overestimate the risk of becoming pregnant from any one instance of sex without

[4] Author's tabulations.
[5] In both Foster et al. (2012) and Biggs and Foster (2013), authors categorize women's pregnancy risk estimates based on their accuracy, but do not report the mean. Moreover, the authors vary in the cutoffs they use to indicate serious underestimations (50% versus 20%, respectively) or overestimations (75% vs 70%) of pregnancy risk. Thus, the results of these studies are not directly comparable. Nevertheless, both studies demonstrate a similar pattern of mistakes in women's pregnancy risk estimates and are consistent with data from the Fog Zone study.
[6] The authors note that many women's estimates of pregnancy risk from one instance of sex were almost as high as their estimates of pregnancy risk after one year of sex without contraception, and speculate that many women do not fully understand the cumulative nature of pregnancy risk. This exact difficulty in quantitative reasoning and its relationship to contraceptive use is the focus of Chapter 4.

contraception, and underestimate the cumulative risk of pregnancy from having sex without contraception repeatedly.

Estimated pregnancy risk and subsequent contraceptive use

The notion that perceptions of risk influence subsequent behavior is central to many theories of health behavior. In a review of four widely-used theoretical models (the Health Belief Model, Subjective Expected Utility Theory, Protection Motivation Theory, and the Theory of Reasoned Action), Weinstein (1993) notes that the predominant theories of preventative health behavior share the principle that preventive health behaviors are motivated by the desire to avoid some unwanted outcome, the perception that one is at risk of that outcome, and some consideration of the expected benefit of the health behavior versus the costs. These theories differ in the extent to which they consider non-financial costs and benefits beyond the domain of health, their consideration of social influences, and the inclusion of intervening variables such as self-efficacy or the perceived effectiveness of the health behavior. Nevertheless, the belief that risk perceptions influence behavior is a commonality of many theoretical approaches to decision-making.

Although these theories all imply a relationship between estimated risk and preventative health behaviors, empirical support for this relationship is mixed. In some cases, high perceptions of risk do predict protective behaviors that may be analogous to contraceptive use. For instance, the perceived likelihood of contracting influenza is connected to vaccination intentions (Setbon & Raude, 2010) and influenza vaccination (Chapman & Coups, 2006; Telford & Rogers, 2003). In a rare longitudinal study of risk perceptions and behavior, Brewer and colleagues (2004) find that adults who perceived a high risk of Lyme disease at the time the Lyme disease vaccine was made available were significantly more likely to be vaccinated during the next 18 months. In several reviews of existing research on risk perceptions. In several reviews of existing research, relationships between risk perceptions and behavior are positive, but much weaker than anticipated (Floyd, Prentice-Dunn, & Rogers, 2000; Harrison, Mullen, & Green, 1992; Milne, Sheeran, & Orbell, 2000) or inconclusive (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011). In some studies, higher risk perceptions are actually associated with riskier behavior (Johnson, McCaul, & Klein, 2002; Reyna & Farley, 2006).Criticizing the methodology of many existing studies on this topic, Brewer and colleagues (2007) and attribute mixed evidence about the relationship between risk perception and behavior to cross-sectional

designs and poor measurement of risk perception.[7] In their own meta-review of 34 studies, they find a strong relationship between risk perception and adult vaccination. Among the studies they review, those with higher-quality risk perception measures[8] indicate the strongest relationships between risk perception and behavior.

Studies of contraceptive use have found more consistent evidence of an association between risk perceptions and behavior. In a review of past research on adult women's reasons for not using contraception, Ayoola and colleagues (2007): identify low perceived risk of pregnancy as a common theme in qualitative studies and a common predictor of contraceptive non-use or inconsistent use in surveys. In a qualitative study of 66 low-income women in Philadelphia (Borrero et al., 2015), women identify beliefs about infertility or sub-fecundity as factors contributing to their non-use or inconsistent use of contraception, alongside other issues such as reproductive coercion and positive feelings about pregnancy. In the Pregnancy Risk Assessment Monitoring System (PRAMS) survey of 7,856 women who had unintended pregnancies resulting in live births, about 33% of women indicate that they thought they could not or would not get pregnant at the time they conceived (Nettleman et al., 2007). Among 1,392 women receiving care in family planning clinics, 42% of women reporting sex without contraception during the prior 3 months indicate that they did not believe they could get pregnant at that time (Biggs et al., 2012). And in a survey of 562 women seeking abortions, women not intending to have sex without contraception in the next three months are more likely to overestimate the risk of pregnancy from one instance of sex; meanwhile, women intending to have sex without contraception in the next three months are more likely to underestimate the risk of having sex without contraception many times. In the present study, I expect to find that pregnancy risk estimates predict women's sexual behavior and contraceptive use in later weeks. I hypothesize that women with lower pregnancy risk estimates will be more likely to have sex and less likely to use contraception than women with high pregnancy risk estimates.

[7] For instance, some studies do not condition the risk question on whether any preventive action is taken (e.g. estimating influenza risk without specifying whether or not a person is vaccinated). Other common issues include not specifying the time frame, not asking about one specific event or outcome at a time, and not specifying whether the question refers to the respondent's own personal risk or the average risk faced by some population.

[8] Brewer and colleagues note that previous meta-analyses (Floyd, Prentice-Dunn, & Rogers, 2000; Harrison, Mullen, & Green, 1992; Milne, Sheeran, & Orbell, 2000) included studies that they chose to omit due to quality concerns, and thus may have underestimated the relationship between risk perceptions and behavior .

It is important to note that the studies described above are cross-sectional; several involve retrospective reporting of pregnancy risk estimates, and none include prospective measures of sex or contraception. They provide evidence of an association between estimated pregnancy risk and behavior, but the temporal ordering is unclear. Risk perceptions and behavior are likely to be endogenous (Brewer et al., 2004). Cross-sectional studies do not adequately account for past behavior, which may influence current risk estimations and current behavior. Demonstrating that lower pregnancy risk estimates are associated with non-use of contraception is a contribution, but it is more valuable to know whether women whose pregnancy risk estimates decrease are more likely to have sex without contraception than they were in the past. Establishing that pregnancy risk estimates are connected to subsequent behavior requires prospective measures of estimated pregnancy risk and longitudinal measurement of sex and contraception.

Contraceptive use, pregnancy, and subsequent pregnancy risk estimates

Whereas risk perceptions are central to theories explaining health behaviors, the origin of risk perceptions has received less scholarly attention. High estimates of pregnancy risk might result from sexual education curricula emphasizing the risk of pregnancy in order to discourage adolescent sex or encourage contraceptive use (Lindberg et al., 2006; Santelli et al., 2017). Low estimates of pregnancy risk may stem from a woman's suspicion of her own infertility, or belief in her partner's infertility (Ayoola et al., 2007). These two beliefs seem at odds with one another, but many young adults appear to hold them simultaneously.

Perceived infertility is more of a descriptor than an explanation. It is not obvious why so many young adults believe they are unlikely to conceive. Prior studies have indicated that the prevalence of concerns about infertility is disproportionate to the actual prevalence of sub-fecundity among young adults (Polis & Zabin, 2012). In the Fog Zone study, about 15% of respondents reported concerns about infertility, while the estimated prevalence of impaired fecundity among women aged 15-29 is only 8.4% (Chandra et al., 2005; Kaye et al., 2009). The contrast between young adults' low risk of infertility and disproportionately high concerns about infertility is striking.

Qualitative studies suggest that women's beliefs about their pregnancy risk are influenced by their prior experiences with sex, contraception and pregnancy. In interviews with 49 women obtaining abortions (Frohwirth et al., 2013), many women describe having avoided pregnancy in the past despite having sex without contraception. Some of these women incorrectly surmised

that they were unable or unlikely to become pregnant in the future because they had not become pregnant yet. This is not the sole explanation women provide for low pregnancy risk estimates—women also reference past illnesses or conversations with healthcare providers that left them with the impression that pregnancy was unlikely—but it is a common thread in many women's narratives. This finding is echoed in other qualitative studies of women seeking abortions and women with histories of abortion (Foster et al., 2012; Hoggart & Phillips, 2011). Meanwhile, a large survey of women without any history of abortion (Biggs et al., 2012) finds that women are more likely to underestimate the risk of pregnancy if they have had sex without contraception in the prior three months.

Collectively, this research suggests an association between estimated risk and subsequent behavior. In the current study, I expect to find that recent experiences with sex, contraception, and pregnancy predict women's subsequent estimates of their pregnancy risk. I hypothesize that women with recent pregnancies will provide higher risk estimates than women without recent pregnancies. Among sexually active women who have avoided pregnancy, recent contraceptive use may determine whether avoiding pregnancy is a surprising outcome that alters a woman's beliefs about pregnancy risk. A consistent contraceptive user may simply conclude that her contraception was effective; an infrequent contraceptive user may question her likelihood of becoming pregnant in the future. Therefore, I anticipate that women who did not always use contraception will estimate the risk of pregnancy to be lower than women who did always use contraception.

Research supporting a link between women's behavior and subsequent risk estimates is subject to many of the same caveats as research indicating a relationship in the opposite direction. Reverse causality is a concern: estimated pregnancy risk may predict contraceptive use, or it may be shaped by past contraceptive use. This relationship may actually be reciprocal, but this cannot be determined from cross-sectional data. The qualitative studies described above rely on retrospective reports of women's beliefs about pregnancy risk before they became pregnant, and it may be difficult to accurately recall risk perceptions accurately after months or years. Social desirability is also a concern due to the stigma attached to unintended pregnancy and abortion in the U.S.: study participants may feel the need to rationalize their non-use of contraception to an interviewer. In some cases, reports of low perceived pregnancy risk might be justifications of potentially stigmatizing behavior instead of literal descriptions of prior risk

estimates. Finally, evidence connecting prior behavior to subsequent pregnancy risk estimates is primarily from small qualitative studies of women that may not be generalizable. These women's narratives may be capturing a phenomenon occurring among young women in general, but they may also be unique to young women with histories of unintended pregnancy and abortion.

Data

The current study uses data from the Relationship Dynamics and Social Life study (RDSL), a longitudinal study of young women residing within a racially and economically diverse Michigan county (Barber, Kusunoki, & Gatny, 2011). Respondents were 18 or 19 years old at the time of recruitment and were randomly selected from the Michigan Department of State's Personal Identification Card and driver's license database.[9] Baseline interviews were conducted on a rolling basis from March 2008 to July 2009; 1,003 women completed a baseline interview, yielding a response rate of 83% and a cooperation rate of 94%. These interviews were conducted in person by a professional interviewer, lasted approximately one hour, and included questions about sociodemographic characteristics, attitudes, relationship characteristics and history, contraceptive use and pregnancy history.

At the end of the baseline interview, participants were invited to participate in a follow-up study that lasted 30 months. Each week, respondents completed a short survey[10] ("journal") about their relationships, sexual behavior, contraceptive use, pregnancy intentions, and pregnancies during the previous week. (If a journal was completed late, these questions referred to the time period since the previous journal.) The journal took approximately 5 minutes to complete, and could be submitted by telephone or via the internet. Respondents were issued re-loadable debit cards and paid $1 per journal submitted, with a bonus for submitting five consecutive journals on time. Women who did not submit a journal for over 60 days were offered an additional $10 to return to the study. Of the 992 women who enrolled in the journal study, 75% contributed at least 18 months of journal data, and the median time between journals was 8 days.

In addition to the core questions asked every week, the journal included rotating sets of questions on topics that varied from week to week. These measures are updated quarterly

[9] Barber et al. (2011) estimated 96 % agreement between the Michigan Department of State database and the projected number of 18- and 19-year-old women in the county based on the 2000 census.
[10] The original text of all survey items used to construct independent and dependent variables can be found in Appendix A.

(approximately every 12 weeks) for the entire length of the journal study. One set of rotating questions includes women's estimations of their pregnancy risk. To the best of my knowledge, RDSL is the only fertility survey to include longitudinal measures of estimated pregnancy risk. These measures permit not only comparisons *between* women, but also analysis of change *within* women over time and in response to their experiences with sex, contraception, and pregnancy. RDSL is also unique in its weekly measurement of sex, contraception, and pregnancy.

RDSL data allow this study to overcome many of the limitations of previous research on estimated pregnancy risk and fertility behaviors. Population-based sampling ensures that selection into the sample is not based on sexual experience, receipt of family planning services, or history of pregnancy or abortion. Longitudinal measurement of pregnancy risk estimates and women's behavior make it possible to use estimated risk to predict subsequent behavior, net of previous behavior. It is also possible to use recent behavior to predict subsequent estimates of pregnancy risk, net of previous risk estimates. Thus, this study is able to assess the direction(s) of the relationship between estimated pregnancy risk and women's behavior.

Analytic Sample

Of the 992 women who enrolled in the journal study, 746 women provided at least two quarterly estimates of their pregnancy risk. Together, these women contributed 3,666 quarters[11] of data. The number of quarters contributed per woman ranges from 2 to 13, with a mean of 5.85. Table 2.1 describes the sociodemographic composition of the analytic sample.

Measures

Estimated pregnancy risk

In the first journal after the baseline interview, respondents are asked to estimate the likelihood of various events on a scale from 0 to 100, where "*0 means that you think there is absolutely no chance, and 100 means that you think the event is absolutely sure to happen.*" This series includes questions about the risk of pregnancy from having sex without contraception once or twice ("*If you were to have sexual intercourse once or twice without using birth control, what are the chances that you would get pregnant?"*) and the risk of pregnancy from having sex without contraception repeatedly ("*If you were to have sexual intercourse regularly, say once a week for a year, without using birth control, what do you think are the chances that you would get pregnant?*"). These questions are repeated approximately every twelve weeks throughout the

[11] Throughout this chapter, I refer to the approximately 12-week intervals between risk updates as "quarters."

study period. For each of these measures, I also calculate change in estimated pregnancy risk during the quarter.

In addition to the longitudinal design, these perceived risk measures meet the quality criteria suggested by Brewer and colleagues (Brewer et al., 2007). They refer to a specific window of time, and they ask about the conditional probability of pregnancy *if they were to have sex without using any contraception*. This reduces the likelihood that women will factor their actual contraceptive use into their pregnancy risk estimates.[12] Finally, women are asked to estimate their own risk of pregnancy, which is more likely to predict subsequent behavior than an estimate of pregnancy risk for women in general.

Sex, contraception, and pregnancy

Measures of sexual behavior and contraceptive use are constructed from responses to the weekly journal. In each journal, respondents are asked about sexual intercourse with a male partner since the previous journal. Women also answer a series of questions about contraceptive use since the previous journal, including a broad introductory question about any contraceptive use and a set of follow-up questions about specific methods (e.g. "*Did you use the NuvaRing?*") Women who report using contraception are also asked about the consistency of their contraceptive use ("*…since the last interview, did you or your partner use some method of birth control every time you had intercourse (even if you are not trying to prevent pregnancy)?*")

Based on women's responses to these questions, I create a measure summarizing sexual behavior and contraceptive use during each quarter. In any given quarter, a woman either 1) had no sex, 2) had sex and always used contraception, or 3) had sex and did not always use contraception. This is the dependent variable in analyses using estimations of pregnancy risk to predict women's subsequent behavior.

Analyses using recent behavior to predict women's estimates of pregnancy risk use a second version of this measure that incorporates pregnancy experiences during the quarter. This measure reflects the apparent consequences of a woman's recent sexual behavior and contraceptive use at the moment she is asked to estimate her pregnancy risk. Among women who did not become pregnant, the measure indicates whether avoiding pregnancy might be an

[12] An unconditional version of this question (one that does not specify "without using birth control") might conflate women who do not use contraception because they believe the overall risk of pregnancy to be low with women who believe their own risk is low because they are already using contraception.

unexpected outcome. A consistent contraceptive user may simply assume that her contraceptive method worked. To an infrequent contraceptive user, avoiding pregnancy may be a more surprising outcome (especially if she previously believed the risk of pregnancy to be high), and she may reevaluate her pregnancy risk accordingly. Becoming pregnant seems likely to affect subsequent estimations of pregnancy risk, although the discovery of the pregnancy itself is more recent and probably more salient than the behavior that led to the pregnancy. Thus, pregnancy experiences during the spell supersede sex and contraceptive use: the "pregnancy scare" [13] and "pregnancy" categories include all quarters in which women had those pregnancy experiences, regardless of their reported sexual and contraceptive behavior during that quarter. In any given quarter, a woman either: 1) had no sex; 2) had sex and always used contraception; 3) had sex and did not always use contraception; 4) experienced a pregnancy scare; or 5) discovered a pregnancy.

Controls

Finally, these analyses control for sociodemographic characteristics that may influence sex, contraceptive use, and estimation of pregnancy risk. These characteristics are measured at the time of the baseline interview (at age 18/19) and include sociodemographic characteristics, family background, adolescent experiences with sex and contraception, and current socioeconomic disadvantage.

Race was measured with the question, "*Which of the following groups describe your racial background? Please select one or more groups: American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Black or African American, or White.*" Based on this measure, I create a variable indicating whether the respondent identifies as Black.[14] Religiosity was measured with the question "*How important if at all is your religious faith to you – would you say not important, somewhat important, very important, or more important than anything else?*" I consider respondents to be highly religious if they describe their religious faith as "very important" or "more important than anything else."

[13] I separate pregnancy scares from confirmed pregnancies because they may have different consequences for estimated pregnancy risk. Believing oneself to be pregnant could lead to higher risk estimates, but learning that one is *not* actually pregnant could lead to lower risk estimates.

[14] Only 24 respondents in the analytic sample provided a response other than "Black" or "White". Together, these respondents contributed 100 spells and account for 2.7% of spells in the analytic sample.

I include several measures describing the respondent's family background, including whether the respondent's mother had a live birth as a teenager, whether her mother has a college degree, whether her family received public assistance during childhood, and whether she grew up in a two-parent household. Adolescent sexual experiences include whether the respondent was 16 years old or younger at first sex, has two or more lifetime sexual partners by age 18/19, has ever had sex without contraception by age 18/19, and whether she has any prior pregnancies.

Finally, I control for several indicators of socioeconomic status (SES) at the time of the baseline interview, at age 18 or 19. These include current receipt of public assistance and current employment. Controlling for educational attainment is not feasible due to the young age of the sample; at the time of the baseline interview, a majority of RDSL respondents had not yet completed their education (13% were still enrolled in high school and another 65% were attending 2-year or 4-year postsecondary institutions.) Instead, I control for high school grade point average (GPA), which reflects recent school performance and should be predictive of eventual educational attainment.

Analysis

I begin with a detailed exploration of young women's pregnancy risk estimates, including initial risk estimates at ages 18/19, and changes observed during the study period. I also look for sociodemographic variation in these estimates.

