SEXUAL ACTIVITY AND CONTRACEPTIVE USE IN YOUNG ADULT WOMEN: A LONGITUDINAL MULTILEVEL APPROACH

by
Susannah E. Gibbs

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Abstract

Background: Patterns of sexual activity have been recognized as a potentially important influence on contraceptive behavior, but prior research is largely limited by cross-section data sources. This dissertation assesses short term longitudinal associations between sexual activity and contraceptive use, contraceptive discontinuation, and contraceptive method selection among young adult women. These short term effects are compared to effects of average sexual activity in the course of a partnership (partnership-level sexual activity) and average sexual activity for a given woman in the course of the 2.5 years of follow up (woman-level sexual activity) on contraceptive behaviors.

Data and Methods: Data come from the Relationship Dynamics and Social Life Study (RDSL), a longitudinal population-based project that sampled woman ages 18-19 at baseline in one county in Michigan. Women completed weekly surveys for up to two and a half years. We consider weekly contraceptive behaviors, including use of four specific types of contraception, method discontinuation, and selection of new methods. The independent variables that we examine are weekly, past month, partnership-level and woman-level sexual activity. We use three-level logistic and multinomial models to account for clustering of weekly observations within partnerships and women.

Results: We find clear evidence of a longitudinal association between patterns of sexual activity and contraceptive use. Sexual activity was associated with selection of condoms relative to other contraceptive methods. For example, the risk ratio of selecting condoms relative to the least effective methods was 23% reduced for each

additional week sexually active in the past month (RRR=0.77, 95% CI: 0.71-0.84). Hormonal and other longer acting contraceptive methods were influenced by recent sexual activity through an effect on method discontinuation. The weekly odds of discontinuing highly effective methods declined by 29% per additional week sexually active in the past month (OR=0.71, 95% CI: 0.60-0.83) and the odds of discontinuing the pill declined by 23% per additional sexually active week in the past month (OR=0.77, 95% CI: 0.70-0.84). Across methods, short term effects of sexual activity were more pronounced than partnership-level and woman-level effects.

Conclusions: These analyses underscore the need for longitudinal research on sexual and reproductive health behaviors. Furthermore, these findings highlight the dynamic nature of both sexual activity and contraceptive use and demonstrate the challenges for clinicians, counselors, and other community-based professionals in providing future-oriented support for women's ongoing contraceptive continuation and selection of new methods.

Dissertation Committee

Committee of Final Thesis Readers

Caroline Moreau, MD MPH PhD
Associate Professor and Thesis Advisor
Department of Population, Family, and Reproductive Health
Johns Hopkins Bloomberg School of Public Health

Amy O. Tsui, MA PhD
Professor
Department of Population, Family, and Reproductive Health
Johns Hopkins Bloomberg School of Public Health

Anne E. Burke, MD MPH
Associate Professor
Department of Gynecology and Obstetrics
Johns Hopkins School of Medicine

Elizabeth Colantuoni, ScM PhD
Associate Scientist
Department of Biostatistics
Johns Hopkins Bloomberg School of Public Health

Alternate Committee Members

Stéphane Hellerginer, MA PhD
Associate Professor
Department of Population, Family, and Reproductive Health
Johns Hopkins Bloomberg School of Public Health

Gypsyamber D'Souza, MS MPH PhD
Associate Professor
Department of Epidemiology
Johns Hopkins Bloomberg School of Public Health

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1 Introduction

1.1 Background

Young adults experience the highest unintended pregnancy rates and the greatest share of unintended births despite general focus on adolescent populations by the prevention and research communities. One in three unintended births in the United States is to a woman aged 20-24 (Mosher, Jones, & Abma, 2012), and the unintended pregnancy rate of 104 pregnancies per 1,000 women in this age group is almost two times the rate among adolescents (Finer & Zolna, 2014). About 40% of unintended births are conceived while women are using contraception (Mosher et al., 2012), in part reflecting use of less effective methods (Trussell, 2011). Furthermore, contraceptive method switches are likely a time of increased risk for unintended pregnancy (Bajos et al., 2006). Understanding when and why young women use specific contraceptive methods can help inform strategies to improve contraceptive continuation and overall effectiveness in this age group and prevent unintended pregnancies. Sporadic patterns of sexual activity, not uncommon in this stage of the life course, may be an important factor that influences contraceptive use but has not been thoroughly examined in the research literature.

Infrequent sexual activity has been suggested as a possible reason for not using a contraceptive method (Frost, Singh, & Finer, 2007a, 2007b; R. K. Jones, Darroch, & Henshaw, 2002; Mosher et al., 2012; Wu, Meldrum, Dozier, Stanwood, & Fiscella, 2008) and for using less effective methods, including coitally dependent methods (Frost &

Darroch, 2008; Kusunoki & Upchurch, 2011; Wildsmith, Manlove, & Steward-Streng, 2015). Prior research in this area, however, largely relies on retrospective data on sexual activity and contraceptive use that is averaged over the course of weeks or months. Frequency of sexual activity changes over time, as does contraceptive use, making it likely that short-term associations between the two are missed in cross-sectional studies.

The assumption of much of the prior research in this area is that the variation between individuals that is captured by a snapshot in time provides an adequate approximation of the dynamic changes in a population as individuals vary their behavior over time. Accordingly, both researchers and public health practitioners often categorize individuals into risk groups, at times losing sight of how risk changes situationally for individuals over time. These changes, as conceptualized in the life course perspective, unfold over time and are impacted by evolving contexts as well as through dynamic links to partners (Elder, Johnson, & Crosnoe, 2003). Multilevel analyses of data on other sexual health behaviors, such as alcohol use prior to sex, have suggested that the majority of variation in these behaviors occurs over time within individuals rather than between individuals (Cooper, 2010). Examining the extent to which cross-sectional summary measures capture the actual longitudinal covariance between sexual activity and contraceptive behaviors can provide important insight for researchers studying the dynamics of contraceptive use. This information is also important for clinicians and counselors providing advice to help women select a contraceptive method based on past and current patterns of sexual behavior in a way

that anticipates future variation in sexual activity and contraceptive behaviors.

Prospective weekly longitudinal data from the Relationship Dynamics and Social Life (RDSL) Study provide an opportunity to examine how individual women's patterns of sexual activity relate to their contraceptive behaviors over time. The influence of sexual activity on dynamic measures of contraceptive use, including method discontinuation and selection, will be assessed.

1.2 Specific Aims

Aim 1: Assess the weekly association between sexual activity and contraceptive use over time. In the first aim we assess effects of weekly sexual activity on weekly contraceptive use. Specifically, the association of weekly sexual activity with use of four specific types of contraceptive methods is assessed. In this aim we investigate whether women's contraceptive behaviors vary according to patterns of sexual activity, perhaps to achieve a tolerable level of exposure to risk of unintended pregnancy.

Aim 2: Evaluate the influence of recent sexual activity on discontinuation of a contraceptive method. In the second aim we examine whether recent past month sexual activity influences women's discontinuation of a specific type of contraceptive method. Building on Aim 1, in this aim we begin to investigate the temporality of the association between patterns of sexual activity and contraceptive behaviors, focusing on the extent to which sexual activity influences prolonged use of specific types of contraceptive methods.

Aim 3: Evaluate the association between patterns of sexual activity leading up to selection of a new contraceptive method and the specific type of method that is selected. In the third aim we explore the association between frequency of sexual activity in the month prior to selection of a new method and the specific method that is selected. Using this approach, we assess whether women take into consideration their recent frequency of sexual activity when deciding which specific contraceptive method to start using. This aim builds on the prior aim by bringing a temporal lens to the analysis with a focus on initiation of a new contraceptive behavior.

1.3 Overview

The second chapter of this dissertation provides a review of the existing research literature on the association between sexual activity and contraceptive behaviors, as well as literature on potentially confounding sociodemographic and sexual and reproductive health characteristics. A conceptual framework is proposed and theoretical underpinnings discussed. The literature review is followed by a methods chapter that includes a description of the data source, the Relationship Dynamics and Social Life Study (RDSL), as well as detail on the analytic samples and statistical methods for each analysis. The next three chapters present findings corresponding to each of this dissertation's three specific aims. The fourth chapter explores weekly associations between sexual activity and contraceptive use. In the fifth chapter, recent prior sexual activity is assessed with respect to subsequent contraceptive discontinuation. In the sixth chapter recent prior sexual activity is assessed with respect to selection and

initiation of specific contraceptive methods. A final chapter synthesizes and discusses all of these results, and proposes future applications for research, public health, and clinical practice.

2 Literature Review, Theory, Conceptual Framework, and Specific Aims

2.1 Young Adult Sexual Health

Increasingly, the young adult period is spent in a sexually active, pregnancy-delaying state, more so than any other age group. The median age at first sex for women in the United States is around age 18 while the median age at first birth is not until age 27 (Finer & Philbin, 2014). Furthermore, young adults experience the greatest share of unintended pregnancies, greater even than adolescents. For women ages 20-24 the unintended pregnancy rate is 104 unintended pregnancies per 1,000 women, while among adolescents ages 15-19 the rate is only 54 per 1,000 women (Finer & Zolna, 2014). Notably, this difference in unintended pregnancy rates is largely because many adolescents are not yet sexually active, while the majority of young adults are sexual active and at risk of unintended pregnancy (Finer, 2010). Out of all unintended births in the United States, 33% are to women ages 20-24, while only 22% are to women ages 15-19 (Mosher et al., 2012). Similarly, 33% of abortions in the United States are to women ages 20-24, while only 11% are to women ages 15-19 (Jatlaoui et al., 2016). The prevention of unintended pregnancy is an important public health priority in order for women to realize their sexual and reproductive rights to decide if and when to become pregnant. Additionally, unintended pregnancy is associated with delayed use of antenatal care, lower rates of breastfeeding, and may negatively influence some aspects of child health and maternal mental health (Gipson, Koenig, & Hindin, 2008; Kost &

Lindberg, 2015).