Next, I use cross-lagged models to test for reciprocal relationships between women's pregnancy risk estimates and their sexual and contraceptive behavior. I test whether estimated pregnancy risk at the beginning of a quarter predicts sex and contraception during that quarter, controlling for sex and contraceptive use during the previous quarter. Using multinomial logistic regression, I estimate the likelihood of not having sex during the quarter and the likelihood of having sex without always using contraception, versus the base outcome of having sex and always using contraception. The key predictors are changes in estimated pregnancy risk occurring just prior to the quarter, and the absolute estimates of pregnancy risk at the beginning of the quarter.

In the second part of the cross-lagged analysis, I test whether sex, contraception, and pregnancy experiences during a quarter predict women's estimates of pregnancy risk at the end of that quarter, controlling for previous estimates of pregnancy risk. I use ordinary-least-squares (OLS) regression models to predict women's estimates of the risk of pregnancy from having sex

without contraception once or twice and from having sex without contraception regularly. The key predictor in these models is the summary measure of sex, contraception, and pregnancy during the quarter. Sexually active women who always used contraception and did not become pregnant are the reference group.

All models control for sociodemographic characteristics and the length of the quarter. Standard errors are adjusted to account for the clustering of quarters within women.

Results

Pregnancy risk estimates

Consistent with past research on young adults' perceived pregnancy risk, women in the RDSL initially overestimate the risk of pregnancy from having sex without contraception once or twice. On average, respondents estimate this risk to be 53.9% (recall that the true risk is approximately 3%). RDSL respondents also underestimate the risk of pregnancy from having sex without contraception regularly for one year. Their mean estimate of this risk is 74.96% (compared to the true risk of 85%).

Both estimated risk measures have large standard deviations, indicating considerable variation around both means. Estimated pregnancy risk at the beginning of the study period is associated with sociodemographic characteristics as well as adolescent sexual experiences taking place prior to the baseline interview. Estimates of the pregnancy risk from having sex once or twice are significantly higher among Black women (58.4% vs 51.9%), highly religious women (55.6% vs 51.6%), and women who received public assistance in childhood (56.6% vs 52.5%). Estimates of pregnancy risk from having sex without contraception once or twice are lower among women who ever had sex without contraception prior the baseline interview (51.0% vs 56.1%).

Estimates of the pregnancy risk from having sex without contraception regularly are lower among Black women (70.9% vs 76.8%), women whose mothers had teen births (70.0% vs 77.4%), and women who did not grow up in a two-parent household (77.2% vs 72.1%). Estimates of pregnancy risk from having sex without contraception regularly are also significantly associated with adolescent sexual experiences: they are lower among women who ever had sex without contraception by age 18/19 (69.9% vs 78.8%), women who were 16 or younger at first sex (72.7% vs 77.0%), and women with two or more lifetime sexual partners by age 18/19 (72.4% vs 78.1%).

Pregnancy risk estimates and subsequent sex and contraception

In Table 2.2, two multinomial logistic regression models predict sex and contraception during the quarter. These models include both types of pregnancy risk: the risk from having sex without contraception once or twice, and the risk from having sex without contraception regularly.[15] The first model considers changes in estimated pregnancy risk prior to the quarter; the second model adds new pregnancy risk estimates at the beginning of the quarter. Recall that the base outcome in this series of models is having sex and always using contraception during the quarter.

Neither pregnancy risk estimate is related to the odds of not having sex during the quarter. Estimates of pregnancy risk from having sex without contraception regularly are a stronger and more robust predictor of having sex and using contraception than estimates of pregnancy risk from having sex without contraception once or twice. Estimated pregnancy risk from having sex without contraception once or twice is associated with sex and contraception during the quarter, but only in models that do not include estimated pregnancy risk from having sex without contraception repeatedly (Table B.2).

Women whose pregnancy risk estimates increase have lower odds of having sex without always using contraception in the next quarter, and women whose pregnancy risk estimates decrease have higher odds of having sex without always using contraception (M1). This inverse relationship between recent change in pregnancy risk estimates and the odds of having sex without always using contraception is significant even after accounting for sex and contraception in the previous quarter, adolescent sexual experiences, and other demographic characteristics. However, when new pregnancy risk estimates at the beginning of the quarter are included in the model (M2), only the new risk estimates are significant. Higher (lower) risk estimates at the beginning of the quarter are associated with lower (higher) odds of having sex without always using contraception, versus having sex and always using contraception.

Although changes in estimated risk are related to subsequent behavior, this relationship operates through the new risk estimates that resulted from these changes. In other words, a

[15] Models considering each pregnancy risk estimate separately are presented in Appendix B (Table B.2 and Table B.3). Estimated risk of pregnancy from having sex once or twice is only significant at the bivariate level; its association with the odds of sex without contraception are explained by sociodemographic characteristics (Table B.2). The relationship between estimated pregnancy risk from having sex without contraception regularly and subsequent behavior is not altered by the inclusion or exclusion of estimated pregnancy risk from having sex without contraception once or twice (Table B.3).

woman whose risk estimate decreases from 50 to 40 has higher odds of having sex without always using contraception during the next quarter. However, the 10-point decrease does not have any *additional* predictive value after accounting for her new pregnancy risk estimate of 40. Moreover, a woman whose risk estimate decreases from 60 to 40 has the same odds of having sex without always using contraception as a woman whose estimate decreases from 50 to 40, all else being equal. These results are net of adolescent sexual experiences and sex and contraception in the previous quarter, all of which are also strong independent predictors of sex and contraception during the quarter.

When evaluating the magnitude of the relationship between estimated pregnancy risk and subsequent behavior, note that these pregnancy risk estimates range from 0 to 100 (changes in risk estimates range from -100 to 100). Thus, a one-unit difference in these measures refers to only one percentage point. Estimating the risk of pregnancy to be one percentage point higher is associated with a decrease of 0.0072 in the log-odds of having sex without always using contraception (OR: 0.99). Estimating the risk of pregnancy to be ten percentage points higher is associated with a decrease of 0.072 in the log-odds of having sex without contraception (OR: 0.93).

Sex, contraception, and pregnancy and subsequent pregnancy risk estimates

Table 2.3 displays OLS regression models predicting women's estimates of pregnancy risk[16] at the end of the quarter. Women who had sex during the quarter, always used contraception, and did not become pregnant are the reference group in all models.

Not having sex during the quarter predicts differences in estimated pregnancy risk from having sex without contraception once or twice (but not the risk from having sex without contraception repeatedly). Women who did not have sex during the quarter estimate the risk of pregnancy from having sex without contraception once or twice to be 2.08 percentage points higher at the end of the quarter.

Among those who had sex during the quarter and did not get pregnant, whether a women always used contraception is associated with her estimate of pregnancy risk from having sex without contraception regularly (but not the risk from having sex without contraception once or

[16] Relationships between recent behavior and change in pregnancy risk estimates are similar in direction and magnitude; these models are presented in Appendix B (Table B.1).

twice). Women who did not always use contraception judge this risk to be 4.10 percentage points lower than women who always used contraception.

Women who became pregnant during the quarter provided higher estimates of both types of pregnancy risk at the end of the quarter, compared to women who always used contraception and did not become pregnant. Women with pregnancies during the quarter judge the risk from having sex without contraception once or twice to be 5.73 percentage points higher and the risk from having sex without contraception regularly to be 8.54 percentage points higher. These women both provided higher risk estimates than the reference group, and were the only group of women whose mean change in pregnancy risk estimates during the quarter was positive (see Appendix B, Table B.1).[17]

Discussion

As in past research on young adults' estimations of pregnancy risk, young women in the RDSL sample tend to overestimate the risk of pregnancy from one instance of sex and underestimate the cumulative risk of pregnancy from having sex without contraception regularly for one year.

Misunderstandings about pregnancy risk are consequential for women's contraceptive use and vice versa. This cross-lagged analysis demonstrates a bi-directional relationship between pregnancy risk estimates and behavior. Women who believe the risk of pregnancy to be low are more likely to have sex without contraception, even after accounting for their past behavior. In turn, women who have sex without contraception and do not become pregnant tend to decrease their estimates of pregnancy risk, even after accounting for their previous risk estimates. Meanwhile, women who experience pregnancies estimate the risk of pregnancy to be significantly higher at the next quarterly risk estimation.

Estimates of the cumulative risk of pregnancy from having sex without contraception regularly are stronger, more robust predictors of contraceptive use than estimations of pregnancy risk from having sex without contraception once or twice. These analyses do not indicate that either type of pregnancy risk estimate is a strong influence on sexual behavior among young adults. This finding challenges the wisdom of promoting either abstinence or contraceptive use

[17] Not having sex during the quarter is positively related to change in estimated risk from having sex without contraception once or twice, but only in the sense that this group experienced smaller negative changes than the reference group. Estimated pregnancy risk only truly increased among the women who became pregnant during the quarter (See Appendix B, Table B.1).

by emphasizing the risk of pregnancy from a single instance of sex (i.e. the ubiquitous message that "it only takes once".) This approach to sexual education is unlikely to achieve its goal of discouraging adolescents from becoming sexually active, it may contribute to perceived infertility among adolescents and young adults who have avoided pregnancy despite having sex without contraception, and it may ultimately undermine contraceptive use in this population. Many young adults do have sex without contraception at some point (Kaye et al., 2009), and most will not immediately become pregnant because the risk of pregnancy from one instance of sex is low.

This study builds on a previous qualitative literature suggesting that avoiding pregnancy in the short term leads young women to conclude they are unlikely to ever conceive and increases the likelihood of risky behavior (Ayoola et al., 2007; Frohwirth et al., 2013; Hoggart & Phillips, 2011). This study provides the first strong quantitative evidence of this phenomenon: women who have sex without contraception and do not become pregnant decrease their estimates of cumulative pregnancy risk over time, and reductions in estimated pregnancy risk increase the risk of sex without contraception later in the study. This is the first study on this topic to use longitudinal, prospective measures of estimated pregnancy risk, along with intensive measurement of sex and contraception. Prospective estimates of pregnancy risk eliminate the concern that reports of low estimated risk are a post-hoc justification for risky behavior. Longitudinal measurement of both estimated pregnancy risk and behavior makes it possible to untangle selection into behavior based on estimated risk from changes in risk estimates due to behavior. That is, women who have sex without contraception are likely to have begun the study with lower estimates of pregnancy risk, but their risk estimates continue to decrease when they have sex without contraception and do not become pregnant. Finally, population-based sampling ensures that selection into this analysis is not based on sexual experience, prior contraceptive use, or pregnancy history. Many prior studies on this topic are qualitative investigations of women's reasons for not using contraception prior to having an unintended pregnancy. This study provides evidence of a reciprocal relationship between estimated pregnancy risk and contraceptive use in a much wider swath of the population.

Limitations

Longitudinal measurement of estimated risk is a major advantage of this analysis, but it raises a potential methodological issue: repeatedly asking women to estimate their pregnancy

risk may have altered their estimates and ultimately their behavior. In anticipation of similar concerns about the intensive measurement of sex and contraception, an experiment was built into the RDSL study to gauge whether weekly measurement of sex and contraception influenced respondents' behavior (Barber, Kusunoki, & Gatny, 2011). A secondary sample of young women completed only the baseline interview and a closeout interview at the end of the study period; these women did not report substantially different behavior than the RDSL respondents in the main sample. If being asked weekly about sex and contraception does not affect contraceptive behavior, it seems even less likely that being asked about pregnancy risk on a quarterly basis would affect risk estimates. However, I cannot rule out this possibility.

Michigan is not an obvious outlier with respect to fertility and reproductive health (Lesthaeghe & Neidert, 2006), but the RDSL sample is not nationally representative. Caution is required when generalizing these findings to young adults in other regions of the U.S. The sample is less diverse than the United States as a whole; most women in the sample identify as either Black or White and there are relatively few participants from other racial/ethnic groups. However, the composition of the sample is advantageous in other respects. The data were conducted from a county with considerable socioeconomic diversity among both Black and White women. Probability sampling from the Personal Identification Card and driver's license database ensures that the sample is representative of 18- and 19-year-olds within the study county, and that participation in the RDSL study is not conditional on sexual history, pregnancy history, past or current contraceptive use, or use of reproductive health services. Conducting the study within one state also reduces heterogeneity in the sexual education RDSL respondents may have received as teenagers. Although sexual education content is locally determined and varies by district, broad guidelines for sexual education content are determined at the state level.

The focus on a narrow age range may limit the generalizability of these findings to younger or older women. Early adulthood may be unique for several reasons: young adults are more likely than younger teens to be sexually active, but less likely to desire a pregnancy than people later in their twenties. Young adults without much experience with sex or contraception may be relying heavily on information from peers and other members of their social network (Yee & Simon, 2010), which may not be entirely accurate. Thus, myths and misconceptions may be more widespread and more consequential at these ages. If this is the case, the relationships

between perceived risks and contraceptive use observed in these analyses may not extend to older, more experienced adults.

On the other hand, focusing on a narrow age range limits some sources of heterogeneity that might otherwise complicate the analysis. Although women aged 18 and 19 have diverse experiences of sex and pregnancy, there is less variation than one would expect in a sample of all reproductive-aged women.[18] Given the topic of this analysis and its relevance to perceived infertility, it is important to note that the prevalence of subfecundity within the RDSL age range is extremely low (Chandra et al., 2005). Thus, most low estimates of pregnancy risk at age 18/19 are not the result of prior unsuccessful attempts to conceive. If the sample included older women, it would be much more difficult to distinguish between anticipation and experiences of infertility.

Implications for Policy and Practice

Many young women underestimate the cumulative risk of pregnancy from having sex without contraception repeatedly. To some extent, this pattern may reflect poor understanding of risk, particularly since women's estimates of pregnancy risk from one instance of sex are very high. However, young women's inaccurate estimates of their pregnancy risk may also result from inadequate sexual education that prioritizes sexual abstinence at the expense of comprehensive information about sex, contraception, and pregnancy.

Sexual education curricula and other pregnancy prevention efforts frequently try to discourage young adults from playing the odds by emphasizing that any instance of sex could result in pregnancy (e.g. "it only takes once.") Young adults should be aware that each instance of sex involves pregnancy risk, but it is essential that they not distill the message that pregnancy is nearly inevitable after one instance of sex. Many young adults do occasionally have sex without contraception, and most of them will not become pregnant the first time this occurs. When this reality collides with young adults' belief in the near-inevitability of pregnancy, they may question their own fertility instead of questioning their prior beliefs about pregnancy risk. Thus, overemphasizing the risk of pregnancy from one instance of sex may be detrimental to the goal of encouraging consistent contraceptive use. It may be more effective to emphasize the high cumulative risk of pregnancy among couples having sex without contraception regularly: having sex without contraception on a regular basis is likely to lead to pregnancy eventually, even

[18] For instance, the National Survey of Family Growth includes women aged 15-49 something: women just beginning their sexual lives and women who have completed their fertility.

though the risk from any one instance of sex is quite low. Finally, it is absolutely vital that young adults receive the message that avoiding pregnancy after having sex without contraception is *not* a reliable indicator of infertility.

Admittedly, in many cases, the primary goal of sexual education is to discourage adolescent and non-marital sex, and the promotion of contraception is seen to detract from that goal (Lindberg et al., 2006; Luker, 2006; Santelli et al., 2017). However, estimates of pregnancy risk do not actually seem to affect sexual behavior. Sexual education programs overemphasizing the risk of pregnancy from one instance of sex are likely to be ineffective, and are missing an opportunity to improve contraceptive use among young people.

Table 2.1: Chapter 2 Analytic Sample

			Quarters (n=3666)		Women (n=756)	
	Min	Max	Proportion/Mean	SD	Proportion/Mean	SD
Estimated pregnancy risk						
…from having sex once or twice	0	100	72.50	26.64		
…from having sex regularly	0	100	50.88	25.69		
Change in estimated pregnancy risk during quarter						
…from having sex once or twice	-100	100	-1.33	26.29		
…from having sex regularly	-100	100	-0.71	23.84		
Sex/contraception/pregnancy during quarter						
No sex	0	1	.40	--		
Had sex and always used contraception	0	1	.30	--		
Had sex without always using contraception	0	1	.23	--		
Pregnancy scare	0	1	.03	--		
Pregnancy	0	1	.04	--		
Sex/contraception during quarter						
No sex	0	1	.41	--		
Had sex and always used contraception	0	1	.31	--		
Had sex without always using contraception	0	1	.28	--		
Sociodemographic characteristics						
Black	0	1	.26	--	.31	--
High religiosity	0	1	.56	--	.57	--
Family background						
Childhood public assistance	0	1	.30	--	.35	--
Mother had teen birth	0	1	.28	--	.33	--
Mother has college degree	0	1	.27	--	.24	--
Two-parent household	0	1	.62	--	.56	--
Adolescent sexual experiences						
Age 16 or younger at first sex	0	1	.40	--	.48	--
Two or more sexual partners by age 18/19	0	1	.48	--	.55	--
Ever had sex without contraception by age 18/19	0	1	.34	--	.43	--
Any prior pregnancy by age 18/19	0	1	.15	--	.21	--
Current socioeconomic status						
High school GPA	0	4.17	3.25	.57	3.17	.59
Public assistance at age 18/19	0	1	.17	--	.22	--
Employed at age 18/19	0	1	.48	--	.49	--
Number of quarterly estimations of pregnancy risk	2	13			5.85	2.77

Table 2.2: Estimated Pregnancy Risk and Sex/Contraception During Next Quarter

	M1		M2	
	No sex	**Had sex without always using contraception**	**No sex**	**Had sex without always using contraception**
Change in estimated pregnancy risk prior to quarter				
…from having sex once or twice	.0018	-.0026	.0013	-.0020
	(.0031)	(.0028)	(.0036)	(.0033)
…from having sex regularly	-.0002	-.0051 *	.0019	-.0012
	(.0026)	(.0023)	(.0032)	(.0029)
Estimate of pregnancy risk at beginning of quarter				
…from having sex once or twice			.0008	-.0015
			(.0033)	(.0035)
…from having sex regularly			-.0042	-.0072 *
			(.0035)	(.0033)
Sex/contraception during previous quarter (ref: had sex and always used contraception)				
No sex	3.82 ***	1.01 ***	3.82 ***	1.01 ***
	(.19)	(.20)	(.19)	(.20)
Had sex without always using contraception	1.20 ***	2.61 ***	1.17 ***	2.56 ***
	(.20)	(.16)	(.20)	(.16)
Sociodemographic characteristics				
Black	.49 **	.02	.49 **	.02
	(.19)	(.19)	(.19)	(.19)
High religiosity	.10	.17	.09	.16
	(.14)	(.15)	(.14)	(.15)
Family background				
Childhood public assistance	-.20	.06	-.20	.04
	(.17)	(.15)	(.17)	(.16)
Mother had teen birth	.10	.15	.07	.11
	(.17)	(.15)	(.17)	(.16)
Mother has college degree	.09	-.32 *	.09	-.34 *
	(.14)	(.16)	(.14)	(.16)
Two-parent household	-.06	-.10	-.05	-.09
	(.15)	(.15)	(.16)	(.16)
Adolescent sexual experiences				
Age 16 or younger at first sex	-.43 **	-.21	-.43 *	-.20
	(.18)	(.17)	(.18)	(.17)
Two or more sexual partners by age 18/19	-.57 ***	.02	-.57 ***	.02
	(.17)	(.17)	(.17)	(.17)
Ever had sex without contraception by age 18/19	-.06	.51 ***	-.09	.47 **
	(.18)	(.16)	(.19)	(.16)
Any prior pregnancy by age 18/19	.00	.47 **	.00	.48 **
	(.26)	(.20)	(.27)	(.20)
Current socioeconomic status				
High school GPA	-.34 **	-.48 ***	-.33 **	-.47 ***
	(.13)	(.13)	(.13)	(.13)
Public assistance at age 18/19	.22	-.14	.23	-.11
	(.22)	(.19)	(.22)	(.20)
Employed at age 18/19	-.29 *	-.16	-.29 *	-.15
	(.13)	(.14)	(.13)	(.14)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Notes: N=2,910 due to lagging of sex/contraception. Base outcome is "Had sex and always used contraception". Coefficients refer to log-odds. Standard errors are in parentheses and account for clustering of quarters within women. All models control for length of the quarter.