Approximately 40% of women with unintended births in the United States were using contraception at the time of conception (Mosher et al., 2012). The large differences between perfect use and typical use failure rates for the pill and condom (Sundaram et al., 2017; Trussell, 2011) reflect unintended pregnancies that arise due to discontinuations, inconsistent use or incorrect method use. Improving our understanding of young adult women's contraceptive and pregnancy prevention behaviors may be important to helping young women and their partners gain control over if and when they conceive.

Contraceptive use, the most immediate proximate determinant of unintended pregnancy (Bongaarts, 1978), is widespread in the United States, particularly among young adult women. In fact, 87% of women ages 20-24 who are at risk of an unintended pregnancy are current contraceptive users (Mosher, Moreau, & Lantos, 2016). For women in this age group who use contraception, the most commonly used method is the pill (52%), followed by the condom (26%) (J. Jones, Mosher, & Daniels, 2012). Use of the most effective methods, including long-acting reversible contraceptive methods (IUD or implant), is not widespread, but these methods have become increasingly common among both adolescents and young adults, accounting for 10% of contraceptive use in the most recently available data (Daniels, Daugherty, Jones, & Mosher, 2015). Among women in this age group who are at risk of an unintended pregnancy, 13% do not use any method of contraception (Mosher et al., 2016).

Contraceptive protection depends not only on the effectiveness of the method

that women choose to use, but also on how long women continue to consistently use that method. The prevalence of discontinuations, inconsistent and incorrect contraceptive use is reflected in the differential between failure rates for perfect method use and typical method use (Sundaram et al., 2017; Trussell, 2011). Perfect pill use, for example, results in only 0.3% of users experiencing unintended pregnancy in the first year of use, whereas typical pill use results in 7% of users experiencing unintended pregnancy. (Sundaram et al., 2017; Trussell, 2011) So too, while only 5% of perfect condom users will experience unintended pregnancy over the first year of use, a full 13% of typical condom users will become unintentionally pregnant (Sundaram et al., 2017; Trussell, 2011). Furthermore, young women may experience significantly higher rates of pill and condom failure than older women (Kost, Singh, Vaughan, Trussell, & Bankole, 2008). Understanding when, why, and how well young women use contraception can help inform strategies to improve reproductive autonomy.

2.2 Sexual activity and contraceptive behaviors

2.2.1 Non-use

Patterns of sexual activity likely influence women's decisions to use contraception and their choice of contraceptive method. In fact, infrequent sexual activity is one of the reasons that some women do not use any method of contraception, possibly due to a perceived low risk of unintended pregnancy. In a nationally representative survey conducted by the Guttmacher Institute in the United States in 2004, almost one third of women at risk of unintended pregnancy who were

not using a contraceptive method cited infrequent sexual activity as the main reason for nonuse (Frost et al., 2007b). In the National Survey of Family Growth (NSFG), not expecting to have sex was the third most common reason for contraceptive nonuse among women experiencing unintended pregnancies, after not thinking they could become pregnant and not really minding about becoming pregnant (Mosher et al., 2012). In both of these samples, infrequent sexual activity was associated with increased odds of non-use of a contraceptive method (Frost et al., 2007a; Wu et al., 2008). On the other hand, no association between frequency of sexual activity and non-use of a contraceptive method was found in a smaller clinic-based sample of low-income young women in the southeast United States (Wilson & Koo, 2008), suggesting a potentially complex association.

These null findings from the clinic-based sample, however, should be interpreted with caution because of the limited generalizability of the sample. For women in this sample with a recent unintended pregnancy (~60% of the sample), data on contraceptive use and sexual activity were collected for the month prior to the unintended pregnancy, while for the remainder of the sample contraceptive use data were collected for the month prior to the interview (Wilson & Koo, 2008). Because both poor contraceptive use and higher frequency of sexual activity are risk factors for unintended pregnancy, the analysis of sexual activity and contraceptive use is highly vulnerable to selection bias in which both women who are more sexually active and women who use less effective methods are oversampled. This study also raises the possibility, however, that the association between sexual activity and contraceptive

behaviors may vary in different socioeconomic contexts.

2.2.2 Method-Specific Use

Conflicting findings may also be due to differences in contraceptive method mix, as a greater proportion of the clinic-based sample of young women used the injectable and fewer used the pill compared to the nationally representative sample (Frost et al., 2007b; Wilson & Koo, 2008). Heterogeneity of the effect of sexual activity on contraceptive use by specific method may lead to dilution of measures of associations when longer acting methods are more prevalent, as these methods are unlikely to be as responsive to short-term changes in patterns of sexual activity. While long-term patterns of sexual activity may influence selection of longer acting methods such as the IUD, implant, or injectable, short-term fluctuations in sexual activity may be more likely to affect use of shorter acting and user-dependent methods such as the pill and condoms.

To understand method-specific use, researchers often compare users of a specific method to all other women who use other methods or no method. In looking at a longer term measure of frequency of sexual activity (averaged over the prior three months), analysis of the Guttmacher Institute's national survey found that generally women who reported more frequent sexual activity were more likely to use the more effective long acting methods compared to all other methods, while women who had sex less often were more likely to use less effective methods, including withdrawal, periodic abstinence and spermicides compared to all other methods (Frost & Darroch,

2008). The association for pill and condom use fell between the least and most effective methods (Frost & Darroch, 2008), but the reference groups for these methods includes users of both more and less effective methods, making these figures difficult to interpret. An analysis of NSFG data found that, at least in cohabiting relationships, more frequent sexual activity was associated with less condom use and less hormonal method use at last sex, each compared to all other methods (Wildsmith et al., 2015).

Condom use may be particularly sensitive to patterns of sexual activity as unexpected sexual activity may result in condom-unprotected sex if a condom is not close at hand. In fact, in the Guttmacher Institute's national survey, the most frequently cited reason for inconsistent condom use was not expecting to have sex or not having a condom handy (Frost et al., 2007b). Despite this possibility that infrequent sex followed by unexpected sex may lead to less condom use, some of the research literature suggests that association may be the inverse. For example, a 1999 meta-analysis found that overall, less frequent sexual activity was associated with greater condom use (Sheeran, Abraham, & Orbell, 1999). Several more recent individual studies have found similar results (Katz, Fortenberry, Zimet, Blythe, & Orr, 2000; Marshall et al., 2016; Sayegh, Fortenberry, Shew, & Orr, 2006). A limitation of this literature is a focus on STI and HIV prevention rather than pregnancy prevention, such that use of other contraceptive methods by condom non-users or inconsistent condom users is not accounted for. Furthermore, the measures of condom use used in the more recent studies are dependent on frequency of sexual activity, unlike many measures of other contraceptive method use. Measures including the number of condom-unprotected

coital events (Sayegh et al., 2006) and perfect condom use (Katz et al., 2000) are dependent on the frequency of sexual activity, as a higher frequency of sexual activity provides additional opportunities for condom non-use.

As previously described, several of these method-specific analyses are problematic from a methodological standpoint, as method-specific use is analyzed as a dichotomous outcome, comparing specific method users to users of all other (more and less effective) methods. The reference group (method-specific non-users), therefore, is likely heterogeneous in its association with the independent variable (frequency of sexual activity), and thus the true association between specific method use and sexual activity may be hidden.

Two studies have used the more methodologically appropriate multinomial logistic regression to examine method-specific use, but each has its own limitations and neither has its primary focus on frequency of sexual activity. A study by Kusunoki and Upchurch used data from the National Longitudinal Study of Adolescent Health to examine how relationship context relates to contraceptive use (Kusunoki & Upchurch, 2011). The authors used multiple measures of relationship context, including frequency of sexual activity, to build a five-category classification of relationship context; two of these categories were “dating with less sex” and “dating with more sex” (Kusunoki & Upchurch, 2011). Comparing method-specific use at last sex between these two types of relationships, condom use was more likely in dating relationships with less sex while hormonal method use was more likely in dating relationships with more sex (Kusunoki & Upchurch, 2011). While this study provides a great deal of information on relationship

contexts and contraceptive use, the classification of relationship types does not allow analysis of frequency of sexual activity within or across other types of relationships (e.g. acquaintance hook-ups or more serious cohabiting couples). The other study that has used multinomial logistic regression to examine this association is the analysis of the Southeastern clinic-based sample of low-income young women, which found no association between frequency of sexual activity and method-specific use (Wilson & Koo, 2008). As previously discussed, however, serious issues of selection bias limit the generalizability of findings from this study.

2.2.3 Sexual activity and contraceptive discontinuation or inconsistent use

Among women who use a contraceptive method, infrequent sexual activity may lead to increased likelihood of discontinuing a method, either in the long term, or temporarily—resulting in inconsistent use. In several studies, women have acknowledged recent changes in sexual activity as a reason for switching or discontinuing a method (Huber et al., 2006; Jaccard et al., 1995; Rosenberg & Waugh, 1998). Two studies have also shown a quantitative association between less frequent sexual activity and discontinuing the pill and condoms (Huber et al., 2006; Sanders, Graham, Bass, & Bancroft, 2001). Analyses of multiple national samples have shown that infrequent sexual activity is associated with greater risk of inconsistent contraceptive use (Frost et al., 2007a; Wu et al., 2008). As with overall measures of contraceptive use, the association between sexual activity and inconsistent contraceptive use is almost certainly greater for coitally dependent and shorter acting methods than for longer

acting methods.

Frost and colleagues' analysis of Guttmacher's national survey provides more methodologically compelling evidence about a possible null association between sexual activity and inconsistent pill and condom use (Frost & Darroch, 2008). Their analyses found no association between average frequency of sexual activity over the past three months and inconsistent pill use or inconsistent condom use; defined as less than perfect condom use or less than perfect pill use over the past three months respectively (Frost & Darroch, 2008). This null finding raises the question of the importance of temporality in this association. While long-term patterns in sexual activity may influence method choice, short-term patterns may be more salient to consistency of method use. The influence of one week of sexual activity on a change in contraceptive behavior in the following week may be hidden when these measures are averaged over the course of months or years.

2.3 Individual Characteristics Associated with Sexual Activity and Contraceptive Use

It is possible that an association between sexual activity and contraceptive outcomes may not be a direct association. There are several individual characteristics that should be considered, as they may be associated with both frequency of sexual activity and contraceptive outcomes and thus confound the association between the two. These potential confounders of the main association between sexual activity and contraceptive use and generally fall into two categories: sociodemographic characteristics and sexual and reproductive health history.

2.3.1 Sociodemographic Characteristics

Contraceptive behaviors vary by age, and also by educational attainment, with more educated women experiencing generally greater contraceptive use (Frost et al., 2007a; Wu et al., 2008), although women who are highly educated may be somewhat less likely to use contraception (Mosher, Jones, & Abma, 2015). In terms of economic resources, while poverty may not be directly related to contraceptive use, short-term changes in a woman's financial situation and changes in insurance coverage may make a difference (Frost et al., 2007a; R. K. Jones, Tapales, Lindberg, & Frost, 2015; Mosher et al., 2015). Contraceptive behaviors also vary by race and ethnicity (Frost et al., 2007a; Mosher et al., 2015; Wu et al., 2008).

Many of these same sociodemographic characteristics relate to patterns of sexual activity. Generally, sexual activity becomes less frequent as age increases (Call, Sprecher, & Schwartz, 1995; Kornrich, Brines, & Leupp; Westoff, 1974). Frequency of sexual activity also varies by educational attainment, with lower frequency among women with a college degree (Call et al., 1995; Gager & Yabiku, 2009; Kornrich et al.), higher frequency among those with moderate education, and less frequent sexual activity among women with the lowest levels of educational attainment (Call et al., 1995). Economic resources also appear to be associated with frequency of sexual activity. Sexual activity may be more frequent among higher income women (Kornrich et al., 2012), and more frequent among women who work more (Gager & Yabiku, 2009). Evidence for variation in frequency of sexual activity by race and ethnicity is not strong

(Call et al., 1995), although some potential differences should not be discounted (Gager & Yabiku, 2009).

2.3.2 Sexual and Reproductive Health History

Sexual and reproductive health histories have an impact on later health behaviors, including contraceptive use. Women with multiple sex partners in the past year are more likely to use contraception than women with only one partner (Frost et al., 2007a) and may be more prone to inconsistent contraceptive use (Wu et al., 2008). Contraceptive behaviors may vary by parity (Mosher & Jones, 2010; Wu et al., 2008), although issues of temporality and confounding by pregnancy intentions complicate the interpretation of these findings. Women who first have sex at a young age are also at an increased risk of not using a contraceptive method (Cavazos-Rehg et al., 2010).

There is more limited evidence that past sexual and reproductive health history may influence patterns of sexual activity. Multiple studies have shown that having an infant or young child in the household is associated with less frequent sexual activity (Call et al., 1995; Gager & Yabiku, 2009; Kornrich et al.). While there is less direct evidence in the literature for an effect of age at first sex or number of prior sex partners on patterns of sexual activity, these characteristics should be considered given their association with contraceptive outcomes.

2.4 Partnership influences on sexual activity and contraceptive use

While sexual activity and contraceptive use are often studied at the individual level, both are behaviors than involve a partner. Prior research has shown that both sexual activity and contraceptive behaviors vary between partners and depend on partner characteristics.

2.4.1 Partnership characteristics and contraceptive behaviors

Characteristics of sexual partners and relationship qualities are important to consider when examining contraceptive decision-making and contraceptive behaviors. Among adolescent and young adult women, for example, those with substantially older partners are less likely to use contraception (Darroch, Landry, & Oslak, 1999; Kusunoki & Upchurch, 2011).

Multiple dimensions of relationship qualities have been shown to be associated with choice of contraceptive method. Overall contraceptive use tends to increase over the course of relationships for young women (Manlove, Ryan, & Franzetta, 2007; Upadhyay, Raifman, & Raine-Bennett, 2016), although the dynamics of method use may be different for hormonal methods than for condoms (Manlove et al., 2011), reflecting possible shifts in HIV/STI risk perceptions versus the importance of preventing pregnancy within relationships over time. Condom use is more common among women who are in dating, non-cohabiting relationships than among married women, while use of hormonal and LARC methods is more common among married women (Frost & Darroch, 2008).

Some studies have found that couple communication is associated with more condom use (Wilson & Koo, 2008), while others find that higher relationship quality may be associated with less condom use (Katz et al., 2000; Sayegh et al., 2006). In terms of consistency of contraceptive use, one study has found that union type was not associated with consistency of pill or condom use (Frost & Darroch, 2008), although cohabiting women were at higher risk of having an at-risk gap in use compared to married women, as were women who believed their partner was not monogamous (Frost et al., 2007a). Another longitudinal study, however, found that consistent contraceptive use was greater when women were in cohabiting or dating relationship compared to marriages (R. K. Jones et al., 2015). Partners and partnerships are clearly important to consider with respect to contraceptive behaviors.

2.4.2 Partnership characteristics and sexual activity

Patterns of sexual activity are also influenced by partnerships, including specific partner characteristics as well as characteristics of relationships. Much of the research on patterns of sexual activity includes both men and women, and finds that for men too, patterns of sexual activity may vary by age, race/ethnicity, and educational attainment (Call et al., 1995; Gager & Yabiku, 2009; Kornrich et al.; Rao & Demaris, 1995). Beyond partner characteristics, certain specific qualities of relationships are also associated with frequency of sexual activity. Overall, frequency of sexual activity declines with increasing relationship duration (Rao & Demaris, 1995). Union type also appears to matter, with cohabiting couples having sex more times per week than dating couples (Wildsmith et

al., 2015), Additionally, relationship satisfaction has also been associated with frequency of sexual activity (Call et al., 1995; Gager & Yabiku, 2009; Kornrich et al.).

The clear associations among relationship characteristics, contraceptive behaviors, and frequency of sexual activity highlight the importance of considering partnerships in answering any question about sexual activity and contraceptive use. In fact, there is also direct evidence that the association between sexual activity and contraceptive use may depend on relationship characteristics. In their analysis of NSFG data, Wildsmith et al. (2015) found that for cohabiting couples, increased frequency of sex was associated with lower odds of condom use and lower odds of hormonal or long-acting method use, while for dating couples there was no association between frequency of sexual activity and method use.

2.5 Methodological and Conceptual issues

Contraceptive use is a dynamic behavior that varies over time and according to short term and long term situational influences, including sexual activity. When public health programs conceptualize risk as static, women who are classified as “low risk” may be missed, despite the likelihood that their risk profiles will change over time as the context in which they are imbedded changes. This situational aspect of maintenance of contraceptive behaviors is likely important, particularly for coital and short-acting methods like condoms and the pill. One longitudinal study of sexual health risk behaviors found that across multiple sexual health outcomes, including sex with a high risk partner, partner risk communication, alcohol use before sex, and condom use, only

25% of variance in the outcomes was between individuals, while the remaining 75% of variance was within individuals over time (Cooper, 2010). For condom use, variation within individuals over time was even greater, accounting for 81% of all variation in condom use in the sample (Cooper, 2010). While an individual's contraceptive behavior with one partner may influence contraceptive practices with a subsequent partner (Lantos, Bajos, & Moreau, 2016), the variation within partnerships and individuals over time has not been well studied. This preliminary evidence suggests that the variation in contraceptive outcomes within individuals over time may be substantial.

Studies of sexual activity and contraceptive use, however, largely rely on cross-sectional data, permitting comparison only between individuals at a moment in time. Some rich datasets, like the NSFG, collect data on contraceptive use over time through retrospective questioning. These data may be collected at the monthly level, and then aggregated and summarized across the entire past year. In one such analysis, for example, inconsistent use is defined as any use of contraception in some but not all months–a definition that classifies women who use contraception for only one week of each month of the year, for example, as completely consistent users (Wu et al., 2008). In analysis of the Guttmacher survey, inconsistent use was defined as missing any pill over the past three months, a measure that more accurately captures the importance of assessing this behavior at the level of daily action (Frost & Darroch, 2008). Still though, these analyses do not adequately capture the variation in contraceptive use over time.

Furthermore, these cross-sectional analyses of associations between sexual activity and contraceptive behaviors are unable to adequately capture the association

between time varying exposures and time varying outcomes. Frequency of sexual activity varies over time for individuals, but is necessarily static in cross-sectional analyses, measured for example according to weekly frequency over the past three months (Frost & Darroch, 2008) or number of months sexually active over the past year (Wu et al., 2008). There is evidence that sexual behaviors are sensitive to other daily and weekly events and behaviors in a person's life. A recent study partitioned the effect of alcohol use on sexual activity into associations between individuals, within individuals between weeks, and within weeks, finding an independent association at each of these levels (Weir & Latkin, 2015). Furthermore, there was greater variation in sexual behaviors over time for individuals than there was variation between individuals in average measures of sexual behavior (Weir & Latkin, 2015).

2.6 Conceptual Framework

In order to understand the influence of sexual activity on contraceptive behaviors a conceptual framework was derived (Figure 2.1) that draws on Bongaarts' (1978) proximate determinants model, Miller's (2004) Traits-Desires-Intentions-Behaviors framework, as well as multiple theories of health behavior. The proposed research question is primarily important because of the role of contraceptive behaviors in preventing unintended pregnancy, which is included in the conceptual framework but not directly assessed in the proposed research.