Table 2.3: Sex/Contraception/Pregnancy and Pregnancy Risk Estimates at End of Quarter

	Estimate of Pregnancy Risk From Having Sex Without Contraception…	
	Once or Twice	**Regularly**
Sex/contraception/pregnancy during quarter (ref: Had sex and always used contraception)		
No sex	2.08 *	.23
	(1.11)	(1.19)
Had sex without always using contraception	.80	-4.10 ***
	(1.11)	(1.28)
Pregnancy scare	.75	-2.34
	(3.00)	(2.94)
Pregnancy	5.73 *	8.54 **
	(3.30)	(3.36)
Previous estimate of pregnancy risk from having sex without contraception…		
Once or twice	.55 ***	
	(.03)	
Regularly		.49 ***
		(.03)
Sociodemographic characteristics		
Black	.33	-.96
	(1.27)	(1.32)
High religiosity	1.49	-.28
	(1.01)	(1.03)
Family background		
Childhood public assistance	-1.32	-1.54
	(1.15)	(1.32)
Mother had a teen birth	-.90	-2.91 **
	(1.00)	(1.22)
Mother has a college degree	-1.24	.36
	(1.10)	(1.17)
Two-parent household	-.43	.59
	(1.02)	(1.10)
Adolescent sexual experiences		
Age 16 or younger at first sex	-.29	.47
	(1.29)	(1.42)
Two or more sexual partners by age 18/19	-1.75	-.58
	(1.30)	(1.41)
Ever had sex without contraception by age 18/19	-2.92 **	-4.32 ***
	(1.18)	(1.35)
Any prior pregnancy by age 18/19	2.33	.24
	(1.53)	(1.78)
Current socioeconomic status		
High school GPA	-1.41 *	.51
	(.75)	(.83)
Public assistance at age 18/19	1.11	.55
	(1.49)	(1.69)
Employed at age 18/19	.47	.09
	(.91)	(.99)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Note: N=3,666 quarters. Standard errors are in parentheses and account for clustering of quarters within women. All models control for the length of the quarter.

Chapter 3: Side Effect Concerns and Young Women's Contraceptive Use

Introduction

In the previous chapter, I focused on women's estimates of their risk of pregnancy, changes in these estimates over time, and reciprocal relationships between estimated risk and behavior. However, pregnancy risk is not the sole consideration in decisions about contraception. Alongside the desire to avoid pregnancy and beliefs about the likelihood of pregnancy, women also must weigh the potential costs of contraception, which include not only financial costs, but also other anticipated consequences of contraception (Luker, 1975).Whereas Chapter 2 examined a set of risk perceptions likely to encourage contraceptive use, this chapter considers a set of risk perceptions likely to discourage contraceptive use: concerns about contraceptive side effects.

Many young women are skeptical about medications. Qualitative investigations have identified recurring concerns about long-term medication use, including the belief that medications are unnatural, worries about lasting health consequences, and the conviction that long-term use of any medication is inherently undesirable (Benson & Britten, 2002; Pound et al., 2005). For some women, contraception also raises concerns about hormones, the possible disruption of menstruation, and fears about future infertility (Cheung & Free, 2005; Clark, 2001; Clark et al., 2006; Gilliam et al., 2009). This rich qualitative evidence of side effect concerns is echoed by a nationally representative study of young adults aged 18-29 (Kaye et al., 2009) which found widespread concerns about contraceptive safety as well as outright misinformation. Although these studies do not measure subsequent contraceptive behavior, they suggest that side effect concerns are a powerful barrier to use of hormonal methods among young women.

In this chapter, I investigate side effect concerns, by which I mean expectations about the likelihood and severity of side effects and other health problems resulting from use of hormonal contraception. I test whether side effects discourage young women who wish to avoid pregnancy from using hormonal contraceptive methods, and whether women concerned about side effects come to rely on non-hormonal methods instead or stop using contraception altogether.

Background

Prior research on side effect concerns has focused heavily on their association with discontinuation of hormonal methods (Brunner Huber et al., 2006; Littlejohn, 2012; Westhoff et al., 2007). Arguably, this is the dimension of contraceptive use where side effect concerns should have the weakest influence, because discontinuation is only possible among women who have self-selected into hormonal contraceptive use. Women who are willing to try hormonal contraception are likely to have more positive initial views of these methods than non-users. Side effect concerns might exert an even stronger influence on contraceptive decisions at earlier junctures. They may play a role in method selection, method switching, or inconsistent or intermittent use. However, data limitations have hindered research about the role of side effect concerns in other dimensions of contraceptive use.

Anticipation of serious side effects may discourage women from ever trying a hormonal method. I hypothesize that women reporting greater side effect concerns will be less likely to ever use an IUD, a contraceptive implant, or oral contraceptive pills during the study period, and more likely to ever rely on non-hormonal methods such as condoms or withdrawal. This notion is consistent with the finding that women with concerns about side effects are less likely to be current users of hormonal methods (Frost et al., 2012), although current use is a function of both uptake and discontinuation. Studying uptake of specific methods requires longitudinal measurement of contraceptive use within a sample that is not restricted to users.

The likelihood that a contraceptive user will continue using her chosen method may also be shaped by her beliefs about side effects. Side effect concerns may affect the likelihood of perceiving side effects while using hormonal methods. That is, women who expect contraception to cause side effects may be primed to attribute changes in their health to their contraception. This is *not* to say that physical complaints are imagined or that women's perceptions of side effects are necessarily incorrect, only that "non-specific" symptoms such as headaches, mood swings, and weight gain are common in the general population and have many possible causes (Grimes & Schulz, 2011). Underlying beliefs about hormonal contraception may shape women's interpretations of these kinds of symptoms when the precise cause remains unknown[19], and these interpretations may influence subsequent contraceptive use.

[19] Incorrect attributions may happen in either direction, but a physical complaint is only likely to influence contraceptive behavior when the woman believes that they are connected.

Whether women discontinue their method in response to perceived side effects may depend the tolerability of the symptoms as well as the significance women attach to them. Identical symptoms can provoke opposite reactions: for instance, some women consider regulation or interruption of the menstrual cycle to be a particular advantage of hormonal methods, while other women interpret contraception-related changes in menstruation as a warning sign of infertility or another underlying health problem (Cheung & Free, 2005; Clark, 2001; Clark et al., 2006). Women may switch to another method or stop using contraception altogether if the perceived side effects are more severe, or if women believe that they foreshadow more serious health consequences. Again, these interpretations are probably shaped by prior beliefs about the fundamental safety of hormonal contraception. Women who are already concerned about long-term safety are probably more likely to interpret side effects as confirmation that hormonal methods are fundamentally unsafe. As a result of a lower likelihood of ever trying hormonal methods and a lower likelihood of continuing to use these methods, I anticipate that women who are very concerned about side effects will ultimately spend less time during the study period using hormonal methods. Decreased use of hormonal contraception implies some combination of more frequent sex without contraception and greater reliance on non-hormonal methods. Thus, I expect side effect concerns to be associated with more weeks in which women use condoms or withdrawal, and also more weeks in which they do not use any method of contraception.

Prior research has considered the role of side effect concerns in discontinuation, but not necessarily women's behavior after discontinuation. In the present study, I distinguish between types of discontinuation that have different implications for women's pregnancy risk: discontinuing in favor of a different method (a method switch) versus discontinuing contraceptive use altogether (a gap in contraceptive use). I hypothesize that women with greater concerns about side effects will experience more method switches and also more gaps in contraceptive use during the study period.

Methodology

This study uses data from the Relationship Dynamics and Social Life study (RDSL), a longitudinal study of young women residing within a racially and economically diverse Michigan county (Barber, Kusunoki, & Gatny, 2011). Respondents were 18 or 19 years old at the time of recruitment and were randomly selected from the Michigan Department of State's

Personal Identification Card and driver's license database.[20] Baseline interviews were conducted on a rolling basis from March 2008 to July 2009; 1,003 women completed a baseline interview, yielding a response rate of 83% and a cooperation rate of 94%. These interviews were conducted in person by a professional interviewer, lasted approximately one hour, and included questions about sociodemographic characteristics, attitudes, relationship characteristics and history, contraceptive use and pregnancy history.

At the end of the baseline interview, participants were invited to participate in a follow-up study that lasted 30 months. Each week, respondents completed a short survey[21] ("journal") about their relationships, sexual behavior, contraceptive use, pregnancy intentions, and pregnancies during the previous week. (If a journal was completed late, these questions referred to the time period since the previous journal.) The journal took approximately 5 minutes to complete, and could be submitted by telephone or via the internet. Respondents were issued re-loadable debit cards and paid $1 per journal submitted, with a bonus for submitting five consecutive journals on time. Women who did not submit a journal for over 60 days were offered an additional $10 to return to the study. Of the 992 women who enrolled in the journal study, 75% contributed at least 18 months of journal data, and the median time between journals was 8 days.

Analytic Sample

Side effect concerns are measured in the Social Life Journal Supplement (SLJS), which took place in May 2010. Of the 982 women still enrolled in the journal study at this time, 590 women completed the SLJS for a response rate of 60%. Of the original 590 SLJS respondents, 573 answered questions in the SLJS about side effects. In order to focus on women's contraceptive behavior *while at risk of an unintended pregnancy*, individual journal weeks are dropped from this analysis if the respondent is already pregnant, reports a strong desire to become pregnant, or does not report sexual intercourse. Consequently, 112 women who are never at risk of unintended pregnancy during the study period are dropped for a final analytical sample of 461 women who contribute a total of 14,634 eligible journals. The number of eligible

[20] Barber et al. (2011) estimated 96 % agreement between the Michigan Department of State database and the projected number of 18- and 19-year-old women in the county based on the 2000 census.
[21] The original text of all survey items used to construct independent and dependent variables can be found in Appendix A.

journals per woman ranges from 1 to 125, and the mean number of eligible journals per woman is 31.7. Characteristics of the analytic sample are described in Table 3.1.

Measures

Side effect concerns

The Social Life Journal Supplement (SLJS) includes a series of questions about anticipated side effects and other perceived health risks of using hormonal contraception. Four of these questions are significant bivariate predictors of contraceptive behavior and are retained to create an additive scale.[22] Two questions focus on perceived long-term health risks of using hormonal methods: "*If you used the birth control pill or other hormonal methods for many years, it is likely to give you a serious health problem (like cancer)"* and "*Which is more risky to a woman's health: taking birth control pills for a year or having a baby, including the pregnancy, labor, and delivery?"* The other two questions focus on the likelihood of more immediate side effects: "*If you used the birth control pill or other hormonal methods, it is likely to give you severe mood swings*" and "*If you used the birth control pill or other hormonal methods, it is likely you will gain weight."* I recode these items 0/1, with a value of 1 indicating concern about that particular side effect. The side effect concerns scale ranges from 0 to 4, with higher values indicating greater concern about contraceptive side effects. The original scale items and the side effects scale are summarized in Table 3.2.

Contraceptive use

Contraceptive outcomes are constructed from a series of questions in the weekly journal. At each journal, respondents are asked, "Did you use or do anything that can help people avoid becoming pregnant, even if you did not use it to keep from getting pregnant yourself?" Women who report using contraception are asked a series of follow-up questions about specific methods. Based on their responses, I classify sexually active weeks according to the most effective contraceptive method used that week[23]: none, withdrawal, condom, pill/patch/ring, or LARC (long-acting reversible contraceptive) methods, which include IUD, implant, and the injectable Depo-Provera. These categories are mutually exclusive: a week with condom and withdrawal use

[22] During the construction of this scale, I conducted two sensitivity analyses. In one version, I include these 4 items as individual predictors in place of a scale. In the second, I create a 6-item scale that includes two additional items that are marginally significant bivariate predictors of contraceptive behavior. These analyses lead to the same substantive conclusions as the version presented here.

[23] 57 journals (0.4% of the 12,726 journals in which women reported using contraception) are dropped because respondents did not specify the method used.

is classified as a condom week, but a week with condom and pill use is considered a pill week. Using this week-level contraceptive method variable, I construct indicators of ever using withdrawal, condoms, pill/patch/ring, and LARC during the study period, as well as an indicator of ever having sex without contraception. I also count the number of times a woman switched to a less effective contraceptive method and the number of gaps in contraceptive use.

Thus, I construct a final series of contraceptive use variables: the percentage of (sexually active) weeks in which women used no method, withdrawal, condoms, pill/patch/ring, and LARC. These proportions are based on the single most effective method used in each week, so a woman's values on this set of variables always sum to 100%. Together, these variables summarize the cumulative effect of starting, stopping, and switching methods over the study period.

Sociodemographic characteristics

These analyses control for sociodemographic characteristics that have been connected to sexual behavior and contraceptive use in past research, and may also be associated with side effect concerns. These characteristics are measured at the time of the baseline interview (at age 18/19) and include sociodemographic characteristics, family background, adolescent experiences with sex and contraception, and current socioeconomic status.

Race is strongly associated with use of specific contraceptive methods in the United States: White women are more likely than Black women to use oral contraceptive pills, while Black women are more likely to use condoms (Kusunoki, Barber, Ela, & Bucek, 2016). In the RDSL, race is measured with the question, "*Which of the following groups describe your racial background? Please select one or more groups: American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Black or African American, or White.*" These analyses include a variable indicating whether the respondent identifies as Black.[24]

Religiosity may shape women's beliefs about the moral acceptability of contraception in general and of specific methods. Even among sexually active women, religious proscriptions against non-marital sexual intercourse may affect devout women's willingness to use hormonal contraception or carry condoms if this is construed as conscious preparation for—or tacit

[24] Only 12 respondents in the analytic sample provided a response other than Black or White. These respondents are grouped with the White respondents; the results of this analysis do not change when these 12 respondents are excluded.

admission of—sexual activity. Religiosity may affect both the likelihood of receiving formal sexual education and the content of the curriculum (e.g. provision of information about contraception), and thus may predict side effect concerns. Religiosity is measured with the question "How important if at all is your religious faith to you – would you say not important, somewhat important, very important, or more important than anything else?" and I consider respondents to be highly religious if they describe their religious faith as "very important" or "more important than anything else."

Socioeconomic status is strongly predictive of both contraceptive use and method selection among contraceptive users (Daniels, Daugherty, Jones, & Mosher, 2015; Kusunoki et al., 2016; Mosher, Jones, & Abma, 2015). These analyses control for several indicators of childhood SES: receipt of public assistance, whether the respondent's mother had a teen birth[25], whether the respondent's mother has a college degree, and whether the respondent grew up in a two-parent household.

Adolescent sexual experiences are likely to predict future behavior, and prior experiences may shape women's beliefs and attitudes about contraception. Therefore, these analyses include measures indicating whether the respondent was 16 or younger at first sex, whether she had two or more lifetime sexual partners by age 18/19, whether she ever had sex without contraception by age 18/19, and whether she had any pregnancies before the beginning of the study period.

Finally, I control for several indicators of current socioeconomic status at age 18/19. Educational attainment is linked to contraceptive use and method selection (Daniels et al., 2015) as well as health literacy (Kutner, Greenburg, Jin, & Paulsen, 2006). I control for high school grade point average (GPA) instead of a direct measure of educational attainment because most respondents had not completed their education at the time of the baseline interview.[26] I also control for current receipt of public assistance and current employment.

Analysis

I use logistic regression models to estimate the likelihood of ever having unprotected sex during the study period and the likelihood of ever using particular contraceptive methods:

[25] Early first births are most likely among socioeconomically disadvantaged young women (Finer & Zolna, 2016). This variable is included as a proxy for childhood disadvantage, but also because a mother's age at her first birth is highly predictive of her daughter's fertility timing (Barber, 2001)

[26] At the time of the baseline interview, 13% of respondents were still enrolled in high school and 65% were attending a 2-year or 4-year postsecondary institution.

withdrawal, condoms, pill, and LARC. Next, I use Poisson regression to predict the number of switches to a less effective contraceptive method, and the number of gaps in contraceptive use. In order to address potential observation bias[27], all logistic and Poisson regressions control for the number of journals used to construct the outcome.

Finally, I estimate OLS regression models predicting the percentage of sexually active journal weeks in which women used each contraceptive method. OLS regression may produce illogical estimates when the outcome is a proportion or percentage. Thus, I conduct another version of these analyses using generalized linear models (GLM) with a binomial error distribution, which is appropriate when the outcome is bounded between 0 and 1 (Papke & Wooldridge, 1993). Since the GLM results lead to the same substantive conclusions, I present the OLS results for ease of interpretation.

Results

Table 3.3 presents five separate logistic regression models predicting the likelihood of ever having sex without contraception, and the likelihood of ever using specific contraceptive methods during the study period. Side effect concerns are positively associated with having sex without contraception: for each additional point on the side effect concerns scale, the log-odds of any sex without contraception increase by 0.31 (equivalent to an odds ratio of 1.36).

Women who are concerned about side effects are considerably more likely to ever rely on non-hormonal contraceptive methods, and less likely to ever use the pill/patch/ring. For each additional point on the side effects scale, the log-odds of relying on withdrawal increase by 0.22 (OR: 1.22), and the log-odds of ever relying on condoms increase by 0.35 (OR: 1.42). Conversely, the log-odds of ever using the pill/patch/ring decrease by 0.24 (OR: 0.79) with each one-point increase in side effect concerns.