Bongaarts' proximate determinants model describes the most influential contributors to population-level fertility. The four proximate determinants of fertility

included in the model are marriage, contraceptive use, abortion, and postpartum infecundability due to breastfeeding or abstinence (Bongaarts, 1982). The original model, proposed more than 30 years ago, may not adequately consider current fertility-related behaviors, particularly for adolescents and young adults. Use of the proportion of currently married women as a measure of exposure to sexual activity fails to take into account social shifts whereby sexual activity and childbearing outside of the context of marriage has become normative. Furthermore, the initial model does not consider the potential variation in sexual activity over time and across populations nor the potential correlation between frequency of sexual activity and contraceptive use as it relates to method selection and continuation. This correlation may lead to inaccurate estimates of the influence of contraceptive use on the total fertility rate when fecundity is assumed to be constant for all levels of contraceptive use. The updates to the proximate determinants model acknowledge and address this issue by introducing a fecundity adjustment factor, accounting for the differential prevalence of contraceptive use by fecundity (Bongaarts, 2015). A thorough exploration of patterns of sexual activity over time and their relation to contraceptive behaviors provides a complimentary perspective to the model.

The potential influence of patterns of sexual activity on contraceptive behaviors may be due to a woman's perceived risk or perceived susceptibility to unintended pregnancy. Multiple theories of health behavior underscore the importance of perceived risk or perceived susceptibility to a health outcome as a construct that shapes health behaviors (Brewer & Rimer, 2008). While weekly data on perceived risk of

unintended pregnancy are not available for the present study, the assumption is that infrequent sexual activity will lead to lower perceived risk. This conceptual framework focuses specifically on the prevention of unintended fertility, and thus on times when women are not intending to become pregnant. Although the reality is that pregnancy intentions are complex and multidimensional (Santelli, Lindberg, Orr, Finer, & Speizer, 2009), multiple studies have found robust longitudinal associations between pregnancy intentions, contraceptive behaviors and subsequent pregnancies (Moreau, Hall, Trussell, & Barber, 2013; Rocca, Hubbard, Johnson-Hanks, Padian, & Minnis, 2010).

An additional complexity to proposing a theoretical basis for contraceptive behavior is the distinction between initiating a new health behavior, which is the focus of many health behavior theories, and maintaining an existing health behavior. Several of the widely used theories of health behavior focus primarily on initiation of health behaviors. While some theories consider maintenance of health behaviors, they largely do not disentangle potential differences in how specific constructs influence initiation versus maintenance. Rothman (2000) has suggested that many of these theories are insufficient for understanding the differences between initiation and maintenance of health behaviors and has proposed that differentials in initiation and continuation of different types of health behaviors depend in part on favorable expectations prior to initiation and perceived satisfaction with outcomes after initiation. Perceived risk of pregnancy may also influence initiation and continuation of contraceptive behaviors in different ways.

While frequency of sexual activity may influence both contraceptive initiation

and continuation via perceived risk of unintended pregnancy, the association may vary in magnitude and by specific contraceptive method. A woman may initiate use of a contraceptive method based on her perceived risk of unintended pregnancy according to her recent frequency of sexual activity. These effects may depend primarily on the perceived effectiveness of a method relative to perceived pregnancy risk due to recent sexual activity. Once using a contraceptive method, she may then decide to continue or discontinue use also based on recent frequency of sexual activity. Discontinuation may be less sensitive to changes in sexual activity if the effort required to continue using a method is small. To understand the dynamics of contraceptive use over time specific method use, discontinuation, and selection of new methods must all be considered.

An additional limitation of applying many health behavior theories to contraceptive use is that most do not take into account the important role of the sexual partner and characteristics of relationships (Lin & Hingson, 1974). Miller and colleagues have proposed a couple-level Traits-Desires-Intentions-Behavior (TDIB) framework that elaborates on the role of partner in fertility-related decision-making (Miller et al., 2004). While some of the constructs elaborated in the couple-level TDIB framework are beyond the scope of the measures available for the present study, the framework provides insight into why it is important to consider the context of a specific partnership. This framework suggests that an individual's fertility desires both *influence* and *are influenced by* a partner's fertility desires. These fertility desires and perceptions of a partner's fertility desires in turn shape intentions and behaviors (Miller et al., 2004).

Bringing together these models and theories (Figure 2.1), the main association of

interest in this study will be between frequency of sexual activity and contraceptive behaviors when women are intending to prevent pregnancy, recognizing that both of these behaviors are dynamic and change over time. Reflecting the life course perspective (Elder et al., 2003), contraceptive behaviors evolve and change over the course of individual life trajectories. This perspective underscores the importance of relying not solely on static measures of contraceptive use, but extending analysis of dynamic measures including selection and initiation of a new contraceptive method and contraceptive continuation over time. The important influence of the dynamic contexts in which lives are led is also underscored, as is the importance of the linked life trajectories of sexual partners (Elder et al., 2003). Individual characteristics and partnership characteristics that may confound the association between sexual activity and contraceptive behaviors are therefore also examined.

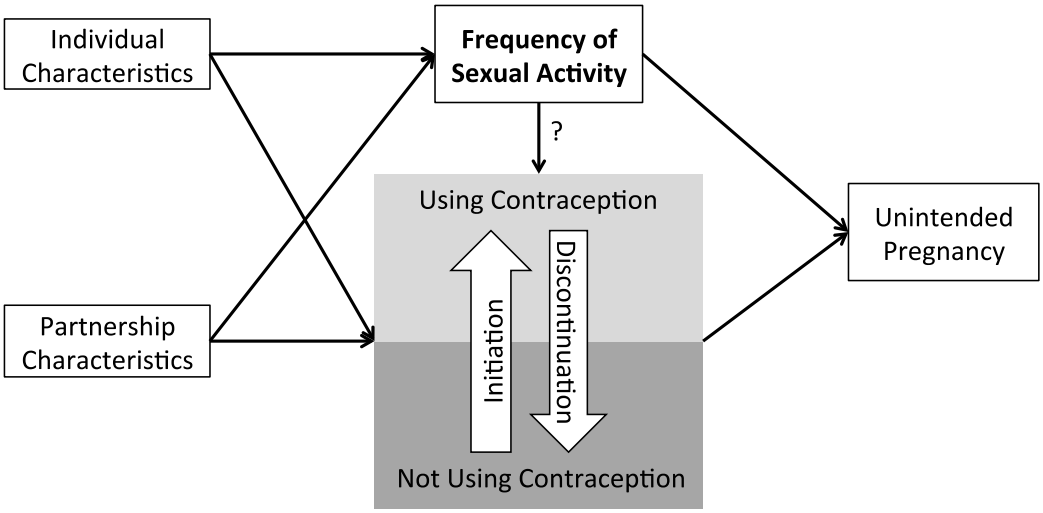

Figure 2.1. Conceptual framework showing the proposed association between frequency of sexual activity and contraceptive behaviors, including initiation and discontinuation, when women are intending to prevent pregnancy. The contribution of both sexual activity and contraceptive use to unintended fertility is illustrated as well as potential confounding by individual and partner characteristics.

2.7 Aims and Hypotheses

Aim 1: Assess the weekly association between sexual activity and contraceptive behaviors over time.

Hypothesis 1.1: increased sexual activity will be associated with greater use of more effective contraceptive methods.

Aim 2: Evaluate the influence of sexual activity on subsequent discontinuation of a contraceptive method.

Hypothesis 2.1: Less frequent sexual activity in the past month will be associated with increased subsequent discontinuation of effective contraceptive method use.

Hypothesis 2.2: The association between frequency of sexual activity and contraceptive discontinuation will vary by characteristics of specific methods, with a greater effect among shorter acting methods and a smaller effect among longer acting methods.

Aim 3: Evaluate the association between specific method selection and patterns of sexual activity leading up to selection of a new contraceptive method.

Hypothesis 2.1: More frequent recent sexual activity will be associated with subsequent selection of more effective methods when women switch or start a new method.

3 Methods

3.1 The Relationship Dynamics and Social Life Study

The Relationship Dynamics and Social Life (RDSL) study is a longitudinal study that began in 2009 with the broad goal of assessing the dynamics of unintended pregnancy through frequent measurement of pregnancy attitudes and intentions, contraceptive use, and relationship characteristics (Barber, Kusunoki, & Gatny, 2015). The National Institute of Child Health and Human Development and the National Institute on Drug Abuse provided funding support for the RDSL.

3.1.1 Sampling and procedures

The RDSL consists of a randomly selected population-based sample of women ages 18-19 at baseline living in a county in Michigan. The county was selected based on its racial diversity as well as socioeconomic diversity. Women were sampled using the Michigan Department of State driver's license and Personal Identification Card database, which corresponded closely to census-based population projects with 96% agreement (Barber, Kusunoki, & Gatny, 2011). The initial baseline survey was completed in 2008 and 2009 through an interviewer-administered in-person survey with 1,003 participants, with an 83% response rate (Figure 3.1). The baseline survey lasted approximately one hour and assessed participant sociodemographic characteristics, relationship experiences, and sexual and reproductive health history.

Of the initial baseline sample, 95% of women participated in weekly follow-up

surveys administered over the phone or online over the course of the subsequent two and a half years. The majority (~92%) of participants completed this weekly journal instrument online, while the remaining participants called in to complete the survey over the phone. Participants were compensated with $1 per weekly journal completed, and with $5 bonuses for completion of five consecutive journals. High retention rates were achieved at six months (84%), one year (79%) and 18 months of follow up (75%). High retention was accomplished using automatic text message or email reminders to complete journals, as well as phone, email or mail contact from the study team if journals were not completed on time.