Table 3.4 shows Poisson regression models predicting the number of switches to a less effective contraceptive method and the number of gaps in contraceptive use while at risk of unintended pregnancy. Net of women's sociodemographic characteristics and adolescent sexual experiences, side effect concerns are significantly related to both outcomes. For each additional point on the side effect concerns scale, the predicted number of switches to a less effective

[27] For instance, a woman who submits more journals has more opportunities to report ever having sex without contraception.

contraceptive method increases by 0.15 and the predicted number of gaps in contraceptive use increases by 0.24.

Table 3.5 displays OLS regression models estimating the overall percentage of sex weeks in which women used specific contraceptive methods. Greater concern about side effects is associated with less frequent use of hormonal methods, offset by more frequent use of non-hormonal methods and more frequent weeks in which women used no method at all. Each additional point on the side effect concerns scale predicts a 6.20 percentage point decrease in weeks using the pill/patch/ring, and a 1.64 percentage point decrease in weeks using LARC methods. Meanwhile, a one-point increase in side effect concerns is associated with a 2.91 percentage point increase in condom use weeks, a 2.16 percentage point increase in withdrawal weeks, and a 2.76 percentage point increase in weeks not using any contraceptive method.

Discussion

Overall, side effect concerns are associated with less effective contraceptive use across many indicators. Women with greater side effect concerns are significantly less likely to ever use hormonal methods and do so in a lower percentage of sex weeks. They are significantly more likely to ever rely on condoms or withdrawal, and use these methods in a higher percentage of sex weeks. Side effect concerns are associated with increased risk of ever having sex without contraception during the study period, and more frequent sex weeks in which women do not use any method. Women with greater concerns about side effects also experience more switches to less effective contraceptive methods and more gaps in contraceptive use. Together, these findings suggest that anticipation of side effects may dissuade women from trying a hormonal contraceptive method, and that some combination of anticipation and/or experience of side effects may convince women who start using hormonal methods to switch to a non-hormonal method or stop using contraception altogether.

Since non-hormonal methods such as withdrawal and condoms have higher failure rates with perfect use and are difficult to use perfectly, concerns about side effects are consequential for women's risk of unintended pregnancy. Women using condoms or withdrawal are less likely to conceive than women not using contraception at all, but these methods have higher failure rates than hormonal methods (Trussell, 2011) even with perfect use and are difficult to use perfectly. Condoms and withdrawal both require the cooperation of the partner, and consistent condom use also requires advanced planning to ensure that condoms are available whenever

intercourse may occur. Thus, avoidance of hormonal contraception may ultimately increase women's risk of unintended pregnancy through some combination of non-use of contraception and reliance on less effective methods.

Over the course of the study period, many young women use multiple contraceptive methods and experience various kinds of disruptions in their contraceptive use (whether in the form of a method switch or a period of non-use). Many existing studies of contraceptive use are forced by data constraints to focus on one point in time, one dimension of contraceptive behavior, or one particular method. The longitudinal design of this study and intensive measurement of contraceptive use allow me to examine dynamic behaviors over a longer stretch of a woman's contraceptive "career." As a result, I am able to consider women's contraceptive behavior more holistically: how side effect concerns relate to women's use of hormonal methods, but also how these concerns may indirectly shape women's use of non-hormonal alternatives.

These findings echo previous studies connecting side effects to discontinuation of hormonal contraception (Littlejohn, 2012), but in this study, I am able to show that side effect concerns predict multiple types of discontinuation. Women concerned about side effects are more likely to switch to less effective contraceptive methods during the study period, and also more likely to experience gaps in their contraceptive use while sexually active. Both of these outcomes are likely to increase women's risk of pregnancy (all else being equal), but different interventions may be appropriate. For instance, women considering discontinuing a hormonal method might not realize they will be at immediate at risk of pregnancy, while women already planning a switch to condoms might benefit from instruction in correct condom use.

Limitations

The U.S. is characterized by large, persistent inequalities in access to contraception, reproductive healthcare, and indeed healthcare more generally, as well as discrepancies in the quality of care (Dehlendorf, Rodriguez, Levy, Borrero, & Steinauer, 2010; Institute of Medicine, 2001). These inequalities probably contribute to misinformation about contraceptive safety and also shape women's contraceptive options. The RDSL data do not include a measure of insurance (which affects women's access to the more expensive hormonal methods), although this analysis does control for several other indicators of socioeconomic disadvantage.

The RDSL data also do not include a lifetime history of specific contraceptive methods ever used prior to the study period, so it is possible that some apparent non-users of hormonal

methods are actually dissatisfied former users who discontinued the method(s) prior to the beginning of the study. Side effect concerns could precede young women's early contraceptive decisions, or vice versa; both scenarios are possible, and may in fact be occurring simultaneously. The survey questions used to measure side effect concerns are general statements about the likelihood of side effects and adverse health events, do not capture respondents' personal experiences while using hormonal contraception, and therefore cannot resolve the issue of causal ordering. Thus, it should not be assumed that the relationship between side effect concerns and contraceptive behavior is necessarily causal.

Ideally, these analyses would also consider partners' beliefs about contraceptive side effects and safety, since women do not necessarily make contraceptive decisions alone. Unfortunately, such measures are not readily available. Indeed, the RDSL is one of only a few datasets to connect women's *own* beliefs about contraceptive safety to longitudinal measures of actual contraceptive behavior. These data also do not include a measure of insurance, which is an important consideration given the higher initial costs of hormonal methods.[28] However, analyses do control for other indicators of financial security, including receipt of public assistance and employment.

Finally, these findings may not generalize to all women at risk of unintended pregnancy. The RDSL sample is limited to women in a narrow age range and living within a single Michigan county. RDSL participants are 18-19 at the time of recruitment and 20-22 by the end of the study. The high rate of unintended pregnancy during the transition to adulthood justifies focusing on young women at these ages, but these women's experiences may not be representative of younger teens or older women. The RDSL sample is geographically limited, and the prevalence of side effect concerns within this sample may not reflect the prevalence of side effect concerns among young women nationwide. However, there is not an obvious reason to suspect regional differences in the *consequences* of women's beliefs about side effects.

The advantages of the RDSL dataset for these analyses outweigh the limitations imposed by a regional sample. Although the sample is not nationally representative, selection into the sample is random and does not depend on women's past contraceptive behavior or use of reproductive health services (as it does in studies conducted using clinic samples or studies of

[28] These data were collected prior to full implementation of the Patient Protection and Affordable Care Act.

discontinuation among current contraceptive users). Second, RDSL is unique in its intensive measurement of pregnancy, pregnancy desire, sex, and contraception. Analyses of contraceptive use can be limited to the specific weeks in which women are at risk of unintended pregnancy (sexually active, not pregnant and no desire to conceive). Multiple dimensions of contraceptive use are measured, and measurement is frequent enough to detect even short-term disturbances in contraceptive behavior (such as a gap in contraceptive use or a method switch). Moreover, the follow-up period is long enough (up to 30 months) for findings about non-use of certain methods to be substantively meaningful.

Implications

Truly informed consent requires accurate information about both risks and benefits, as well as sound reasoning about those risks (Reyna, 2008), such as the ability to distinguish between possible and probable side effects, and some consideration of competing risks (e.g. oral contraceptive pills versus pregnancy and delivery). If concerns about the health consequences of contraception outweigh a woman's desire to avoid pregnancy, not using contraception or using a less effective method may be a rational decision (Luker, 1975). However, rational decisions may still be based upon incorrect information. The statements about side effects that predict contraceptive use in these analyses represent distortions of the risks associated with hormonal contraception. Two statements—that hormonal contraception is likely to cause cancer and is riskier to a woman's health than pregnancy, labor, and delivery—are factually incorrect, while the remaining two statements discuss side effects that are possible (severe mood swings and weight gain), but overstate their likelihood. Non-trivial proportions of women in the sample agreed with each of the four statements, suggesting that credible sources of contraceptive information, particularly sexual education and healthcare providers, are inaccessible, underutilized, or not responsive to young women's needs.

In theory, sexual education should ensure that nearly all young adults begin their sexual lives with basic knowledge about sex, contraception, and pregnancy. Most American adolescents do receive some kind of formal sexual education from a school, religious community, or other community organization (Vanderberg et al., 2016), although sexual education is not universal and programs vary widely in both content and quality. The content of school-based sexual education programs is determined by local school districts, within legal guidelines that vary by state. Michigan allows (but does not require) schools to provide information on contraception

(Guttmacher Institute, 2017). Michigan also requires school-based sexual education programs to emphasize abstinence, discourage non-marital intercourse, and discuss negative outcomes of teen sex.

Although comprehensive sexual education reduces the risk of adolescent pregnancy (Kohler, Manhart, & Lafferty, 2008), providing practical information (such as a demonstration of correct condom use or instructions to obtain oral contraceptive pills) is contentious in many locales (Luker, 2006), and may be forbidden by state laws or by restrictions attached to federal funds. Even in states that do not mandate abstinence-only education, many sexual education programs omit instruction about contraception and other sexual health topics in order to avoid the appearance of condoning adolescent or non-marital sex. Among women aged 15-24 in the 2011-2013 NSFG sample (an age range which includes the birth cohorts of the RDSL sample), Vanderberg and colleagues (Vanderberg et al., 2016) found that only 68% had received any formal contraceptive education. This information may or may not have included practical details, may have been part of an STI module focusing exclusively on condoms, and may have assigned contraceptive use a negative moral valence.

Only thirteen states (including Michigan) require sexual education to be medically accurate, and even lessons on contraception that are technically factual may still be presented in a manner that implies that contraception is ineffective or dangerous. For instance, curricula mentioning contraception frequently emphasize failure rates and side effects in an effort to encourage sexual abstinence (Landry, Darroch, Singh, & Higgins, 2003), and in states receiving abstinence-only sexual education funding, this is the only context in which contraception may be discussed (Santelli et al., 2017). Consequently, young adults are likely to begin their sexual lives with doubts about the effectiveness of contraception and an inflated sense of associated health risks.

Healthcare providers cannot singlehandedly compensate for inadequate sexual education. Whereas secondary education is near-universal in the U.S., access to reproductive healthcare is not (Ralph & Brindis, 2010). A significant number of young women may never seek contraceptive counseling, either because they lack the financial resources or because their concerns about side effects have already dissuaded them from considering hormonal methods. Healthcare providers also operate under significant time constraints, and may need to address multiple health concerns during one clinic visit. At the very least, healthcare providers can help

by meeting their patients where they are, engaging seriously with women's side effect concerns, and supplying accurate risk information using evidence-based strategies of risk communication. Proactive, respectful counseling about possible side effects is linked to method satisfaction and continued use (Dehlendorf et al., 2014). Ultimately, the acceptability of a contraceptive method is subjective and depends on the concerns and priorities of individual women, but providers can help ensure that women base these decisions on accurate information. They can also help ensure that all of their patients, including women who ultimately opt for non-hormonal methods such as condoms, have the knowledge required to use their chosen method effectively.

Table 3.1: Chapter 3 Analytic Sample

	N	Min	Max	Mean/Proportion	SD
Contraception during study period					
Ever had sex without contraception	461	0	1	.70	--
Ever used withdrawal	461	0	1	.54	--
Ever used condom	461	0	1	.71	--
Ever used pill/patch/ring	461	0	1	.66	--
Ever used LARC	461	0	1	.22	--
Number of switches to less effective contraceptive method[a]	456	0	18	1.69	2.21
Number of gaps in contraceptive use[a]	456	0	14	.95	1.78
Percentage of sex weeks R used no contraception	461	.00	100.00	10.56	21.03
Percentage of sex weeks R used withdrawal	461	.00	100.00	16.09	26.00
Percentage of sex weeks R used condoms	461	.00	100.00	28.62	33.11
Percentage of sex weeks R used pill/patch/ring	461	.00	100.00	36.88	38.64
Percentage of sex weeks R used LARC	461	.00	100.00	7.84	19.74
Side effect concerns					
Side effect concerns scale	461	0	4	1.76	1.15
Sociodemographic characteristics					
Black	461	0	1	.28	--
High religiosity	461	0	1	.54	--
Family background					
Childhood public assistance	461	0	1	.34	--
Mother had teen birth	461	0	1	.33	--
Mother has college degree	461	0	1	.23	--
Two-parent household	461	0	1	.57	--
Adolescent sexual experiences					
Age 16 or younger at first sex	461	0	1	.52	--
Two or more sexual partners by age 18/19	461	0	1	.64	--
Ever had sex without contraception by age 18/19	461	0	1	.50	--
Any prior pregnancy by age 18/19	461	0	1	.23	--
Current socioeconomic status					
High school GPA	461	0	4.17	3.19	.58
Receiving public assistance at age 18/19	461	0	1	.23	--
Employed at age 18/19	461	0	1	.52	--

Note: N=461 women who had sex during study period.

[a] Among women who ever used contraception (n=456).

Table 3.2: Items in Side Effect Concerns Scale

	Min	Max	Mean
Hormonal contraception is likely to cause weight gain[a]	0	1	.73
Hormonal contraception is likely to cause a serious health problem[a]	0	1	.26
Hormonal contraception is likely to cause severe mood swings[a]	0	1	.48
Using the pill is riskier to a woman's health than having a baby[b]	0	1	.29
Side effect concerns scale	0	4	1.76

Notes: N=461 women who had sex during study period. Side effect concerns scale is the sum of four indicators listed above.

[a] 0: Strongly Disagree/Disagree, 1: Agree/Strongly Agree

[b] 0: No, 1: Yes

Table 3.3: Side Effect Concerns, Likelihood of Ever Having Sex Without Contraception, and Likelihood of Ever Using Specific Contraceptive Methods

	Ever Had Sex Without Contraception	Ever Used…			
		Withdrawal	Condoms	Pill/Patch/Ring	LARC
Side effect concerns	.31 **	.22 **	.35 ***	-.24 **	-.19
	(.11)	(.09)	(.10)	(.10)	(.12)
Sociodemographic characteristics					
Black	-.63 *	-.13	.62 *	-.23	.37
	(.32)	(.27)	(.30)	(.27)	(.32)
High religiosity	.39	-.11	-.19	-.23	-.10
	(.26)	(.22)	(.24)	(.24)	(.28)
Family background					
Childhood public assistance	.23	.13	.35	-.11	.45
	(.29)	(.24)	(.27)	(.25)	(.28)
Mother had teen birth	.50 *	.26	-.02	-.10	.22
	(.28)	(.23)	(.25)	(.24)	(.27)
Mother has college degree	-.85 ***	-.49 *	-.01	.24	-.14
	(.27)	(.25)	(.26)	(.29)	(.34)
Two-parent household	-.41	-.13	-.50 *	.31	-.09
	(.27)	(.23)	(.25)	(.24)	(.27)
Adolescent sexual experiences					
Age 16 or younger at first sex	-.35	-.06	-.19	.97 ***	.44
	(.30)	(.25)	(.27)	(.28)	(.31)
Two or more sexual partners by age 18/19	.48 *	.21	.09	-.04	.93 **
	(.29)	(.25)	(.28)	(.28)	(.36)
Ever had sex without contraception by age 18/19	.79 **	.70 **	-.02	-.82 **	-.55 *
	(.27)	(.24)	(.26)	(.27)	(.30)
Any prior pregnancy by age 18/19	1.70 ***	.23	.04	.03	1.36 ***
	(.44)	(.29)	(.33)	(.30)	(.32)
Current socioeconomic status					
High school GPA	-.02	-.27	.14	.51 **	-.10
	(.23)	(.19)	(.20)	(.20)	(.22)
Receiving public assistance at age 18/19	-.72 *	-.19	-.14	-.18	.34
	(.36)	(.29)	(.32)	(.30)	(.32)
Employed at age 18/19	-.33	-.10	-.28	.17	-.25
	(.24)	(.21)	(.22)	(.22)	(.26)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Notes: N=461 women who had sex during study period. Standard errors are in parentheses. Models control for the number of journals submitted.

Table 3.4: Side Effect Concerns and Disruptions in Contraceptive Use

	Number of Switches to Less Effective Method	Number of Gaps in Contraceptive Use
Side effect concerns	.14 ***	.27 ***
	(.02)	(.04)
Sociodemographic characteristics		
Black	.07	-.15
	(.07)	(.12)
High religious importance	.01	.10
	(.06)	(.11)
Family background		
Childhood public assistance	.11 *	.35 ***
	(.06)	(.11)
Mother had teen birth	.02	-.08
	(.06)	(.10)
Mother has college degree	-.08	-.36 **
	(.06)	(.14)
Two-parent household	-.02	-.29 **
	(.06)	(.11)
Adolescent sexual experiences		
Age 16 or younger at first sex	.08	.51 ***
	(.06)	(.12)
Two or more sexual partners by age 18/19	.20 **	.10
	(.07)	(.13)
Ever had sex without contraception by age 18/1	.04	.37 ***
	(.06)	(.11)
Any prior pregnancy by age 18/19	.26 ***	.02
	(.07)	(.13)
Current socioeconomic status		
High school GPA	.01	-.27 ***
	(.04)	(.08)
Receiving public assistance at age 18/19	-.06	-.14
	(.07)	(.13)
Employed at age 18/19	-.31 ***	.18 *
	(.05)	(.10)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Notes: N=456 women who ever used contraception during study period. Standard errors are in parentheses. Models control for the number of journals submitted.

Table 3.5: Side Effect Concerns and Percentage of Sex Weeks Using Specific Contraceptive Methods

	No Method	Withdrawal	Condoms	Pill/Patch/Ring	LARC
Side effect concerns	2.76 ***	2.16 *	2.91 *	-6.20 ***	-1.64 *
	(.84)	(1.08)	(1.35)	(1.44)	(.81)
Sociodemographic characteristics					
Black	-2.53	-4.36	8.04 *	-4.12	2.97
	(2.43)	(3.11)	(3.88)	(4.16)	(2.34)
High religiosity	-.09	-.94	-1.06	2.59	-.50
	(2.03)	(2.60)	(3.24)	(3.47)	(1.95)
Family background					
Childhood public assistance	7.84 ***	-3.22	-1.08	-4.37	.84
	(2.18)	(2.79)	(3.49)	(3.74)	(2.10)
Mother had teen birth	-2.19	4.09	2.66	-6.04 *	1.47
	(2.10)	(2.69)	(3.35)	(3.59)	(2.02)
Mother has college degree	-3.47	-4.45	-.96	9.72 **	-.83
	(2.30)	(2.94)	(3.67)	(3.94)	(2.21)
Two-parent household	-2.67	.77	-4.68	5.39	1.19
	(2.06)	(2.63)	(3.29)	(3.52)	(1.98)
Adolescent sexual experiences					
Age 16 or younger at first sex	1.51	-1.86	-10.07 **	9.41 **	1.01
	(2.29)	(2.93)	(3.66)	(3.92)	(2.20)
Two or more sexual partners by age 18/19	.59	.32	-1.48	-2.56	3.13
	(2.36)	(3.02)	(3.76)	(4.03)	(2.27)
Ever had sex without contraception by age 18/19	5.22 **	11.87 ***	-.57	-12.60 ***	-3.92 *
	(2.17)	(2.78)	(3.47)	(3.72)	(2.09)
Any prior pregnancy by age 18/19	2.96	-1.47	-2.33	-10.24 *	11.08 ***
	(2.68)	(3.43)	(4.28)	(4.59)	(2.58)
Current socioeconomic status					
High school GPA	-2.96 *	-3.87 *	-.20	7.90 **	-.88
	(1.71)	(2.18)	(2.72)	(2.92)	(1.64)
Receiving public assistance at age 18/19	-1.93	-3.09	-3.40	3.04	5.38 *
	(2.67)	(3.42)	(4.27)	(4.57)	(2.57)
Employed at age 18/19	-3.31 *	-1.58	-3.52	8.82 **	-.41
	(1.91)	(2.45)	(3.06)	(3.28)	(1.84)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Note: N=461 women who ever had sex during study period. Standard errors are in parentheses. Models control for the number of journals submitted.