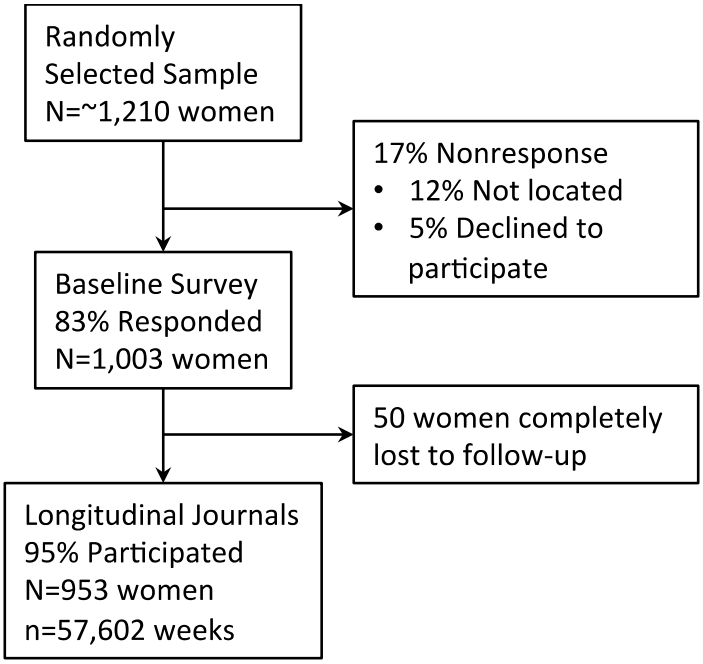

Figure 3.1. Flow diagram showing recruitment and participation for the RDSL.

The journal instrument was kept as short as possible to minimize the burden of weekly completion. Participants were asked weekly about sexual activity, pregnancy

intentions, contraceptive use, and pregnancy. Other questions were asked only when applicable. For example, if a participant reported a new sexual partner, a series of questions was asked about that new partner. Additional interview modules were administered quarterly, but were not used for these analyses. Greater detail about the implementation of the study has been published elsewhere (Barber et al., 2011).

3.1.2 Data structure and analytic samples

The longitudinal dataset includes 953 women who completed a total of 57,602 weekly surveys on contraceptive use and partnership characteristics. Longitudinal data collection continued over the course of two and a half years (~130 weeks), with 75% of women participating for at least 18 months and 65% participating for the whole 2.5 year duration.

Based on information about the primary partner, weeks with the same partner can be identified and grouped within the dataset, providing the basis for a three-level dataset with individual, partnership, and week levels. This structure is illustrated in Figure 3.2. While women occasionally report sex with multiple partners in the same week (2% of weeks), data are analyzed according to their primary partner, as detailed information is collected only for one partner.

Because the focus of these analyses is unintended pregnancy, for all aims the analyses were limited to time when women had a partner and clearly wished to avoid pregnancy. Risk of unintended pregnancy is dynamic, so for any specific woman in the sample, some weeks may be excluded if her pregnancy intentions changed or if she no

longer reported having a partner.

For Aim 1 analyses, assessing weekly contraceptive use, weeks were excluded if women indicated that they did not have a partner (n=22,078), pregnancy was reported (n=2,602), pregnancy intentions were not strongly anticonception (n=2,987) or were missing (n=812). In Aim 1, sexually inactive weeks were included in the analysis if women were otherwise considered to be at risk of unintended pregnancy (i.e. with a partner, not pregnant, and not intending to become pregnant). This poses difficulties in assigning coital contraceptive use to sexually inactive weeks, which is discussed subsequently in the measures sections. In brief, however, because information about coital contraceptive use in the last sexually active week was carried forward into subsequent sexually inactive weeks, weeks in the study prior to the first report of sexual activity (including weeks reported by women who were never sexually active) were excluded (n=5,593). The total analytic sample for Aim 1 included a total of 737 women and 24,533 weeks of data. Weeks with missing data on sexual activity or contraceptive use (n=69) were excluded from the analysis.

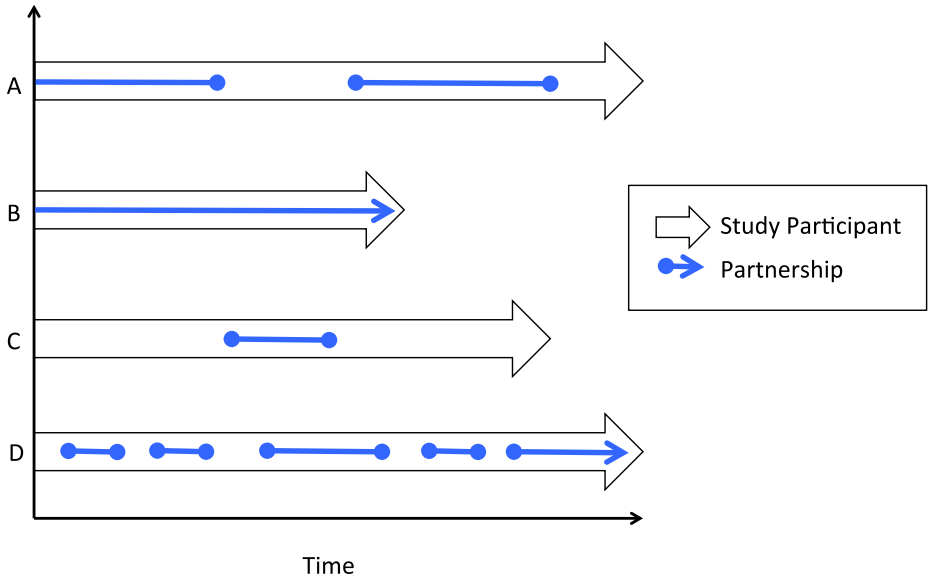

Figure 3.2. Schematic of RDSL data structure showing four participants' data. Each participant is represented by a thick black-outlined arrow. She is enrolled at baseline (time=0) and followed until lost to follow up or until the end of the study. She reports data on her primary partnerships (shown in blue). A participant may report on a single partnership that lasts the duration of the study (B), a single partnership that begins and ends during the study (C), or on multiple partnerships (A & D) over the course of the study.

Aims 2 and 3 are limited to sexually active weeks. For Aim 2, in which the association between recent sexual activity in the past month and method discontinuation is assessed, weeks that do not have enough available data on past month sexual activity are dropped. Specifically, weeks without at least two previous weeks of sexual activity data in the past 60 days were dropped. This resulted in dropping 9.9% (n=1,575 weeks) from the sample. More restrictive definitions were tested, requiring at least three and four weeks of data in the past 60 days, and resulted in 14% and 19% of weeks dropped. The more flexible strategy, allowing only two weeks of data, was taken to allow for late and missing survey responses. Thus, the sample is restricted to sexually active weeks with at least two recent prior weeks of sexual activity data in

the past 60 days, resulting in an analytic sample of 664 women and 14,300 weeks.

Aim 3, which assesses selection of new contraceptive methods, focuses only on the sexually active weeks where a new method is reported that is different from the method reported in the most recent sexually active week, resulting in an analytic sample of 439 women and 1,941 sexually active weeks with new methods.

3.2 Measures

3.2.1 Outcomes

Three core contraceptive use measures are examined as dependent variables to capture the various dimensions of contraceptive behavior. Data on contraceptive use were collected as part of the weekly journal instrument. Women were asked about use of non-coital methods in all weeks and about coital methods only in sexually active weeks.

Weekly use of specific types of contraceptive methods (categorical). Weekly specific contraceptive method use was assessed since the prior completed weekly journal instrument. For these analyses, weeks are classified into four categories of specific types of method use. If women reported using multiple types of methods in a given week, those weeks were classified according to the most effective method that was reported. Highly effective methods include reported use of the injectable, implant, IUD, or male or female sterilization. The injectable was included in this category for two reasons. First, the effort required to continue use is low, as an injection is required only every three months, compared to the daily effort required taking the pill. Second, the

frequency of implant and IUD use was too low for these methods to be considered alone in a category. The second category, referred to as pill, includes the pill as well as the similarly effective patch and the ring. The third category includes condoms. The fourth category, the least effective methods, includes all other less effective methods, such as withdrawal, as well as no method. For primary analyses, there were too few weeks of no method use to be considered as a separate fifth category. No method weeks were excluded for sensitivity analyses.

As previously described, in Aim 1 sexually inactive weeks are included in the analysis, so weekly use of condoms was carried forward into sexually inactive weeks. In traditional cross-sectional surveys women are often asked about what method they are currently using. We make the assumption that for condom users not sexually active in the current week, they would respond according to whether they used condoms the last time they were sexually active. In the RDSL women were not specifically asked about current condom use if they were not sexually active in a specific week, so we use this assumption and carry forward condom use information from the last prior sexually active week. Specifically, for primary analyses if women did not indicate using a non-coital method in a sexually inactive week following a sexually active condom use week, that week was classified as a sexually inactive week of condom use. This approach makes the assumption that if a woman had been asked about the method she is currently using in these weeks, she would indicate condoms because it is the method that she would use if she had sex. We conduct several sensitivity analyses for this assumption for imputed sexually inactive condom use weeks that are followed by a

switch to a new method. In one scenario we carry forward condom use only half way to the method switch. In another scenario we do not carry forward condom use at all before a method switch.

Weekly contraceptive discontinuation (dichotomous). In Aim 2, weekly contraceptive method discontinuation is analyzed. Weekly discontinuation is defined as a sexually active week in which a woman reports using a different type of contraceptive method, according to the four-category typology described above, than in the prior reported sexually active week.

New method selection (categorical) For Aim 3, selection of new methods of contraception is analyzed. This outcome is categorical and uses the same four category typology as weekly method use. New method selection is assessed only in weeks where discontinuation occurs, as defined in Aim 2. To account for discontinuations where women switched from dual method use (i.e. condoms and the pill or a highly effective method) to using condom only, these types of switches were excluded from the new method selection analysis. Specifically, new method weeks where women started using condoms were excluded from the analysis if condom use was reported in each of the prior two weeks in addition to a more effective method. The second prior week was taken into account because women reporting condoms and a more effective method just in the first prior week were likely switchers in that week rather than true dual method users.

3.2.2 Key independent variables

Sexual activity (dichotomous). The primary independent variables are based on weekly sexual activity. Weekly sexual activity (assessed dichotomously) is analyzed using data collected in weekly journal instruments. For Aim 1, the primary independent variable is dichotomous weekly sexual activity. For Aims 2 and 3, a summary measure of recent past month sexual activity is constructed. Past month sexual activity is calculated as the proportion of sexually active weeks prior to weeks of observation with at least two and up to four prior weekly survey responses within the past 60 days. This flexible definition was crafted to account for late and missed survey responses. For regression models, this past month measure of sexual activity is scaled by a factor of four so that estimates approximate the effect of an additional week of sexual activity in the past month.

To examine between-partnerships and between-individuals effects of sexual activity, the overall proportion of weeks sexually active is calculated for each partnership and for each individual woman across all weekly observations. Including these summary measures of sexual activity in models permits assessment of the effect of weekly sexual activity on contraceptive use, independently of the effect of the overall level of sexual activity within the partnership and for the individual woman. These summary measures of sexual activity are scaled by a factor of ten in regression models so that results reflect the effect of a 10% increase in the overall proportion of sexually active weeks for a partnership or for an individual woman. This separation of individual-level and partnership-level effects is described in greater detail in the Analysis section.

3.2.3 Individual and partner-level confounders

Additional individual and partner-level confounders that may relate to both contraceptive use and sexual activity are explored. While time invariant confounders measured at the woman or partnership level will not confound the short term associations (week-level), they are important to consider as they may confound the partnership-level and woman-level effects of sexual activity on contraceptive behaviors. The association between each potential confounder and the contraceptive outcome of interest is assessed in bivariate analyses appropriate to the outcome. If time-varying confounders, such as partnership characteristics, were not associated overall with weekly contraceptive use or weekly sexual activity, we then assessed effects at the partnership level and woman level. This decomposition strategy is described in greater detail for the main predictor, sexual activity, subsequently. Age was included in all adjusted models. Additional candidate confounders were included as a confounder in respective full adjusted models for each aim if identified as associated with the contraceptive outcome as well as the measure of sexual activity at any level for each aim. Variable types, data sources, and variation over time are summarized in Table 3.1.

3.2.3.1 Individual-level variables

3.2.3.1.1 Sociodemographic characteristics

A series of individual sociodemographic variables are known to relate to contraceptive use and may also relate to sexual activity. These variables include age, education, race/ethnicity, religion, and public assistance. In this sample, each of these

characteristics is measured at baseline and, aside from age and public assistance, is analyzed as a time-invariant variable. In other words, each of these characteristics is measured once at baseline and that value is carried forward to each week of longitudinal data.

Age is continuous and measured in years. In order to be eligible for the study, participants had to be 18 or 19 years of age at enrollment.

Table 3.1. Summary of variable types and data sources for study measures.

Variable	Type	Instrument	Varies within individuals / partnerships
Outcome			
Contraceptive Use	Dichotomous	Journal	Varies/varies
Key Exposure			
Sexual Activity	Dichotomous	Journal	Varies/varies
Individual Characteristics			
Sociodemographics			
Age	Continuous	Baseline	Varies/varies
Race/Ethnicity	Categorical	Baseline	Fixed/fixed
HS GPA	Continuous	Baseline	Fixed/fixed
Post-HS Enrollment	Dichotomous	Baseline	Fixed/fixed
Religiosity	Dichotomous	Baseline	Fixed/fixed
Public Assistance	Dichotomous	Baseline	Varies/varies
SRH History			
Age at First Sex	Dichotomous	Baseline	Fixed/fixed
Multiple Prior Sex Partners	Dichotomous	Baseline & Journal	Fixed/fixed
Any Pregnancies	Dichotomous	Baseline & Journal	Fixed/fixed
Partnership Characteristics			
Relationship Characteristics			
Relationship Type	Categorical	Journal	Varies/varies
Relationship Stability	Categorical	Journal	Varies/varies
Relationship Duration	Continuous	Journal	Varies/varies
Pregnancy with current partner	Dichotomous	Journal	Varies/varies
Partner Characteristics			
Partner age difference	Dichotomous	Journal	Varies/fixed
Partner Race/Ethnicity	Dichotomous	Journal	Varies/fixed
Partner Education	Dichotomous	Journal	Varies/fixed
Partner fertility intentions	Categorical	Journal	Varies/varies

Education is analyzed using two variables that capture educational achievement. The first is a continuous measure of high school grade point average (GPA). An additional dichotomous indicator of educational attainment is post-secondary school enrollment at baseline.

Race/ethnicity is analyzed as a single categorical variable and compares participants who identify as of Hispanic origin, African American, white, multiple races or ethnicities and other races or ethnicities. For some analyses women who are African American are compared to all other women, because of small numbers of women who identify as Hispanic or in other groups.

Religiosity is analyzed dichotomously based on responses to a question about how important religion is to the participant, comparing those who find religion more important than anything else or very important to those who find religion somewhat important or not important.

Public assistance is used as a measure of economic disadvantage. A dichotomous variable at baseline indicates whether the participant reported receiving any public assistance from WIC, the Family Independence Program, cash welfare, or food stamps. This variable is updated longitudinally if a woman indicated no public assistance at baseline, and then later reported receiving public assistance.

3.2.3.1.2 Sexual and reproductive health history

Additional individual-level variables relating to sexual and reproductive health history that are assessed include age at first sex, number of prior sexual partners, and

past pregnancies. *Age at first sex* was assessed dichotomously at baseline and compares participants who reported that they had sex for the first time before age sixteen to those who had not yet had sex by age sixteen. *Multiple prior sex partners* and *prior pregnancies* are assessed dichotomously at baseline. These variables describe women's early sexual experiences. Prospective experiences with new partners and new pregnancies are captured in partnership-level variables.

3.2.3.2 Partnership-level variables

Several partnership-level variables are associated with contraceptive use and may also relate to sexual activity. These variables include partner's sociodemographic characteristics as well as measures of relationship commitment and stability. Data for these variables are collected in the journal instrument when a new partner is indicated, as well as in the baseline survey for partners at baseline.

Partner age differential is assessed using a dichotomous variable for the age differential between the participant and her partner, with partners more than three years older considered to have an age difference. *Partner education* is assessed with a dichotomous variable, comparing partners with a greater level of education than participant to those who do not have more education. *Partner has prior children* is also examined dichotomously, comparing partners with children from prior relationships (not with participant) to those without prior children. *Perceived partner pregnancy intentions* is a categorical variable constructed based on weekly responses to questions about women's perception of their partners' pregnancy avoidance and pregnancy

desire, with those expressing unambiguously not wanting a pregnancy to all others.

Information about relationship characteristics drew on previous work of the RDSL. *Relationship type* is a time-varying composite measure that includes information on time spent together, commitment, cohabitation, engagement, and marriage. This six category variable has the following classification: casual (no commitment, low time intensity); non-exclusive dating (no commitment, high time intensity); long distance (high commitment, high time intensity); exclusive dating (high commitment, high time intensity); cohabiting; and married or engaged. (Kusunoki, 2014) In some analyses the casual and non-exclusive dating categories are collapsed because of small cell sizes. *Relationship instability* is a dichotomous variable that captures any prior partnership break-ups with the current partner. Relationship stability can vary over time for individuals and over the course of partnerships. *Relationship duration* is measured continuously in weeks and is modeled using a spline term at one year based on exploratory analyses. *Prior pregnancies with current partner* is the final relationship characteristic that is assessed. This variable can change over the course of a partnership if the participant experiences a new pregnancy.

3.3 Analysis

3.3.1 Aim 1

The first aim explores the association between weekly sexual activity and specific contraceptive method type through the estimation of marginal three-level multinomial models that take into account clustering of weekly data within partnerships and

clustering of partnerships within individual women. The complex correlation structure is accounted for by estimating bootstrapped bias corrected and accelerated (BCa) confidence intervals (Carpenter & Bithell, 2000) with resampling at the level of the individual woman, so that all partnerships and weeks of data within a selected woman were resampled together in blocks. We preserved all partnerships and weeks for individual women during resampling and estimated each model with 1,000 bootstrap replications.

To estimate independent effects of sexual activity on the outcome for this aim and each subsequent aim at each level, we centered weekly sexual activity on each partnership's overall proportion of sexually active weeks, and each partnership's proportion of sexually active weeks on women's overall proportion of sexually active weeks. These centered variables are calculated by subtracting, for example, the overall proportion of weeks sexually active in a specific partnership from the dichotomous measure of weekly sexual activity, or by subtracting the woman-level proportion of weeks sexually active from the partnership-level proportion of weeks sexually active. This decomposition of effects at different levels, week-level, partnership-level, and woman-level is an approach that has been taken for other similar analyses (Begg & Parides, 2003; Harvey, Washburn, Oakley, Warren, & Sanchez, 2016; Weir & Latkin, 2015):

$$Log\left(\frac{\Pr[Y_{ijk}=k]}{\Pr[Y_{ijk}=K]}\right) = \beta_0 + \beta_1\left(x_{ijk} - \overline{x_{ij\cdot}}\right) + \beta_2\left(\overline{x_{ij\cdot}} - \overline{x_{i\cdot\cdot}}\right) + \beta_3\left(\overline{x_{i\cdot\cdot}}\right) + \beta_4 confounders$$

In this multinomial logistic regression equation, the log of the relative risk ratio for use of method *k* (e.g. condoms, pills, or highly effective methods) relative to the comparison method *K* (e.g. least effective methods) is modeled for woman *i* in partnership *j* and in week *k.* In this equation x_{ijk} is the dichotomous weekly sexual activity variable for woman *i* in partnership *j* and in week *k* and $x_{ijk} - \overline{x_{ij\cdot}}$ is the weekly measure of sexual activity centered on the partnership-level measure of sexual activity $\overline{x_{ij\cdot}}$. The partnership-level measure of sexual activity centered on woman-level sexual activity is $\overline{x_{ij\cdot}} - \overline{x_{i\cdot\cdot}}$ where $\overline{x_{i\cdot\cdot}}$ is the measure of overall woman-level proportion of weeks sexually active.