Chapter 4: Numeracy and Young Women's Contraceptive Use

Many health decisions hinge on comparisons of risk: the probability of experiencing an illness versus the mitigating effect of preventive health behaviors, or the success rate of a treatment versus the risk of an adverse outcome. Risk perceptions and risk comparisons are central to many influential theories applied to health decisions and health behaviors (Weinstein, 1993). Risk comparisons require sophisticated quantitative reasoning. Theories relating risk perceptions to health decisions implicitly assume that decision-makers can make competent judgments about risk, but low numeracy may interfere with this process.

Numeracy encompasses a broad set of skills from basic arithmetic to more complicated mathematical operations, logic, and facility with ratios, fractions, and probability (Reyna & Brainerd, 2008). Numeracy also requires problem-solving abilities, including identification of the skills needed in some particular situation as well as the ability to perform the required operations (Rothman et al., 2006). Numeracy is analogous to literacy and is sometimes conceptualized as a subdomain of literacy, but poses distinct challenges, and many academically accomplished individuals struggle with quantitative reasoning (Golbeck et al., 2005; Rothman, Montori, Cherrington, & Pignone, 2008).

Health numeracy specifically refers to the "capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions" (Golbeck et al., 2005). These skills are involved in many health-related tasks, from administering correct dosages of medication to sophisticated judgments about the risks and benefits of a treatment. Patient numeracy is especially important in an era emphasizing both evidence-based medicine and patient involvement in medical decisions (Institute of Medicine, 2014).

Americans lag behind other industrialized nations in mathematical performance (Galesic M & Garcia-Retamero R, 2010; Gonzales et al., 2004; Lemke et al., 2004). Many adults lack the mathematical skills required to interpret and apply numerical health information (Anderson & Schulkin, 2014; Reyna & Brainerd, 2007; Reyna et al., 2009), and the Institute of Medicine

considers low health numeracy among US adults to be a serious obstacle to healthcare (Institute of Medicine, 2014). Numeracy is associated with many social and demographic characteristics, including gender, socioeconomic status, race/ethnicity, and education (Gonzales et al., 2004; Lemke et al., 2004; Reyna & Brainerd, 2007). Much of this variation is probably attributable to inequality in educational attainment and instructional quality. However, high educational attainment is not a guarantee of numeracy: numeracy typically improves with education, but many people who are academically accomplished in other domains struggle to perform calculations or reason effectively about numbers (Anderson & Schulkin, 2014).

Although Dehlendorf and colleagues (2014) identify disparities in patient numeracy as a challenge in appropriate contraceptive counseling, very few studies have examined the impact of numeracy on contraceptive use. However, numeracy is associated with health behaviors and outcomes in other domains, including cancer treatment choices (López-Pérez et al., 2015), vaccination (Ball et al., 1998; Brewer et al., 2007), successful self-management of HIV medication (Waldrop-Valverde et al., 2009, 2010), and anticoagulation control (Estrada et al., 2004). This research suggests that numeracy influences the medical decision-making process and also affects patients' long-term success in following a medication regimen. In the context of contraception, numeracy may be an important factor in women's decisions about contraceptive use and may also affect women's ability to use contraception effectively.

In this chapter, I use longitudinal data to investigate whether numeracy is associated with sex and contraceptive use among young women at risk of unintended pregnancy. I test whether numeracy predicts sex without contraception, contraceptive method choice, and method switching. My overarching hypothesis is that women with low numeracy will have more sex without contraception and rely on less effective contraceptive methods.

Background

Numeracy and sexual behavior

Low numeracy includes poor conceptual understanding of risk, particularly cumulative risk. Understanding even a simple probability requires familiarity with fractions or ratios, and cumulative risk is more challenging because it involves the multiplication of ratios. In a study of adolescent smoking, Slovic (2000) connects poor understanding of cumulative risk to adolescents' willingness to repeatedly take short-term risks. In this study, both smokers and non-smokers acknowledge long-term health risks associated with smoking, but the smokers are more

likely to agree that the next single cigarette smoked is unlikely to cause harm, and that "there is really no risk at all for the first few years." These results indicate that smokers may appreciate that their behavior has long-term health risks, but underestimate the rate at which small risks accumulate. Among women who do not wish to become pregnant, having sex means exposure to the risk of unintended pregnancy. If poor understanding of risk is associated with increased risk-taking, I hypothesize that low numeracy women will be more likely to have sex during the study period than high numeracy women.

The previous scenario involves underestimation of a short-term risk despite awareness of a cumulative risk. Alternatively, young adults may be cognizant of the short-term risk associated with a risky behavior without grasping the cumulative nature of risk. Most young women are aware that having sex even once could result in a pregnancy. In fact, overestimating the risk of pregnancy from one instance of sex is much more common than underestimating this risk (Biggs & Foster, 2013; Foster et al., 2012; Kaye et al., 2009). Young adults with poor understanding of cumulative risk who believe the pregnancy risk from one instance of sex to be very high may not perceive any meaningful increase in pregnancy risk from additional instances of sex. Among women who are already sexually active, women with low numeracy may not perceive any disincentive from additional sexual activity. Therefore, I hypothesize that women with low numeracy will have higher sexual frequency among sexually active women.

Numeracy and sex without contraception

Among sexually active women who do not wish to become pregnant, numeracy may influence the likelihood of effective contraceptive use. First, low numeracy may contribute to misunderstandings about the risk of pregnancy and the effectiveness of contraception. Reyna and colleagues (2008; 2009) theorize that when individuals encounter quantitative information, they encode several versions of this information into memory, from rote memorization (which they call "verbatim" representations) to more qualitative statements about the meaning of that information (termed "gist" representations). For instance, "the risk of pregnancy from one instance of sex is about 3%" is a verbatim representation. There are many possible gist representations of this information, such as "the risk of pregnancy from one instance of sex is low," "the risk of pregnancy is low," or "I probably won't get pregnant." According to Reyna's fuzzy trace theory (2008), individuals tend to rely on gist representations instead of verbatim representations when making medical decisions. However, not all gist representations are good

summaries of the original information (as is clear from the example above), and not all people are equally skilled at converting quantitative information into qualitative statements that preserve the key information. Numeracy affects the accuracy of these representations, and people with low numeracy have difficulty extracting a gist that accurately represents the original information.

An implication of fuzzy trace theory is that low numeracy may result in misinformation, even after individuals are presented with correct information. For instance, a patient may know that the risk of condition A is 20/100 and the risk of condition B is 33/10000. Determining that 20/100 is a larger quantity (and therefore a higher risk) than 33/10000 requires the ability to accurately compare and interpret fractions, an operation that even highly educated adults find challenging (Golbeck et al., 2005). An individual may be able to recite the risks of both condition A and condition B and still make an incorrect judgment about the relative size of these risks, retaining the notion that condition B is more likely.

In practical terms, this means that low numeracy may result in distorted understandings of the likelihood of pregnancy or the effectiveness of contraception. Women with poor understanding of cumulative risk may also be more willing to have sex without contraception; Biggs and Foster (2013) speculate that this may be the case in their study of women's pregnancy risk estimates. (In their sample of 1,472 family planning clients, many women overestimate the risk of pregnancy from one instance of sex so dramatically that their estimates of cumulative pregnancy risk from one *year* of sex without contraception are quite similar.) Women with low numeracy may also underestimate the effectiveness of contraception. Presented with contraceptive failure rates, women with high numeracy may retain the notion that "the risk of pregnancy is low if I always use contraception correctly," but women with low numeracy may rely on a gist such as "contraception doesn't work." This may contribute to fatalism about whether pregnancy can be prevented. Pregnancy fatalism is common among young adults (Kaye et al., 2009) and may reduce women's urgency about using contraception at each instance of sex, even among women who do not wish to conceive.

Fuzzy trace theory is most applicable to women's conscious decisions about having sex without contraception. But low numeracy may also lead to practical difficulties using contraception consistently and correctly among women who do intend to use contraception. In one of very few studies to explicitly consider the link between numeracy and contraception, Yee and Simon (2013) conduct semi-structured interviews with 30 low-income postpartum women

and found that those with lower numeracy reported difficulty understanding instructions for various contraceptive methods, and difficulty using contraception correctly.

These studies suggest that numeracy may influence women's choices about whether to use contraception at all, but also their ability to follow through on their decisions. I hypothesize that women with low numeracy will be more likely to ever have sex without contraception, will do so more frequently than high numeracy women, and will experience more gaps in contraceptive use while sexually active.

Numeracy and use of specific contraceptive methods

Among contraceptive users, numeracy may affect women's decisions about contraceptive methods. Selecting a contraceptive method requires synthesizing information about the relative efficacy of different contraceptive methods and information about potential side effects or negative health consequences. Comparisons of fractions, proportions, and other kinds of ratios are susceptible to a number of cognitive biases, and even mathematically skilled individuals are more likely to make errors on these kinds of questions than they are when performing other types of calculations (Blumenthal-Barby & Krieger, 2015; Liberali, Reyna, Furlan, Stein, & Pardo, 2012; Peters, 2012; Reyna & Brainerd, 2007, 2008).

When comparing fractions, people tend to give undue importance to the numerator and give less consideration to the denominator, a phenomenon known as "denominator neglect" (Reyna & Brainerd, 2008). This tendency may be consequential for health decisions because individuals may be expected to compare risks described as incidences per 1,000 with risks described as incidences per 10,000 or 100,000. Decision-makers may not immediately register the difference between a risk of 10/1000 and 12/12000; if presented with risks of 3/1000 and 17/10000, many individuals would conclude at a glance that 17/10000 is larger. People of all ability levels may commit these kinds of errors when interpreting numerical health information, but people with low numeracy make them more frequently and are less likely to catch their mistakes. Furthermore, their interpretations of quantitative information are more easily swayed by the presentation format (i.e. "15 in 100" versus "15%" versus "30:200"), by mood and affect, and by extraneous information (Peters, 2012; Reyna et al., 2009; Rothman et al., 2006). Healthcare providers may exacerbate these difficulties: while counseling patients, they may fail to communicate risk information appropriately (Dehlendorf et al., 2014), and physicians are not

immune from the errors in quantitative reasoning exhibited by many of their patients (Anderson & Schulkin, 2014).

Given the difficulty of the risk comparisons involved in choosing a contraceptive method, women with low numeracy may have more difficulty identifying the most effective contraceptive methods. They may also overestimate the likelihood of side effects and other adverse health consequences resulting from hormonal contraceptive use. Consequently, I expect that women with lower numeracy will be less likely to use highly effective contraceptive methods such as inter-uterine devices (IUDs), implants, or oral contraceptive pills. I also hypothesize that women with low numeracy will experience more switches from a more effective method to a less effective method during the study period.

Data

This analysis uses data from the Relationship Dynamics and Social Life study (RDSL), a longitudinal study of young women residing within a racially and economically diverse Michigan county (Barber, Kusunoki, & Gatny, 2011). Respondents were 18 or 19 years old at the time of recruitment and were randomly selected from the Michigan Department of State's Personal Identification Card and driver's license database.[29] Baseline interviews were conducted on a rolling basis from March 2008 to July 2009; 1,003 women completed a baseline interview, yielding a response rate of 83% and a cooperation rate of 94%. These interviews were conducted in person by a professional interviewer, lasted approximately one hour, and included questions about sociodemographic characteristics, attitudes, relationship characteristics and history, contraceptive use and pregnancy history.

At the end of the baseline interview, participants were invited to participate in a follow-up study that lasted 30 months. Each week, respondents completed a short survey[30] ("journal") about their relationships, sexual behavior, contraceptive use, pregnancy intentions, and pregnancies during the previous week. (If a journal was completed late, these questions referred to the time period since the previous journal.) The journal took approximately 5 minutes to complete, and could be submitted by telephone or via the internet. Respondents were issued re-loadable debit cards and paid $1 per journal submitted, with a bonus for submitting five

[29] Barber et al. (2011) estimated 96 % agreement between the Michigan Department of State database and the projected number of 18- and 19-year-old women in the county based on the 2000 census.
[30] The original text of all survey items used to construct independent and dependent variables can be found in Appendix A.

consecutive journals on time. Women who did not submit a journal for over 60 days were offered an additional $10 to return to the study. Of the 992 women who enrolled in the journal study, 75% contributed at least 18 months of journal data, and the median time between journals was 8 days.

Analytic Sample

The analytic sample includes 931 women[31] who participated in the journal study, contributed at least one journal after the baseline interview, and responded to both survey items used to assess numeracy. Since I am primarily concerned with women's behavior while at risk of unintended pregnancy, I exclude weeks in which respondents are already pregnant or report strong desire to become pregnant.[32] The 931 women in the analytic sample contributed 51,584 eligible journals. The median number of eligible journals contributed per respondent is 54.4. Certain outcomes are constructed from a subset of journals; these variables are described in greater detail below.

Measures

Numeracy

During the baseline interview, respondents are asked to estimate the likelihood of various events (e.g.) on a scale from 0 to 100, where "*0 means that you think there is absolutely no chance, and 100 means that you think the event is absolutely sure to happen*."[33] This question series includes a question about the risk of pregnancy from having sex without contraception once ("*If you were to have sexual intercourse once or twice without using birth control, what are the chances that you would get pregnant?*") and the cumulative risk of pregnancy from having sex without contraception regularly ("*If you were to have sexual intercourse regularly, say once a week for a year, without using birth control, what do you think are the chances that you would get pregnant?*")

I use women's responses to these two questions to construct an indicator of their conceptual understanding of risk: namely, that the *cumulative* risk of pregnancy after *repeated*

[31] Of the 992 women who enrolled in the journal study, 953 completed at least one journal after the baseline interview. Seven women are missing on one or both risk questions, and one woman desired a pregnancy in all of her journal week.

[32] Of the 57,602 journals submitted by eligible respondents, 3,009 journals (5%) are excluded because the respondent was pregnant that week, and an additional 571 journals (1%) are excluded because the respondent reported strong desire to become pregnant that week.

[33] The original text of all survey items used to construct independent and dependent variables can be found in Appendix A.

unprotected intercourse must be higher than the risk of pregnancy after any *one* instance of unprotected intercourse. Women providing a higher estimate for cumulative risk of pregnancy than one-time risk of pregnancy are considered to have high numeracy. Women providing equal estimates for cumulative and one-time pregnancy risk are considered to have medium numeracy. Women providing a lower estimate for cumulative pregnancy risk than one-time pregnancy risk are considered to have low numeracy.[34] Whereas the original survey questions measure the accuracy of women's knowledge about pregnancy, the constructed measure indicates whether women's risk estimates—even when inaccurate—are logically *consistent* and reflect some basic conceptual understanding of risk. Nearly a third of the sample falls into one of the lower numeracy categories.[35]

Sex and contraception

In each journal, respondents were asked: "*…did you have sexual intercourse with [partner]? By sexual intercourse, we mean when a man puts his penis into a woman's vagina*." Based on responses to this question, I create an indicator of any sexual intercourse during the study period. I also calculate the percentage of weeks with any sexual intercourse.

Summary measures of contraceptive use are constructed from a series of questions in the weekly journal. Every week, respondents are asked, "*Did you use or do anything that can help people avoid becoming pregnant, even if you did not use it to keep from getting pregnant yourself*?" Respondents are also asked a series of follow-up questions about use of specific methods, as well as the consistency of their contraceptive use *("…since the last interview, did you or your partner use some method of birth control every time you had intercourse (even if you are not trying to prevent pregnancy)*?") Women are considered to be contraceptive users in a given week if they answer affirmatively to any of these questions.

Based on these questions, I create a variable indicating whether the respondent ever has sex without contraception during the study period. I also calculate the percentage of (sex) weeks

[34] Black and colleagues (1995) follow a similar approach in their analysis of risk perception and breast cancer screening: women are considered numerate if they estimated that their risk of dying of breast cancer over the next 20 years was equal to or greater than their risk of dying of breast cancer in the next 10 years. This measure is not a global measure of mathematical proficiency, but it emphasizes a component of numeracy that is highly pertinent to contraceptive use.

[35] I recreate this measure using data from the 2009 National Survey of Reproductive and Contraceptive Knowledge (commonly referred to as the "Fog Zone" study), a nationally representative telephone survey of 1,800 young adults aged 18-29. The Fog Zone survey includes the two pregnancy risk estimation questions that I use to construct a numeracy measure in the RDSL data, and the distribution of numeracy in the nationally representative Fog Zone sample is nearly identical (author's tabulations; see Appendix B, Table B.6).

in which women have any sex without contraception. Among women who ever use contraception, I count the number times a woman switches to a less effective contraceptive method, and also her number of gaps in contraceptive use while sexually active. Finally, I identify the primary contraceptive method (the method used most frequently) for each woman who ever uses contraception during the study period.

Controls

Among American adults, numeracy is associated with many individual characteristics that also predict contraception, such as race, affluence, and education (Reyna & Brainerd, 2007). In order to ensure that differences in sexual and contraceptive behavior are not an artifact of compositional differences between the numeracy groups, these analyses include correlates of numeracy that are also known predictors of sexual and contraceptive behavior. These variables include sociodemographic characteristics, family background, adolescent experiences with sex and contraception, and current socioeconomic status. They are measured in the baseline interview (at age 18/19) and are summarized in Implications for Policy and Practice

Although individuals vary in their mathematical competency, numeracy is the product of individual competency and the demands of a particular social context. In other words, individuals may have adequate numeracy in certain situations and inadequate numeracy in others, depending on the complexity of numerical reasoning required. For this reason, the Institute of Medicine conceptualizes health literacy—and by extension, health numeracy—as an interaction between the skills of the patient and the demands made by his or her environment, such as a particular healthcare system (Institute of Medicine 2014). If low numeracy is an obstacle to contraceptive use among women who wish to avoid pregnancy, the situation might be improved by increasing young women's numeracy, *or* by reducing the level of numeracy required for effective contraceptive use.