For each multinomial model, the least effective methods (including no method) were used as the base category for the models reported in tables. Postestimation Wald tests were used to assess for the overall significance of the effect of sexual activity within each level (weekly, partnership, individual) across all of the specific methods. In text, we report effects sizes with alternate base method categories where useful for interpretation of the findings, for example the relative increase in risk of using the pill relative to using the condom with respect to sexual activity. For this aim and each subsequent aim, we compare the short-term effect of sexual activity to the partnership-level effect of sexual activity and woman-level effect of sexual activity using postestimation Wald tests. These comparisons indicate whether the independent effects of sexual activity on contraceptive behavior at a given level is significantly different than the effect at the other levels. For example, one such test for a multinomial model would test the null hypothesis that for use of condoms relative to

use of least effective methods, the effects of week-level sexual activity, partnership-level sexual activity, and woman-level sexual activity are all equivalent. A significant *p*-value for this comparison would indicate that at least one of these effects differs from the rest of the effects. Subsequent pairwise test are used to identify which effects differ.

3.3.2 Aim 2

The analysis for the second aim, in which we assess the association between recent sexual activity and method discontinuation, follows the analytic strategy for the first aim. In this case, the outcome is a dichotomous measure of whether a woman discontinued a contraceptive method or not, such that the models are less complex than for the multinomial outcome. Mixed effects logistic models are estimated with random intercepts for both individual women and partnerships within women. While in Aim 1 we estimated marginal models because of the complexity of the three-level multinomial model, the random effects model for the logistic regression models in Aim 2 is not overly complex. As in Aim 1, woman-level and partnership-level effects are decomposed from the weekly effects, and the relative magnitudes of these effects are compared using postestimation Wald tests.

$$
\begin{aligned}
LogOdds\left(Y_{ijk}=1\middle|\beta_{0ij},X_{ijk},\overline{X_{\imath J\cdot}},\overline{X_{\imath\cdot\cdot}}\right) \\
&= \left(\beta_0+b_{0ij}+b_{0i}\right)+\beta_w\left(x_{ijk}-\overline{x_{\imath J\cdot}}\right)+\beta_{bp}\left(\overline{x_{\imath\cdot}}-\overline{x_{\imath J\cdot}}\right)+\beta_{bs}\left(\overline{x_{\imath\cdot}}\right) \\
&+\beta_1 confounders_{ijk}
\end{aligned}
$$

$$
\begin{aligned}
b_{0ij}&\sim N(0,{\tau_s}^2) \\
b_{0i}&\sim N(0,{\tau_p}^2)
\end{aligned}
$$

For this equation, x_{ijk} is a measure of the proportion of sexually active weeks in the past month, and the partnership- and woman-level measure of sexual activity are the same as in Aim 1. This model also includes random intercepts for weeks within specific partnerships , b_{0ij}, as well as random intercepts for partnerships within women, b_{0i}, each of which are normally distributed with means of zero. These random intercepts allow, for example, each partnership to have an average log odds of contraceptive use that differs from the woman's overall average log odds of contraceptive use. The random intercept for a specific woman allows her to have an overall average log odds of contraceptive use that diverges from the population average log odds. The normal distribution of the random intercepts at each level results in an exchangeable correlation structure, whereby weeks within a given partnership have a certain single correlation with each other.

3.3.3 Aim 3

The analysis for Aim 3, assessing new method selection, is analogous to the analysis for Aim 1. As in Aim 1, because of the complexity of the three-level multinomial model, we estimate marginal multinomial regression models with bootstrapped BCa confidence intervals to take into account the complex correlation structure of the data. This approach gives reasonably accurate estimates of the standard errors of the regression coefficients while avoiding the computational complexity of estimate two levels of random intercepts for each outcome category (for a 4 category outcome).

3.4 Ethical Considerations

The original study received ethical approval from the University of Michigan Institutional Review Board and by the National Institutes of Health. Johns Hopkins Bloomberg School of Public Health IRB exempted this secondary analysis from full review. The analytic dataset used for this secondary analysis was completely de-identified. Personal identifiers were not included in the dataset provided by the Population Studies Center at the University of Michigan (UM-PSC). The data was stored at all times on a secure server at the UM-PSC and accessed remotely for analysis.

4 Aim 1: Sexual Activity and Weekly Contraceptive Use in Young Adult Women

4.1 Background

Infrequent sexual activity is one of the main reasons that women who are at risk of unintended pregnancy cite for not using contraception (Frost et al., 2007b; Mosher et al., 2012). While the association between more frequent sexual activity and increased use of contraception has been substantiated in national cross-sectional surveys (Frost et al., 2007a; Wu et al., 2008), not all studies have consistently found this association (Wilson & Koo, 2008). Although many studies assess contraceptive broadly using a dichotomous measures (Frost et al., 2007a; Wu et al., 2008), prior research that has accounted for method selection found that more frequent sexual activity is associated with use of more effective methods (Frost & Darroch, 2008; Kusunoki & Upchurch, 2011; Wildsmith et al., 2015), though here too, not all studies agree (Wilson & Koo, 2008). Interpretation and comparison of these studies can be difficult, as the measures vary widely, particularly with respect to the amount of time over which measures of sexual activity and contraceptive use are summarized. Measures used in prior research often summarize behaviors over the course of many months rather than looking for short-term associations over the course of days or weeks, a timescale in which women likely make short-term and medium-term contraceptive decisions.

Numerous individual characteristics are known to relate to contraceptive use, and may confound the relationship between sexual activity and contraceptive use. Contraceptive behaviors vary by age and by educational attainment (Frost et al., 2007a;

Wu et al., 2008). In terms of socioeconomic status, while poverty may not be directly related to contraceptive use, insurance coverage does make a difference (Frost et al., 2007a), and contraceptive behaviors also vary by race and ethnicity (Frost et al., 2007a; Wu et al., 2008). Many of these same sociodemographic characteristics also relate to patterns of sexual activity, raising the potential for confounding of the association between sexual activity and contraceptive use. Generally, sexual activity becomes less frequent as age increases (Call et al., 1995; Kornrich et al.; Westoff, 1974) and also varies by educational attainment (Call et al., 1995; Gager & Yabiku, 2009; Kornrich et al.). Economic resources also appear to be associated with sexual activity which may be more frequent among higher income women (Kornrich et al.) and among women who work more (Gager & Yabiku, 2009).

Characteristics of relationships and partners are also important to consider as potential influences on both contraceptive behaviors and sexual activity. Among adolescent and young adult women, for example, those with substantially older partners are less likely to use contraception (Darroch et al., 1999; Kusunoki & Upchurch, 2011). Overall contraceptive use tends to increase over the course of relationships for young women (Manlove et al., 2007), although the dynamics of method use may be different for hormonal methods than for condoms (Manlove et al., 2011), reflecting possible shifts in HIV/STI risk perceptions versus the importance of preventing pregnancy within relationships over time. The specific methods used vary across different types of relationships, for example, with condom use more common among women who are in dating, non-cohabiting relationships than among married women

(Frost & Darroch, 2008). Patterns of sexual activity are also influenced by partnerships, including specific partner characteristic, such as age and educational attainment (Call et al., 1995; Rao & Demaris, 1995) as well as characteristics of relationships. Union type also matters, with cohabiting couples having sex more times per week than dating couples (Wildsmith et al., 2015), while frequency of sexual activity declines with increasing relationship duration (Rao & Demaris, 1995). The clear associations among relationship characteristics, contraceptive outcomes, and frequency of sexual activity highlight the importance of considering partnerships in answering any question about sexual activity and contraceptive use.

The first objectives of this chapter are to describe variation in sexual activity and contraceptive use within individuals and within partnerships over time, and to examine weekly associations between sexual activity and those contraceptive behaviors. According to multiple theories of health behavior, perceived risk or perceived susceptibility to a health outcome is important in shaping health behaviors (Brewer & Rimer, 2008). A woman may therefore adjust her contraceptive behavior according to her level of sexual activity because of a change in perceived risk of unintended pregnancy. It is expected in this analysis that increased weekly sexual activity will be associated with use of more effective and longer acting methods.

The second objective of this study is to compare the associations between contraceptive use and sexual activity over different timeframes, accounting for the short term and long term dynamics of sexual activity. Specifically, we will compare the association between contraceptive use as a function of weekly sexual activity, level of

sexual activity within a partnership and overall sexual activity over the course of the study. In cross-sectional studies, each woman's behavior is summarized into single measures of sexual activity and contraceptive use. This measure is a collapsed representation of a dynamic behavior that varies over time for individuals. This approach assumes that the inference obtained from associating women's overall levels of sexual activity with overall levels of contraceptive use corresponds to the association that occurs dynamically over time (at the weekly and partnership levels) for individual women. In reality, however, the independent associations between sexual activity and contraceptive behavior at different levels and timescales (in the short term or long term) may not be the same. For example, there may be no effect of a woman's average sexual activity on her average contraceptive behaviors, but on a week-to-week basis these behaviors may be correlated after taking into account average sexual activity.

With longitudinal data, the dynamic week-to-week association can be assessed, but these repeated measures of behaviors can also be aggregated or averaged over longer periods of time, approximating the approach of cross-sectional studies. When these summary measures are included in models along with weekly measures of sexual activity, the within woman short term effect of sexual activity on contraceptive use can be assessed independently of the overall or average effects of sexual activity between women and between partnerships that are usually assessed in cross-sectional studies. Results from this study will provide information about the extent to which this influence on contraceptive behavior is dynamic and situational for individuals over time versus largely static and between groups of individuals.

4.2 Methods

Sample

The Relationship Dynamics and Social Life (RDSL) study is a longitudinal study with the broad goal of assessing the dynamics of unintended pregnancy through frequent measurement of pregnancy intentions, contraceptive use, and relationship characteristics. The population-based sample of women ages 18-19 at baseline was randomly selected from a racially and socioeconomically diverse single county in Michigan. Women were sampled using the Michigan Department of State driver's license and Personal Identification Card database. The initial baseline survey was completed in 2008 and 2009 through an interviewer-administered in-person survey with 1,003 participants, with an 83% response rate. The baseline survey lasted approximately one hour and assessed participant sociodemographic characteristics, relationship experiences, and sexual and reproductive history.