Improved math instruction may help ensure that future cohorts have the numeracy required to make informed health decisions, but will not directly benefit adults who have completed their education. But the healthcare system could mitigate some of the negative consequences of low numeracy in many ways, such as improving the quantitative skills of healthcare providers (Anderson & Schulkin, 2014) and ensuring that package inserts for contraception and other medications are written at appropriate levels.

Contraceptive counseling is an opportunity for healthcare providers to provide more accurate, complete information about pregnancy risk and contraception than young women are likely to receive in school. In their extensive discussion of best practices for contraceptive counseling, Dehlendorf and colleagues (2014) note that clinicians vary in their approach, from their level of involvement in contraceptive decision-making to the degree to which they tailor counseling to individual women's concerns, including side effects. Some providers give information about methods but do not participate in decision-making, while others enthusiastically promote certain methods. Both extremes have pitfalls: providers who minimize their involvement in decision-making may not perceive gaps in patients' knowledge or adequately address their concerns, while an overly directive approach poses ethical issues (Gubrium et al., 2016) and may undermine women's trust in providers (Higgins, Kramer, & Ryder, 2016) if they feel they are receiving incomplete information or being pressured into using a specific method.

Healthcare providers need to consider women's numeracy in order to counsel patients appropriately. It is also vital to acknowledge the potential for tension between the need to tailor content to women's quantitative reasoning ability, the principle of informed consent, and the danger of medical paternalism. Informed consent is threatened when risk information is insufficient, but also when risk information is overly technical or not communicated appropriately (Fuller, Dudley, & Blacktop, 2002; Reyna et al., 2009). It may be difficult to quickly assess women's numeracy in a clinical setting, and there is a danger that healthcare providers will (perhaps unconsciously) rely on stereotypes when determining what kind of information a patient should receive about contraception. Reproductive healthcare is a site in which these stereotypes have already been shown to influence the quality of care. For instance, in a randomized experimental study asking providers whether hypothetical patients are good candidates for an IUD, providers are more likely recommend IUDs for Black women (Dehlendorf, Ruskin, et al., 2010). Given the lengthy history of reproductive coercion of low-income and minority women in the United States (Roberts, 1997; Stern, 2005; Washington, 2006), reproductive healthcare providers must avoid the assumption that low-income and minority women are less capable of making decisions about their fertility and contraceptive use.

Providers should expect to encounter patients with a broad range of numerical skills. They should not assume that affluent, highly-educated patients have the skills to interpret

numerical health information correctly without guidance, and they should not assume that low-income, non-White, or otherwise disadvantaged patients are not able to make informed decisions about their healthcare when counseled appropriately and respectfully. Regardless of the perceived competence of the patients, healthcare providers and health educators should employ evidence-based methods of communicating risk information.

Table 4.1.

Race is measured with the question, "*Which of the following groups describe your racial background? Please select one or more groups: American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Black or African American, or White."* The number of respondents providing a response other than "Black" or "White" is too small for separate analyses of these groups to be feasible, so I code respondents as either Black or non-Black. Religiosity is measured with the question "*How important if at all is your religious faith to you – would you say not important, somewhat important, very important, or more important than anything else*?" Respondents are considered to be highly religious if they describe their religious faith as "very important" or "more important than anything else".

Socioeconomic disadvantage is associated with lower numeracy (Reyna & Brainerd, 2007), a higher likelihood of sex without contraception, and less use of highly effective contraceptive methods (Daniels et al., 2015; Kusunoki et al., 2016). Indicators of childhood advantage/disadvantage in this analysis include receipt of public assistance, whether the respondent's mother had a teen birth, whether the respondent's mother has a college degree, and whether the respondent grew up in a two-parent household. Adolescent sexual experiences include indictors of whether the respondent was sixteen or younger at first, whether she has two or more lifetime sexual partners by age 18/19, whether she has ever had sex without contraception by age 18/19, and whether she has any prior pregnancies by age 18/19.

Education is an additional indicator of SES, and a predictor of unintended pregnancy (Finer & Zolna, 2016); it is also correlated with numeracy (Reyna & Brainerd, 2007), although conceptually distinct. Controlling for educational attainment is not feasible due to the young age of the sample; at the time of the baseline interview, a majority of respondents had not yet completed their education (13% were still enrolled in high school and another 65% were attending 2-year or 4-year postsecondary institutions.) Thus, I control for high school grade point average (GPA), which reflects recent school performance and should be predictive of eventual educational attainment. Other indicators of socioeconomic status at age 18/19 include current receipt of public assistance and current employment.

Differences in these traits across the three numeracy groups are presented in Table 4.2. Echoing past research on numeracy in the U.S., women with lower numeracy are relatively disadvantaged on many indicators, especially with respect to childhood disadvantage. The

medium and low numeracy group include more children whose mothers had teen births, fewer women whose mothers have college degrees, fewer women who grew up in two-parent households, and more women receiving public assistance in childhood and at the time of the baseline interview. These groups also have significantly lower mean GPAs than the high numeracy group, although the absolute differences between groups are small. The medium and low groups are significantly different from the high numeracy group on all of these characteristics, but the only significant difference between the low and medium numeracy groups is the proportion of women raised in two-parent households.

Analysis

I use logistic regression to predict the likelihood of ever having sexual intercourse during the study period and the likelihood of ever having sex without contraception. Next, I estimate a set of ordinary-least squares (OLS) regression models[36] predicting the percentage of journal weeks during which women were sexually active and the percentage of sex weeks in which women had sex without contraception. I use Poisson regression to predict the number of times women switch to a less effective contraceptive method during the study period and the number of gaps in contraceptive use while sexually active. Finally, I use multinomial logistic regression to predict women's primary contraceptive method during the study period.

Variation in the number of journals women contributed to the analytic sample is a potential source of bias, particularly for models predicting the likelihood of ever reporting certain behaviors (e.g. sex without contraception), and for models predicting the number of method switches and gaps. Thus, all logistic regression models and Poisson models include a control for the number of journals used to construct that particular outcome.

Results

Numeracy does not predict sexual behavior during the study period (Appendix B, Table B.5). Contrary to my hypothesis that numeracy would predict exposure to the risk of pregnancy, low numeracy women are no more likely than high numeracy women to ever have sex during the study period. Sexual frequency also does not vary across numeracy groups. However, among sexually active women, numeracy is a strong predictor of sex without contraception (Table 4.3).

[36] OLS regression may yield illogical estimates when the outcome is a proportion. Thus, I run the same analyses using generalized linear models (GLM) with a binomial error distribution, which is appropriate when the outcome is bounded between 0 and 1 (Papke & Wooldridge, 1996). This method produced the same substantive conclusions and virtually identical predicted values by numeracy group, so I present the OLS models for ease of interpretation.

The low numeracy group is significantly more likely to ever have sex without contraception than both the medium and high numeracy groups. The difference between the low and high numeracy women in the log-odds of having sex without contraception is 0.97, equivalent to an odds ratio of 2.64. Meanwhile, both the low and medium numeracy women have sex without contraception more frequently than the high numeracy women: there is a 6.69 percentage point difference between the medium and high numeracy groups, and a 10.14 percentage point difference between the low and high numeracy groups. (The difference between the medium and low numeracy groups is not significant.) In other words, the lower numeracy women are more likely to ever have sex without contraception, and do so much more frequently during the study period than women in the high numeracy group.

Table 4.4 displays results from Poisson regressions predicting the number of switches to a less effective contraceptive method and the number of gaps in contraceptive use. On average, women in the low numeracy group report 0.28 more switches to a less effective method than high numeracy women. They also experience an average of 0.43 more gaps in contraceptive use during the study period. Differences between the low and medium numeracy groups are significant; differences between the medium and high numeracy groups are not significant. In other words, medium numeracy women more closely resemble the high numeracy women on this set of outcomes.

Among contraceptive users, the primary contraceptive method varies with numeracy (Table 4.5). The primary method refers to the contraceptive method used more frequently than any other contraceptive method during the study period, among all women who ever use contraception during the study period. The base outcome in this multinomial regression is that the primary method is condoms. Condoms were the most common primary method overall. Medium numeracy women do not differ from high numeracy women in their odds of the primary method being withdrawal, pill/patch/ring, or LARC versus condoms. Low numeracy women are less likely than high numeracy women to use pill/patch/ring or LARC as their primary method: the difference in log-odds of pill/patch/ring versus condoms is -0.72 (OR: 0.49), and the difference in log-odds of LARC versus condoms is -1.62 (OR: 0.20). In other words, low numeracy women are much less likely than high numeracy women to use a hormonal method as their primary method, and particularly likely to use condoms.

Discussion

Contrary to expectations, numeracy does not predict sexual behavior among the young women in this sample. However, numeracy *does* predict the actions taken by sexually active women to reduce their risk of unintended pregnancy. Lower numeracy women are more likely to ever have sex without contraception during the study period and do so more frequently. When they do use contraception, they experience more disruptions in their contraceptive use, and tend to rely on condoms instead of highly effective hormonal methods. And although numeracy is associated with many sociodemographic predictors of sexual and contraceptive behavior, it is also a strong predictor of contraceptive use net of sociodemographic characteristics, family background, adolescent sexual experiences, and current socioeconomic disadvantage.

Research on numeracy and health behaviors is relatively uncommon compared to research on health knowledge or risk perceptions, and this work is hindered by data limitations. A good deal of numeracy research is experimental and does not measure behavioral outcomes; meanwhile, large surveys of health behaviors such as RDSL rarely include measures of numeracy. The measure I construct from RDSL questions about pregnancy risk identifies women with poor conceptual understanding of risk and probability, but this measure does not capture all numerical skills that may be relevant to contraceptive use or health decisions more generally. Although critically important to the outcomes of interest in this study, risk and probability are among the most difficult elements of health numeracy, and some of the respondents I categorize as low- or medium numeracy might perform better on numeracy measures including a wider range of skills.

Given the regional nature of the sample, RDSL respondents may differ from other young adults in their quantitative reasoning ability. To check whether RDSL sample is an outlier with respect to numeracy, I recreate the numeracy measure from these analyses using nationally representative data from the 2009 National Survey of Reproductive and Contraceptive Knowledge (commonly known as the "Fog Zone" study), a nationally representative survey of 1,800 unmarried adults aged 18-29 that includes the same two estimations of pregnancy risk (see Appendix B, Table B.6). The distribution of numeracy in the Fog Zone data is quite similar to the distribution of numeracy in the RDSL, although women in the Fog Zone sample are less likely to be in the high numeracy group and more likely to be in the medium numeracy group.

The similar distributions of numeracy in the RDSL and the Fog Zone studies also provide some additional reassurance concerning the validity of the numeracy measure. In the RDSL, the questions used to assess numeracy are part of a longer series of risk estimation questions. The two questions about pregnancy risk are separated by five other questions, raising the possibility that women did not recall their first estimate when making their second estimate, or that the women considered to have low or medium numeracy are simply less attentive survey respondents. In the Fog Zone study, women are slightly more likely to provide combinations of estimates indicating low or medium numeracy, even though the two pregnancy risk questions are asked consecutively. Thus, it is unlikely that low numeracy is an artifact of RDSL survey design. Members of the low and medium numeracy groups did submit fewer journals on average than women in the high numeracy group, but the mean number of journals per woman is high in all three groups: 47.2 in the low group, 49.5 in the medium group, and 58.3 in the high group. Numeracy is not associated with the percentage of journals submitted on time.

Numeracy is related to interviewer perceptions about the respondents' understanding of survey questions. (At the end of the baseline interview, interviewers answered several questions about the respondent, including whether they judged respondents' understanding of questions to be "poor," "acceptable," "good," or "excellent."). I would expect worse scores on this measure among women in the lower numeracy groups, since my numeracy measure is meant to identify conceptual difficulties with the subset of questions about risk. Interviewers perceived significantly lower understanding of survey questions among women in the low and medium numeracy groups than in the high numeracy group. This is an additional indication that the numeracy measure is capturing meaningful differences in comprehension among the RDSL respondents.

The results of this analysis are consistent with the overarching hypothesis that women with low numeracy are less effective contraceptive users. This pattern of behavior is likely to increase the risk of pregnancy among women with lower numeracy, and future research should evaluate the specific mechanisms though which numeracy influences women's behavior. Since this analysis controls for women's absolute estimates of pregnancy risk, differences in contraceptive use between numeracy groups are not attributable to different beliefs about pregnancy risk. In their study of estimated pregnancy risk, Biggs and Foster (2013) note that many women provide similar estimates of pregnancy risk from one instance of sex versus many

instances of sex. The authors speculate that these particular women may be more willing to have sex without contraception because they do not fully appreciate the cumulative nature of pregnancy risk when a woman has sex without contraception frequently. However, in the RDSL sample, numeracy is not associated with reported willingness to have sex without contraception or stated desire to use contraception during the next year.[37]

Women with lower numeracy may find contraception difficult to use, as Yee and Simon (2013) observed in their qualitative study of low-income post-partum women. The current analysis does not examine women's knowledge or beliefs about contraception, but perhaps women with low numeracy underestimate the effectiveness of contraception in general, or the effectiveness of hormonal methods. To some extent, indicators of poor contraceptive use (such as gaps in use and the higher frequency of sex without contraception) may be attributable to low-numeracy women's reliance on condoms as their primary method. Condoms are difficult to use perfectly. Advanced planning is required in order to have a condom available whenever sex might occur, and consistent condom use also depends on the cooperation of a male partner.

Numeracy may intersect with or contribute to pregnancy fatalism, the belief that pregnancy is not fully within a woman's control. Without some understanding of the cumulative nature of pregnancy risk, the apparent randomness of conception may lead someone to conclude that nothing can be done to effectively control or reduce the risk of pregnancy. High levels of pregnancy fatalism have been observed among young adults in previous studies: in the 2009 National Survey of Reproductive and Contraceptive Knowledge, 55% of women aged 18-19 agree with the statement, "it doesn't matter whether you use birth control or not, when it is your time to get pregnant, it will happen" (Kaye et al., 2009). Pregnancy fatalism is just one example of misinformation about sex, contraception, and pregnancy that may be aggravated by poor quantitative reasoning and incorrect interpretations of quantitative health information.

Many young adults have poor reproductive health knowledge. The prevalence of myths and misunderstandings about sex, contraception, and pregnancy and their consequences for young adults' behavior have received a good deal of scholarly attention (Frost et al., 2012; Guzzo & Hayford, 2012; Kaye et al., 2009; Pratt, Stephenson, & Mann, 2014). Numeracy has not attracted the same attention, with the exception of Yee and Simon's (2013) qualitative study

[37] Not shown; available upon request.

connecting low numeracy to difficulties using contraception among low-income women. The current study shows that this relationship extends to a larger, socioeconomically and racially diverse group of young women, and that the relationship between numeracy and contraceptive use is independent from women's pregnancy risk estimates. This study also shows the potential value of incorporating more comprehensive measures of numeracy into studies of fertility and other health behaviors. At present, research on numeracy and contraception in other populations is severely limited by the lack of numeracy data. Future research in this vein may help explain how numeracy, knowledge, and risk perceptions work separately and together to influence women's contraceptive use, as well as health behaviors in other domains.

Implications for Policy and Practice

Although individuals vary in their mathematical competency, numeracy is the product of individual competency and the demands of a particular social context. In other words, individuals may have adequate numeracy in certain situations and inadequate numeracy in others, depending on the complexity of numerical reasoning required. For this reason, the Institute of Medicine conceptualizes health literacy—and by extension, health numeracy—as an interaction between the skills of the patient and the demands made by his or her environment, such as a particular healthcare system (Institute of Medicine 2014). If low numeracy is an obstacle to contraceptive use among women who wish to avoid pregnancy, the situation might be improved by increasing young women's numeracy, *or* by reducing the level of numeracy required for effective contraceptive use.

Improved math instruction may help ensure that future cohorts have the numeracy required to make informed health decisions, but will not directly benefit adults who have completed their education. But the healthcare system could mitigate some of the negative consequences of low numeracy in many ways, such as improving the quantitative skills of healthcare providers (Anderson & Schulkin, 2014) and ensuring that package inserts for contraception and other medications are written at appropriate levels.

Contraceptive counseling is an opportunity for healthcare providers to provide more accurate, complete information about pregnancy risk and contraception than young women are likely to receive in school. In their extensive discussion of best practices for contraceptive

counseling, Dehlendorf and colleagues (2014) note that clinicians vary in their approach[38], from their level of involvement in contraceptive decision-making to the degree to which they tailor counseling to individual women's concerns, including side effects. Some providers give information about methods but do not participate in decision-making, while others enthusiastically promote certain methods. Both extremes have pitfalls: providers who minimize their involvement in decision-making may not perceive gaps in patients' knowledge or adequately address their concerns, while an overly directive approach poses ethical issues (Gubrium et al., 2016) and may undermine women's trust in providers (Higgins, Kramer, & Ryder, 2016) if they feel they are receiving incomplete information or being pressured into using a specific method.

Healthcare providers need to consider women's numeracy in order to counsel patients appropriately. It is also vital to acknowledge the potential for tension between the need to tailor content to women's quantitative reasoning ability, the principle of informed consent, and the danger of medical paternalism. Informed consent is threatened when risk information is insufficient, but also when risk information is overly technical or not communicated appropriately (Fuller, Dudley, & Blacktop, 2002; Reyna et al., 2009). It may be difficult to quickly assess women's numeracy in a clinical setting, and there is a danger that healthcare providers will (perhaps unconsciously) rely on stereotypes when determining what kind of information a patient should receive about contraception. Reproductive healthcare is a site in which these stereotypes have already been shown to influence the quality of care. For instance, in a randomized experimental study asking providers whether hypothetical patients are good candidates for an IUD, providers are more likely recommend IUDs for Black women (Dehlendorf, Ruskin, et al., 2010). Given the lengthy history of reproductive coercion of low-income and minority women in the United States (Roberts, 1997; Stern, 2005; Washington, 2006), reproductive healthcare providers must avoid the assumption that low-income and minority women are less capable of making decisions about their fertility and contraceptive use.

Providers should expect to encounter patients with a broad range of numerical skills. They should not assume that affluent, highly-educated patients have the skills to interpret numerical health information correctly without guidance, and they should not assume that low-

[38] Patients also vary in their preferences concerning provider involvement in their decisions.

income, non-White, or otherwise disadvantaged patients are not able to make informed decisions about their healthcare when counseled appropriately and respectfully. Regardless of the perceived competence of the patients, healthcare providers and health educators should employ evidence-based methods of communicating risk information.

Table 4.1: Chapter 4 Analytic Sample

	Obs	Min	Max	Proportion/Mean	SD
Numeracy					
High numeracy	748	0	1	.69	--
Medium numeracy	748	0	1	.22	--
Low numeracy	748	0	1	.09	--
Sex and contraception					
Ever had sex without contraception	748	0	1	.67	--
Percentage of sex weeks R had any sex without contraception	748	0	100	30.56	33.56
Number of switches to less effective contraceptive method[a]	735	0	18	1.37	1.94
Number of gaps in contraceptive use[a]	735	0	14	.74	1.55
Primary contraceptive method[a]					
Withdrawal	735	0	1	.16	--
Condoms	735	0	1	.35	--
Pill/patch/ring	735	0	1	.39	--
LARC	735	0	1	.10	--
Estimated pregnancy risk…					
…from having sex without contraception once or twice	748	0	100	57.09	28.43
Sociodemographic characteristics					
Black	748	0	1	.34	--
High religiosity	748	0	1	.55	--
Family background					
Childhood public assistance	748	0	1	.37	--
Mother had teen birth	748	0	1	.37	--
Mother has college degree	748	0	1	.20	--
Two-parent household	748	0	1	.52	--
Adolescent sexual experiences					
Age 16 or younger at first sex	748	0	1	.59	--
Two or more sexual partners by age 18/19	748	0	1	.68	--
Ever had sex without contraception by age 18/19	748	0	1	.55	--
Any prior pregnancy by age 18/19	748	0	1	.28	--
Current socioeconomic status					
High school GPA	748	0	4.17	3.10	.63
Public assistance at age 18/19	748	0	1	.28	--
Employed at age 18/19	748	0	1	.51	--

Note: N=748 women who had sex during study period.

[a] Among women who used contraception during study period (n=735).

Table 4.2: Sociodemographic Composition of Numeracy Groups

	Mean/Proportion					
	High numeracy (*n=516*)	**Medium numeracy (*n=161*)**	**Low numeracy (*n=71*)**	**High vs Medium**	**High vs Low**	**Medium vs Low**
Sociodemographic characteristics						
Black	.28	.49	.44	***	**	
High religiosity	.54	.58	.55			
Family background						
Childhood public assistance	.34	.46	.42	**		
Mother had teen birth	.32	.48	.51	***	**	
Mother has college degree	.23	.13	.14	**		
Two-parent household	.57	.42	.37	***	**	
Adolescent sexual experiences						
Age 16 or younger at first sex	.55	.65	.73	*	**	
Two or more sexual partners by age 18/19	.67	.70	.73			
Ever had sex without contraception by age 18/19	.51	.63	.68	**	**	
Any prior pregnancy by age 18/19	.23	.39	.37	***	*	
Current socioeconomic status						
High school GPA	3.15	2.98	2.99	**	*	
Public assistance at age 18/19	.23	.35	.44	**	***	
Employed at age 18/19	.54	.47	.38		**	

*p<0.05; **p<0.01; ***p<0.001 (two-tailed tests)

Note: N=748 women who had sex during study period.

Table 4.3: Numeracy and Non-Use of Contraception

	Log-Odds R Ever Had Sex Without Contraception[a]	Percentage of Sex Weeks R Had Any Sex Without Contraception
Numeracy (ref: High numeracy)		
Medium numeracy	**.23**	6.69 *
	(.23)	(3.20)
Low numeracy	**.97** **	10.14 **
	(.36)	(4.33)
Estimated pregnancy risk		
…from having sex without contraception "once or	-.0039	-.0969 *
twice"	(.0035)	(.0472)
Sociodemographic characteristics		
Black	.02	-.43
	(.22)	(2.91)
High religiosity	.38 *	4.54 *
	(.18)	(2.52)
Family background		
Childhood public assistance	.02	1.65
	(.19)	(2.64)
Mother had teen birth	.14	.89
	(.19)	(2.56)
Mother has college degree	-.85 ***	-9.95 ***
	(.21)	(3.01)
Two-parent household	-.18	-2.52
	(.19)	(2.58)
Adolescent sexual experiences		
Age 16 or younger at first sex	-.29	-3.79
	(.22)	(2.97)
Two or more sexual partners by age 18/19	.46 *	5.07
	(.23)	(3.13)
Ever had sex without contraception by age 18/19	.33	8.84 ***
	(.21)	(2.83)
Any prior pregnancy by age 18/19	.77 ***	7.90 **
	(.25)	(3.20)
Current socioeconomic status		
High school GPA	-.32	-3.93
	(.24)	(3.19)
Public assistance at age 18/19	-.10	-5.88 **
	(.15)	(1.97)
Employed at age 18/19	-.32 *	-6.02 **
	(.18)	(2.44)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests).

Notes: N=748 women who had sex during study period. Standard errors are in parentheses. Significant differences between medium and low numeracy groups are in bold.

[a] Model controls for number of journals submitted.

Table 4.4: Numeracy and Disruptions in Contraceptive Use

	Number of Switches to a Less Effective Contraceptive Method	Number of Gaps in Contraceptive Use
Numeracy (ref: High numeracy)		
Medium numeracy	**-.05**	**-.10**
	(.09)	**(.13)**
Low numeracy	**.28** **	**.43** ***
	(.10)	**(.14)**
Estimated pregnancy risk		
…from having sex without contraception "once or twice"	.0010	-.0002
	(.0013)	(.0017)
Sociodemographic characteristics		
Black	.07	-.27 **
	(.08)	(.11)
High religiosity	.08	.28 **
	(.07)	(.09)
Family background		
Childhood public assistance	.11	.28 **
	(.07)	(.10)
Mother had teen birth	.01	-.10
	(.07)	(.09)
Mother has college degree	-.20 **	-.40 ***
	(.09)	(.13)
Two-parent household	-.08	-.10
	(.07)	(.10)
Adolescent sexual experiences		
Age 16 or younger at first sex	.00	.36 ***
	(.08)	(.12)
Two or more sexual partners by age 18/19	.32 ***	.12
	(.09)	(.12)
Ever had sex without contraception by age 18/19	.08	.25 **
	(.07)	(.11)
Any prior pregnancy by age 18/19	.14	.04
	(.09)	(.11)
Current socioeconomic status		
High school GPA	-.17 *	-.15
	(.09)	(.12)
Public assistance at age 18/19	.00	-.27 ***
	(.05)	(.07)
Employed at age 18/19	-.43 ***	.05
	(.07)	(.09)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests).

Notes: N=735 women who used contraception during study period. Models control for number of journals submitted. Standard errors of Poisson regression coefficients are in parentheses. Significant differences between medium and low numeracy groups are in bold.

Table 4.5: Numeracy and Primary Contraceptive Method

	Withdrawal	Pill/Patch/Ring	LARC
Numeracy (ref: High numeracy)			
Medium numeracy	-.26	-.04	-.48
	(.33)	(.26)	(.38)
Low numeracy	-.60	-.72 *	-1.62 **
	(.43)	(.36)	(.60)
Estimated pregnancy risk			
…from having sex without contraception "once or twice"	.0011	.0051	.0119 *
	(.0047)	(.0038)	(.0058)
Sociodemographic characteristics			
Black	-.34	-.39 *	.21
	(.28)	(.23)	(.33)
High religiosity	-.04	-.16	-.14
	(.25)	(.20)	(.31)
Family background			
Childhood public assistance	-.04	-.07	.00
	(.26)	(.21)	(.30)
Mother had teen birth	-.15	-.57 **	-.26
	(.25)	(.21)	(.29)
Mother has college degree	.30	.76 ***	.06
	(.33)	(.25)	(.43)
Two-parent household	.22	.50 **	.15
	(.25)	(.20)	(.30)
Adolescent sexual experiences			
Age 16 or younger at first sex	.47	.75 ***	.62
	(.30)	(.24)	(.37)
Two or more sexual partners by age 18/19	.20	.25	.90 *
	(.32)	(.25)	(.42)
Ever had sex without contraception by age 18/19	.97 ***	-.37	-.94 **
	(.30)	(.23)	(.36)
Any prior pregnancy by age 18/19	-.30	-.38	1.02 **
	(.31)	(.27)	(.36)
Current socioeconomic status			
High school GPA	-.46	-.18	.49
	(.31)	(.26)	(.34)
Public assistance at age 18/19	-.21	.22	-.28
	(.19)	(.17)	(.22)
Employed at age 18/19	-.07	.42 *	.10
	(.24)	(.19)	(.29)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests).

Notes: N=735 women who used contraception during study period. Coefficients indicate log-odds of each method versus base outcome of condoms. Standard errors are in parentheses. Significant differences between medium and low numeracy groups are in bold.

Chapter 5: Conclusion

In the previous chapters, I have described young women's perceptions of the risk of pregnancy and their association with subsequent contraceptive use. I have examined changes in these risk estimations over time and in response to women's experiences with sex, contraception, and pregnancy. I have evaluated a set of competing risks that may discourage contraceptive use among women who wish to prevent pregnancy, and I have investigated women's conceptual understanding of risk itself as a predictor of contraceptive use. In this final chapter, I revisit key findings from previous chapters, considering their implications for research, policy, and practice.

Key findings

Young women generally believe pregnancy to be a likely outcome of sex. As in a number of previous studies, they dramatically overestimate the risk of pregnancy from having sex without contraception once or twice, and they also underestimate the cumulative likelihood of pregnancy from having sex without contraception repeatedly. These pregnancy risk estimates evolve in response to women's experiences during the study period. Avoiding pregnancy despite having sex without contraception is associated with subsequent reductions in women's estimates of their pregnancy risk; in turn, lower estimates of pregnancy risk are associated with a higher likelihood of sex without contraception in later weeks. Meanwhile, side effect concerns discourage use of hormonal contraception at many junctures. Women concerned about side effects are less likely to ever use hormonal methods, more likely to switch to less effective methods or stop using contraception. As a result, they are more reliant on condoms and withdrawal, methods which are more difficult to use correctly and more likely to fail. Side effect concerns also predict more frequent sex without any contraception. Finally, numeracy is associated with poor contraceptive use among women of risk of unintended pregnancy. Young women with low numeracy resemble their higher numeracy peers in terms of their sexual behavior, but have more frequent sex without contraception and are more likely to rely on condoms as their main method of contraception.

Limitations

Access to contraception

This research has focused primarily on individual-level predictors of contraceptive use: personal estimations of risk and individual numeracy in the U.S. It is important to knowledge structural barriers to effective contraceptive use, although they are not the primary focus of these analyses. The U.S. is characterized by large, persistent inequalities in access to contraception, reproductive healthcare, and indeed healthcare more generally, as well as discrepancies in the quality of care (Dehlendorf, Rodriguez, et al., 2010; Institute of Medicine, 2001)

However, poor contraceptive use is observed even within affluent populations and among women who do not report substantial difficulties in accessing contraception (Kaye et al., 2009). These data suggest that if all structural barriers to contraceptive use disappeared overnight, inconsistent contraceptive use and unintended pregnancy would not necessarily vanish with them. Since non-use and inconsistent use of contraception are not entirely attributable to a lack of access, it is important to understand other factors that might discourage or inhibit contraceptive use among young women who do not desire pregnancy.

Affect and risk

This analysis has considered the numerical character of risk. I have not considered the emotional component of risk perception, which has also been shown to influence health decisions (Chapman & Coups, 2006; Nordgren, van der Pligt, & van Harreveld, 2007; Slovic, Finucane, Peters, & MacGregor, 2004), but is beyond the scope of this research. In some cases, anticipation of regret or worry may be a stronger predictor of behavior than risk perception alone (Chapman & Coups, 2006), and should be a consideration in future research on perceived pregnancy risk and contraceptive use.

Male partners

The RDSL sample is restricted to young women, and includes only limited information about their sexual partners. However, women do not necessarily make decisions about sex and contraception alone. Relationship characteristics and partner characteristics are associated with sex and contraception (Kusunoki & Upchurch, 2011; Manlove, Ryan, & Franzetta, 2007). It would be useful to know whether and how men's understanding of risk and estimations of risk matter in couple-level decisions about sexual behavior and contraception. For instance, if risk estimates differ within couples, whose risk estimates are more consequential for behavior?

Unfortunately, practical concerns limited the collection of data on male partners[39]. These kinds of questions are not answerable in this study, but are worth considering in future research.

Generalizability

Michigan is around the national median with respect to many fertility and reproductive health outcomes such as age at first sex and the teenage pregnancy rate (Lesthaeghe & Neidert, 2006). But although Michigan is not an obvious outlier with respect to fertility and reproductive health, the RDSL sample is not nationally representative, and the results of this research may not be generalizable to young adults in other regions of the U.S. The sample is less diverse than the United States as a whole: due to the demographic composition of the county where the RDSL study was conducted, most women in the sample identify as either Black or White and there are relatively few participants from other racial/ethnic groups. Among the highly religious women, the majority identify as Christian.

Appendix Table B.7 compares the analytic samples from each chapter to women in the same age cohort in the 2006-2010 National Survey of Family Growth (NSFG). The RDSL sample has a higher proportion of Black women, reflecting the demographic composition of the study site. RDSL participants are more likely to be highly religious than young women in the NSFG. They are slightly less likely to have a mother with a college degree and more likely to have a mother who had a teen birth. These differences may affect the *distribution* of estimated pregnancy risk, side effect concerns, and/or numeracy within the RDSL sample, although there is little reason to suspect that they would alter the *effects* of estimated pregnancy risk, side effect concerns, or numeracy on contraceptive use.

Although the RDSL sample is not nationally representative, the composition of the sample is advantageous in other respects. The study was conducted in a county with considerable socioeconomic diversity among both Black and White women. Probability sampling from the Personal Identification Card and driver's license database ensures that the sample is representative of 18- and 19-year-olds within the study county, and that participation in the RDSL study is not conditional on sexual history, pregnancy history, past or current contraceptive use, or use of reproductive health services. Avoiding selection on the dependent variable(s) in

[39] RDSL questions about relationships are designed to capture a range of relationship types, from casual sexual relationships to marriages. Many women had several partners over the 30-month study period, and collecting data from the shorter-term and less serious partners would have been particularly challenging.

this study is particularly advantageous given that much of the existing research on estimated pregnancy risk was conducted using samples of women visiting family planning clinics. Conducting the study within one state also reduces heterogeneity in the sexual education RDSL respondents may have received as teenagers. Although sexual education content is locally determined and varies by district, broad guidelines for sexual education content are determined at the state level.

The focus on a narrow age range may limit the generalizability of these findings to younger or older women. Early adulthood may be unique for several reasons: young adults are more likely than younger teens to be sexually active, but less likely to desire a pregnancy than people later in their twenties. Young adults without much experience with sex or contraception may be relying heavily on information from peers and other members of their social network (L. Yee & Simon, 2010), which may not be entirely accurate. Thus, myths and misconceptions may be more widespread and more consequential at these ages. If this is the case, the relationships between perceived risks and contraceptive use observed in these analyses may not extend to older, more experienced adults.

On the other hand, focusing on a narrow age range limits some sources of heterogeneity that might otherwise complicate the analysis. For instance, Chapter 2 is concerned with changes in estimated pregnancy risk over time and in response to women's experiences with sex, contraception, and pregnancy. Thus, it is advantageous that RDSL respondents are in a similar moment in their sexual lives. There is certainly variation in sexual experience at ages 18 and 19, but less variation than one would expect in a sample of all reproductive-aged women.[40] The prevalence of subfecundity within the RDSL age range is extremely low (Chandra et al., 2005), despite widespread concerns about possible infertility in this age group (Kaye et al., 2009). Intended pregnancies are also fairly rare at these ages (Finer & Zolna, 2016), so in most cases, low estimations of pregnancy risk at age 18/19 are probably not attributable to prior unsuccessful attempts to conceive. If the sample included slightly older women, the anticipation and experience of infertility would be more difficult to disentangle. The small age range also means that RDSL participants were exposed to similar media and a similar policy environment with respect to sexual education. RDSL respondents attended middle school and high school in the

[40] For instance, the National Survey of Family Growth includes women aged 15-49 something: women just beginning their sexual lives and women who have completed their fertility.

early- to mid-2000s, an era in which formal instruction about contraception had been declining nationwide for several years (Lindberg et al., 2006) and a substantial federal investment in abstinence-only education was underway (Lindberg & Maddow-Zimet, 2012).

Contributions

This research provides strong evidence that risk perceptions are consequential for health behavior. Consistent with the argument made in Brewer et al (2007), well-designed, longitudinal measures of risk perception are strong predictors of protective behavior. I build on this finding by showing that recent behavior is also a strong predictor of future risk perception, a conclusion which would not be possible with the longitudinal design of this analysis. A number of qualitative studies have suggested a reciprocal relationship between perceived pregnancy risk and contraceptive use: to the best of my knowledge, this analysis provides the first longitudinal, quantitative evidence of such a reciprocal relationship.

This analysis also improves on past research on risk perception by considering multiple types of perceived risk: the immediate risk of pregnancy from having sex without contraception once, as well as the cumulative risk of pregnancy from having sex without contraception on a regular basis for a year. By including both types of risk, I am able to conclude that the perceived cumulative risk of pregnancy is a stronger predictor of women's contraceptive use, which may have implications for efforts to reduce unintended pregnancy.

With respect to side effect concerns, the longitudinal design of this research allows me to consider dynamic behaviors over a longer stretch of a woman's contraceptive "career" than in many existing studies of side effects. Past research has connected side effect concerns to discontinuation of hormonal methods; I am able to show that women who are concerned about side effects are also less likely to try hormonal methods in the first place, and experience more instability in their use of particular methods (i.e. gaps in use and method switches). I also consider alternatives to hormonal contraceptive use: side effect concerns contribute to greater reliance on non-hormonal methods, but also increase the likelihood and frequency of not using contraception at all.

Past research has suggested that numeracy influences risk perception and comprehension of risk information (Peters, 2012; Peters, Hibbard, Slovic, & Dieckmann, 2007; Reyna et al., 2009). I am not able to comment on the effect of numeracy on risk perception because I used risk perception measures to construct a numeracy measure. However, I show that that numeracy is a

strong independent predictor of preventative health behaviors even after accounting for risk perception. Previous research has connected perceived risk of pregnancy to contraceptive use (although this research is mainly cross-sectional), and a prior qualitative study has connected low numeracy to difficulties using contraception (L. M. Yee & Simon, 2013). As far as I am aware, this is the first quantitative study to demonstrate that numeracy predicts young women's subsequent contraceptive use, above and beyond women's knowledge or beliefs about pregnancy risk. A broader implication of this research on numeracy is that theoretical models emphasizing risk perception as a driver of medical decisions or health behaviors should incorporate numeracy whenever possible. The omission of numeracy is a tacit assumption that all individuals have the quantitative reasoning skills needed to compare risks, and in many populations this is not a defensible assumption.

All three analytic chapters reveal significant gaps in knowledge and even outright misinformation about sex, contraception, and pregnancy among young women. Improving contraceptive use among women who do not desire pregnancies will require improving access to reproductive health information, and also ensuring that this information is accessible the owmen with varying levels of numeracy. These findings suggest that credible sources of information about these topics are currently inaccessible, underutilized, or not responsive to young women's needs.

Appendices

APPENDIX A

Original Text of Survey Items Used to Construct Key Variables

Estimated Pregnancy Risk and Numeracy

If you were to have sexual intercourse regularly, say once a week for a year, without using birth control, what do you think are the chances that you would get pregnant?

Responses range from 0-100

If you were to have sexual intercourse once or twice without using birth control, what are the chances that you would get pregnant?

Responses range from 0-100

Side Effect Concerns

If you used the birth control pill or hormonal methods, it is likely you will gain weight.

Strongly agree/Agree/Disagree/Strongly Disagree

If you used the birth control pill or hormonal methods for many years, it is likely to give you a serious health problem (like cancer).

Strongly agree/Agree/Disagree/Strongly Disagree

If you used the birth control pill or other hormonal methods, it is likely to give you severe mood swings.

Strongly agree/Agree/Disagree/Strongly Disagree

Which is more risky to a woman's health: taking birth control pills for a year or having a baby, including the pregnancy, labor, and delivery?

Taking birth control for a year/Having a baby

Pregnancy

Do you think there might be a chance that you are pregnant right now?

Yes/No

Has a pregnancy test indicated that you are currently pregnant?

Yes/No

Do you think you are probably pregnant or not?

Probably pregnant/Probably not pregnant

How much do you want to get pregnant during the next month? Please give a number between 0 and 5, where 0 means you don't at all want to get pregnant and 5 means you really want to get pregnant.

0-5

How much do you want to avoid getting pregnant during the next month? Please give a number between 0 and 5, where 0 means you don't at all want to avoid getting pregnant and 5 means you really want to avoid getting pregnant.

0-5

Sexual Intercourse

In the past [NUMBER] days since [DATE], did you have sexual intercourse with [PARTNER NAME]? By sexual intercourse, we mean when a man puts his penis into a woman's vagina.

Yes/No

In the past [NUMBER] days since [DATE], did you have sexual intercourse with anyone other than [PARTNER NAME]?

Yes/No

Contraception

Since your last interview on [DATE], did you use or do anything that can help people avoid getting pregnant, even if you did not use it to keep from getting pregnant yourself?

Yes/No

Did you use birth control pills (for any reason)?

Yes/No

Did you use the birth control patch (for any reason)?

Yes/No

Did you use the NuvaRing?

Yes/No

Did you use Depo-Provera or any other type of contraceptive shot?

Yes/No

Did you have an implant such as Norplant or another contraceptive implant?

Yes/No

Did you have an IUD?

Yes/No

In the past [NUMBER] days since [DATE], did you or your partner(s) use some method of birth control every time you had intercourse (even if you are not trying to prevent pregnancy)? This could be a method you mentioned earlier, or a method you haven't mentioned such as condoms, pills, or another method.

Yes/No

In the past [NUMBER] days since [DATE], did you use a condom?

Yes/No

In the past [NUMBER] days since [DATE], did you use a female condom?

Yes/No

In the past [NUMBER] days since [DATE], did your partner withdrawal before ejaculating?

Yes/No

In the past [NUMBER] days since [DATE], did you do anything else to avoid becoming pregnant that you haven't mentioned today?

Yes/No

If Yes: What was that?

Sociodemographic Characteristics

Which of the following groups describe your racial background? Please select one or more groups.

American Indian or Alaska Native/Asian/Native Hawaiian or Other Pacific Islander/Black or African American/White

How important if at all is your religious faith to you - would you say not important, somewhat important, very important, or more important than anything else?

Not important/Somewhat important/Very important/More important than anything else

Family Background

While you were you were growing up, did your family ever receive public assistance?

Yes/No

How old was your biological mother when she had her first child?

Less than 18 years/18-19 years/20-24 years/25-29 years/30 or older

What is the highest level of education your [mother/step-mother/foster mother/grandmother] completed?

Less than high school/High school grad or GED/Some college/Bachelor's degree or higher

Which of these people did you live with for the majority of the time when you were growing up? Please select one or more from the list.

Biological mother/Biological father/Adoptive mother/Adoptive father/Step-mother/Step-father/Grandmother/Grandfather/Other relatives/Foster mother/Foster father/Institution

Adolescent Sexual Experiences

Have you ever had sexual intercourse? Sexual intercourse is when a man inserts his penis into a woman's vagina.

Yes/No

How old were you the first time you had sexual intercourse?

Responses range from 0-20

With how many total partners have you had sexual intercourse?

Responses range from 1-99

Have you ever used anything that can help people avoid becoming pregnant?

Yes/No

Have you ever had sexual intercourse without using some method of birth control such as condoms, pills, or another method?

Yes/No

Sometimes women who take part in this study are reluctant to tell an interviewer about some of their pregnancies. Now that you are answering questions in privacy, please think of all the times you have been pregnant, whether you are currently pregnant or the pregnancy ended in live birth, miscarriage, stillbirth, abortion, or ectopic pregnancy. How many times have you been pregnant in your life?

Responses range from 0-10

Current Socioeconomic Status

What was your [high] school GPA at the end of the last semester you completed?

Responses range from 0-100.00

Are you currently receiving public assistance from any of the following sources? Please select one or more from the list:

WIC (The Women, Infants & Children Program)/FIP (The Family Independence Program)/ Cash welfare/ Food stamps/ None

Are you currently working for pay?

Yes/No

Estimated Pregnancy Risk and Numeracy in the 2009 National Survey of Reproductive and Contraceptive Knowledge ("Fog Zone")

And, if a couple is having sex regularly and they are not using any method to prevent pregnancy, what are the chances of getting pregnant in a year? (IF NECESSARY, SAY: Using the same scale from 0 to 100.) (IF NECESSARY, SAY: Regularly means about once a week.)

Responses range from 0-100

What are the chances of getting pregnant after one single act of unprotected sex? (IF NECESSARY, SAY: Again, using a scale from 0 to 100.)

Responses range from 0-100

APPENDIX B

Supplementary Analyses

Table B.1: Change in Women's Pregnancy Risk Estimates During Quarter

	Change in Estimated Risk of Pregnancy From Having Sex Without Contraception…	
	Once or twice	**Regularly**
Sex/contraception/pregnancy during quarter (ref: Had sex and always used contraception)		
No sex	2.17 *	.10
	(1.01)	(1.12)
Had sex without always using contraception	.60	-4.29 ***
	(1.01)	(1.13)
Pregnancy scare	-.93	-2.65
	(2.58)	(3.06)
Pregnancy	9.30 ***	6.54 **
	(2.38)	(2.47)
Previous estimate of pregnancy risk from having sex without contraception…		
Once or twice	-.45 ***	
	(.02)	
Regularly		-.52 ***
		(.02)
Sociodemographic characteristics		
Black	.50	
	(1.14)	
High religiosity	1.74 *	
	(.93)	
Family background		
Childhood public assistance	-1.06	-1.98 *
	(1.03)	(1.19)
Mother had teen birth	-.92	-2.87 **
	(.90)	(1.12)
Mother has college degree	-1.08	.96
	(1.03)	(1.10)
Two-parent household	-.08	.37
	(.95)	(1.04)
Adolescent sexual experiences		
Age 16 or younger at first sex	-.54	.76
	(1.18)	(1.33)
Two or more sexual partners by age 18/19	-1.44	-.19
	(1.19)	(1.29)
Ever had sex without contraception by age 18/19	-2.22 *	-3.74 **
	(1.06)	(1.24)
Any prior pregnancy by age 18/19	2.25 *	-.35
	(1.26)	(1.51)
Current socioeconomic status		
High school GPA	-1.61 *	.23
	(.70)	(.78)
Public assistance at age 18/19	2.36 *	1.88
	(1.27)	(1.44)
Employed at age 18/19	.23	.46
	(.84)	(.93)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Note: N=3,666 quarters. Standard errors are in parentheses and account for clustering of quarters within women. Models control for length of the quarter.

Table B.2: Sex and Contraception During Quarter, Given Estimated Pregnancy Risk From Having Sex Without Contraception Once or Twice

	M1		M2	
	No sex	Had sex without always using contraception	No sex	Had sex without always using contraception
Estimated pregnancy risk from having sex without contraception once or twice				
Change in risk estimate during previous quarter	.0019	-.0038	.0024	-.0012
	(.0030)	(.0027)	(.0033)	(.0032)
Risk estimate at beginning of quarter			-.0012	-.0053 *
			(.0028)	(.0032)
Sex/contraception during previous quarter (ref: had sex and always used contraception)				
No sex	3.82 ***	1.01 ***	3.82 ***	1.02 ***
	(.19)	(.20)	(.20)	(.20)
Had sex without always using contraception	1.20 ***	2.59 ***	1.20 ***	2.59 ***
	(.20)	(.16)	(.20)	(.16)
Sociodemographic characteristics				
Black	.49 **	.02	.49 **	.04
	(.19)	(.19)	(.19)	(.19)
High religiosity	.10	.16	.10	.17
	(.14)	(.15)	(.14)	(.15)
Family background				
Childhood public assistance	-.20	.06	-.20	.05
	(.17)	(.15)	(.17)	(.15)
Mother had teen birth	.10	.14	.09	.13
	(.17)	(.15)	(.17)	(.16)
Mother has college degree	.10	-.32 *	.09	-.34 *
	(.14)	(.16)	(.14)	(.16)
Two-parent household	-.06	-.10	-.06	-.10
	(.15)	(.15)	(.15)	(.15)
Adolescent sexual experiences				
Age 16 or younger at first sex	-.43 **	-.21	-.44 **	-.21
	(.18)	(.17)	(.18)	(.17)
Two or more sexual partners by age 18/19	-.57 ***	.02	-.57 ***	.01
	(.17)	(.17)	(.17)	(.17)
Ever had sex without contraception by age 18/19	-.06	.52 ***	-.07	.50 ***
	(.18)	(.16)	(.18)	(.16)
Any prior pregnancy by age 18/19	.01	.47 **	.02	.51 **
	(.26)	(.20)	(.27)	(.20)
Current socioeconomic status				
High school GPA	-.34 **	-.48 ***	-.34 **	-.50 ***
	(.13)	(.13)	(.13)	(.14)
Public assistance at age 18/19	.23	-.14	.23	-.13
	(.22)	(.19)	(.22)	(.19)
Employed at age 18/19	-.29 *	-.15	-.29 *	-.15
	(.14)	(.13)	(.13)	(.14)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Notes: N=2,910 due to lagging of sex/contraception. Base outcome is "Had sex, always used contraception". Coefficients refer to log-odds. Standard errors are in parentheses and account for clustering of quarters within women. All models control for the length of the quarter.

Table B.3: Sex and Contraception During Quarter, Given Estimated Pregnancy Risk From Having Sex Without Contraception Regularly

	M1		M2	
	No sex	Had sex without always using contraception	No sex	Had sex without always using contraception
Estimated pregnancy risk from having sex without contraception regularly				
Change in risk estimate during previous quarter	.0002	-.0056 **	.0021	-.0014
	(.0025)	(.0023)	(.0030)	(.0029)
Risk estimate at beginning of quarter			-.0037	-.0079 **
			(.0029)	(.0030)
Sex/contraception during previous quarter (ref: had sex and always used contraception)				
No sex	3.82 ***	1.01 ***	3.82 ***	1.00 ***
	(.19)	(.20)	(.19)	(.20)
Had sex without always using contraception	1.20 ***	2.60 ***	1.18 ***	2.54 ***
	(.20)	(.16)	(.20)	(.16)
Sociodemographic characteristics				
Black	.48 **	.02	.48 **	.01
	(.19)	(.19)	(.19)	(.19)
High religiosity	.10	.17	.09	.16
	(.14)	(.15)	(.14)	(.15)
Family background				
Childhood public assistance	-.20	.06	-.20	.05
	(.17)	(.15)	(.17)	(.16)
Mother had teen birth	.10	.15	.08	.10
	(.17)	(.15)	(.17)	(.16)
Mother has college degree	.09	-.32 *	.09	-.33 *
	(.14)	(.16)	(.14)	(.16)
Two-parent household	-.06	-.10	-.05	-.09
	(.15)	(.15)	(.15)	(.16)
Adolescent sexual experiences				
Age 16 or younger at first sex	-.43 **	-.21	-.43 **	-.20
	(.18)	(.17)	(.18)	(.17)
Two or more sexual partners by age 18/19	-.58 ***	.02	-.58 ***	.02
	(.17)	(.17)	(.17)	(.17)
Ever had sex without contraception by age 18/19	-.06	.51 ***	-.08	.47 **
	(.18)	(.16)	(.19)	(.16)
Any prior pregnancy by age 18/19	.00	.47 **	.00	.47 **
	(.26)	(.20)	(.26)	(.20)
Current socioeconomic status				
High school GPA	-.34 **	-.48 ***	-.34 **	-.47 ***
	(.13)	(.13)	(.13)	(.13)
Public assistance at age 18/19	.22	-.14	.24	-.12
	(.22)	(.19)	(.22)	(.20)
Employed at age 18/19	-.29 *	-.15	-.29 *	-.14
	(.13)	(.14)	(.13)	(.14)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests)

Notes: N=2,910 due to lagging of sex/contraception. Base outcome is "Had sex, always used contraception". Coefficients refer to log-odds. Standard errors are in parentheses and account for clustering of quarters within women. All models control for the length of the quarter.

Table B.4: Mean Estimates of Pregnancy Risk in the 2009 National Survey of Reproductive and Contraceptive Knowledge (Fog Zone) and the Relationship Dynamics & Social Life Study (RDSL)

	RDSL[a] (n=756)	Fog Zone Study[b]: Women Aged 18/19 (n=229)	Fog Zone Study[b]: Women Aged 18/29 (n=883)
Estimated pregnancy risk…			
...from having sex without contraception once or twice[c]	53.89	63.26	65.40
...from having sex without contraception repeatedly[d]	74.96	83.70	85.50

Note: The 2009 National Survey of Reproductive and Contraceptive Knowledge (commonly known as the "Fog Zone" study) is a nationally representative telephone survey of unmarried adults aged 18-29.

[a] Pregnancy risk estimates at first quarterly observation (at age 18/19)

[b] Means are weighted to account for the complex sampling design.

[c] In the Fog Zone, respondents are asked to estimate pregnancy risk "after one single act of unprotected sex."

[d] In both studies, respondents are instructed that "regularly" means once per week for one year.

Table B.5: Numeracy and Sexual Behavior

	Likelihood of Ever Having Sex	Percentage of Weeks R Has Sex
Numeracy (ref: High numeracy)		
Medium numeracy	-.11	-2.36
	(.24)	(2.72)
Low numeracy	-.27	1.66
	(.35)	(3.73)
Estimated pregnancy risk		
…from having sex without contraception "once or twice"	.00	.00
	(.00)	(.04)
Sociodemographic characteristics		
Black	-.25	-12.63 ***
	(.24)	(2.57)
High religiosity	-.27	-3.55
	(.20)	(2.21)
Family background		
Childhood public assistance	.01	-.74
	(.22)	(2.34)
Mother had teen birth	-.17	-.52
	(.22)	(2.27)
Mother has college degree	-.15	-1.97
	(.22)	(2.57)
Two-parent household	.29	4.92 *
	(.22)	(2.30)
Adolescent sexual experiences		
Age 16 or younger at first sex	.47 *	5.32 *
	(.27)	(2.73)
Two or more sexual partners by age 18/19	1.56 ***	16.65 ***
	(.26)	(2.78)
Ever had sex without contraception by age 18/19	1.04 ***	12.56 ***
	(.27)	(2.59)
Any prior pregnancy by age 18/19	-.55 *	-3.62
	(.31)	(2.94)
Current socioeconomic status		
High school GPA	-.06	1.62
	(.17)	(1.78)
Public assistance at age 18/19	-.10	-.02
	(.28)	(2.86)
Employed at age 18/19	.09	2.52
	(.19)	(2.10)

*p<0.05; **p<0.01; ***p<0.001 (one-tailed tests).

Notes: N=748 sexually active women. Standard errors are in parentheses. Significant differences between medium and low numeracy groups are in bold.

Table B.6: Numeracy in the 2009 National Survey of Reproductive and Contraceptive Knowledge and the Relationship Dynamics & Social Life Study

	RDSL (n=748)	Women Aged 18/19 in Fog Zone Study[a] (n=229)	Women Aged 18/29 in Fog Zone Study[a] (n=883)
High numeracy	.69	.57	.58
Medium numeracy	.22	.31	.30
Low numeracy	.09	.12	.12

Note: The 2009 National Survey of Reproductive and Contraceptive Knowledge (commonly known as the "Fog Zone" study) is a nationally representative telephone survey of unmarried adults aged 18-29. Numeracy is constructed in the Fog Zone sample using the same two pregnancy risk estimation questions used to construct numeracy in the RDSL.

[a] Proportions are weighted to account for the complex sampling design.

Table B.7 Comparison of Analytic Samples (RDSL) and National Survey of Family Growth Sample (NSFG)

	RDSL Analytic Samples			NSFG:
	Chapter 2 (n=756)	Chapter 3 (n=461)	Chapter 4 (n=748)	Women Aged 18/19 (n=988)[a]
Sociodemographic characteristics				
Black	.31	.28	.34	.16
High religiosity[b]	.57	.54	.55	.45
Family background				
Childhood public assistance[c]	.35	.34	.37	--
Mother had teen birth	.33	.33	.37	.29
Mother has college degree	.24	.23	.20	.26
Two-parent household[d]	.56	.57	.52	.57
Adolescent sexual experiences				
Age 16 or younger at first sex	.48	.52	.59	.60
Two or more sexual partners by age 18/19	.55	.64	.68	.44
Any prior pregnancy by age 18/19	.21	.23	.28	.19
Current socioeconomic status				
High school GPA[c]	3.17	3.19	3.10	--
Public assistance at age 18/19	.22	.23	.28	.31
Employed at age 18/19	.49	.52	.51	.53

[a] Weighted proportions among women aged 18/19 during the last two years of the 2006-2010 National Survey of Family Growth. Analysis is limited to these years in order to correspond as closely as possible to the timing of the RDSL baseline survey; all proportions and means are calculated using a dedicated survey weight for the final two years of the NSFG.

[b] RDSL: "*How important if at all is your religious faith to you - would you say not important, somewhat important, very important, or more important than anything else?* " Asked of all respondents; "high religiosity" indicates an answer of "very important" or "more important than anything else".
NSFG: "*Currently, how important is religion in your daily life? Would you say it is very important, somewhat important, or not important?* " Asked of women reporting some religious affiliation other than "none"; "highly religious" indicates an answer of "very important."

[c] Not available in 2006-2010 NSFG.

[d] RDSL version indicates whether respondent lived in a two-parent household during "*the majority of the time when you were growing up* ." NSFG version indicates whether respondent lived with two biological or adoptive parents from birth until age 18.

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