Of the initial baseline sample, 95% of women participated in weekly follow-up surveys administered over the phone or online over the course of the subsequent two and a half years. Participants were compensated with $1 per weekly journal completed, and with $5 bonuses for completion of five consecutive journals. High retention rates were achieved at six months (84%), one year (79%) and 18 months of follow up (75%). Participants were asked weekly about sexual activity, pregnancy intentions, contraceptive use, and pregnancy, with other questions asked only when applicable. Additional detail about the implementation of the study has been published elsewhere

(Barber et al., 2011). The original study received ethical approval from the University of Michigan Institutional Review Board and by the National Institutes of Health. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board exempted these secondary analyses from full review.

We conducted analyses of contraceptive method use for women ever sexually active in weeks where they were with a sexual partner, were not pregnant, and indicated clearly not wanting to become pregnant. Weeks were excluded if no sexual partner was reported (n=22,078), pregnancy was reported (n=2,602), pregnancy intentions were not strongly anticonception (n=2,987) or were missing (n=812), and if they were sexually inactive weeks prior to first report of sexual activity during the study (n=5,593). The analytic sample included a total of 737 women and 24,533 weeks. Weeks with missing data on sexual activity or contraceptive use (n=69) were excluded from the analysis. There were no missing data for potential confounders except for partner fertility desires, which were missing in 0.2% of weeks (40/24,533). Missing data were not imputed due to the very low frequency of missingness.

Exposure variables

Each week women were asked whether they had vaginal sexual intercourse in the prior week. The primary exposure for this analysis is a dichotomous measure of weekly sexual activity. We decomposed the information on sexual activity into three independent parts: i) the proportion of weeks sexually active among all weeks in which women had a partner during the study; ii) the proportion of weeks sexual active among

all weeks in a specific partnership; and iii) the weekly report of sexual activity. The first indicator “woman-level weeks sexually active” is used to estimate “between women” or “woman-level” effects of sexual activity. The second indicator “partnership-level weeks sexually active” is used to estimate the “between partnerships” or “partnership-level” effects of sexual activity. The third indicator “weekly sexual activity” represents the “week-level” effect of sexual activity within women and within partnerships. The measure of weekly sexual activity is centered on partnership-level sexual activity, and partnership-level sexual activity is centered on woman-level sexual activity.

Regression estimates using these centered measures give the effect of sexual activity at a specific level independent, or regardless, of the amount of sexual activity at the other levels. For example, the regression coefficient for the centered weekly sexual activity measure gives the effect of weekly sexual activity on contraceptive method use regardless of a specific partnership and a specific woman’s overall proportion of weeks sexually active. Estimating models without centering weekly sexual activity on partnership- and woman-level sexual activity could, for example give results that are indicative of an overall woman-level effect without an independent week-level effect. It could be the case that women who have sex more often overall are more likely to use pills relative to no method, but on a week-to-week basis there is no independent effect of weekly sexual activity on pill use (or an independent effect of a different magnitude). If we were to use an uncentered measure of weekly sexual activity, a significant finding could be the result of a significant effect at any specific level, but is not necessarily indicative of the specific independent week-level effect. This approach has been

recommended and described in detail in the statistical literature (Begg & Parides, 2003), and has been applied to analyses of other sexual health behaviors (Harvey et al., 2016; Weir & Latkin, 2015).

Outcome variable

Contraceptive use was ascertained every week by asking women if they used anything to prevent pregnancy. Those who answered affirmatively were then asked sequentially about specific non-coital methods. Methods were grouped according to effectiveness (Trussell, 2011), and weeks were classified into four categories according to the most effective method used that week: (1) least effective methods, such as withdrawal, or no method (referred to as least effective methods); (2) condoms; (3) pill, patch, and ring (referred to as pill use for convenience); and (4) highly effective methods, including the injectable, IUD, implant, and male and female sterilization. Information about condom use was carried forward to sexually inactive weeks that followed sexually active weeks of condom use if no other method was reported during these sexually inactive weeks (n=2,449 weeks). This approach assumes that if a woman had sex during that week then she would have used a condom. Sensitivity analyses were conducted using more conservative approaches to carrying forward information about condom use and are described in further detail with the statistical methods.

Potential Confounding Variables

We considered a series of potential confounders and included in adjusted models as indicated. Potential sociodemographic confounders were assessed at baseline and included age, race/ethnicity, high school GPA, post-secondary school enrollment, receipt of public assistance and religiosity. Potential sexual and reproductive health history confounders were also assessed at baseline and included first sex by age 15, multiple sexual partners prior to enrollment, and any pregnancies prior to enrollment.

Partnership qualities and partner sociodemographic characteristics were also assessed for potential confounding. Relationships were typified according to seriousness and time intensity into six categories: casual, nonexclusive dating, long distance, cohabiting, and married or engaged (Kusunoki, 2014). We used a time-varying measure of whether the relationship had a prior breakup and reconciliation over the course of the study to assess relationship stability. We considered a time-varying measure of total relationship duration with a specific partner, as was a time-varying measure of whether a participant ever had a pregnancy with her current partner. Characteristics of partners that we considered include partner age difference where a partner was three or more years older than a participant, education differential in which a partner was reported to have more education than the participant, and whether a partner had children from a previous relationship. Finally, we considered a weekly measure of whether partners were strongly anti-conception, or whether they expressed pronatal, ambivalent, or indifferent fertility desires.

Statistical Methods

We calculated descriptive statistics at the woman level for individual-level characteristics and at the week level for partnership-level characteristics. The outcome and exposure variables were summarized at both the woman and weekly levels. Weekly sexual activity and weekly specific method use were also summarized descriptively in lasagna plots, which provide a visual summary of categorical measures over time for panel data (Swihart et al., 2010).

To decide whether to include candidate confounders in adjusted models, we first examined the association between each confounder with weekly measures of sexual activity and contraceptive use. As needed, we then considered associations between confounders and partnership-level and woman-level measures of sexual activity. A priori, we included women's age as an important confounder based on the available research (Call et al., 1995; Frost et al., 2007a; Kornrich et al.; Westoff, 1974; Wu et al., 2008).

We examined the strength of the association between weekly contraceptive use with additional candidate confounders using bivariable multinomial regression models for specific method use. We report descriptive statistics at the woman-level for individual characteristics and at the week-level for partnership characteristics and *p*-values from week-level models in Tables S1-S4.

We assessed the weekly bivariable associations between sexual activity and potential confounders using logistic regression models estimated with generalized estimating equations. These models were estimated with a working exchangeable correlation structure to account for clustering of weeks within women and robust

standard errors. While the correlation between weekly observations of sexual activity appeared to weaken somewhat over time, the exchangeable correlation structure was selected over an autoregressive correlation structure based on better fit according to the estimated QIC statistics (Pan, 2001).

For partnership-level potential confounders that were not associated with weekly sexual activity, associations with partnership-level sexual activity, which is a continuous measure of the proportion of weeks sexually active within a specific partnership, associations with confounders were assessed using marginal linear regression models with a working exchangeable correlation structure and partnerships as the unit of analysis. For remaining potential confounders that were associated with neither week- nor partnership-level sexual activity, woman-level associations with overall proportion of sexually active weeks were assessed using linear regression models. Woman-level candidate confounders that were associated with woman-level measures of sexual activity were included in adjusted models, as were candidate confounders associated with partnership-level or week-level sexual activity.

The final set of confounders that were included in adjusted models includes race/ethnicity, age, HS GPA, post-secondary enrollment, religiosity, receipt of public assistance, sex at or before age 15, prior pregnancies, multiple prior sex partners at enrollment, relationship type, relationship duration, prior pregnancies with current partner, partner age and education differences, and partner's pregnancy intentions. Relationship duration was modeled as a linear spline with knot at one year in all models to allow different associations during and after the first year of the relationship.

Multicolinearity of the adjusted model was assessed by estimating variance inflation factors (VIFs), which averaged 1.54 for all covariates.

The primary objective of the study is to quantify the relationship between the type of contraceptive method that women use on a weekly basis and weekly sexual activity within a woman over time. We also compare this short-term association with the overall or long-term association that would typically be obtained from a cross-sectional study, which in this analysis is evaluated according to the overall proportion of women's weeks sexually active across all weekly observations. We fit multinomial logistic regression models with robust standard errors to account for the clustering of weekly data within women and partnerships. To account for clustering of partnerships within women and of weeks within partnerships, we estimated parameter confidence intervals using bootstrapped models with clustered resampling at the level of women in the sample, such that all partnerships and weeks of data within a selected woman were resampled together in blocks. We preserved all partnerships and weeks for individual women during resampling and estimated each model with 1,000 bootstrap replications. Bias corrected and accelerated (BCa) confidence intervals were estimated for each model. This approach of boostrapping and estimating the BCa confidence intervals provides more accurate estimates of the standard errors of the regression coefficients and corrects the variance for the correlation among weeks within partnerships and partnerships within women (Carpenter & Bithell, 2000).

To estimate independent effects of sexual activity on specific method use at each level (weekly, partnership, and woman), we centered weekly sexual activity on

each partnership's overall proportion of sexually active weeks, and each partnership's proportion of sexually active weeks on women's overall proportion of sexually active weeks:

$$Log\left(\frac{\Pr[Y_{ijk}=k]}{\Pr[Y_{ijk}=K]}\right) = \beta_0 + \beta_1\left(x_{ijk} - \overline{x_{ij\cdot}}\right) + \beta_2\left(\overline{x_{ij\cdot}} - \overline{x_{i\cdot\cdot}}\right) + \beta_3\left(\overline{x_{i\cdot\cdot}}\right) + \beta_4 confounders$$

This model specifies the risk ratio of use of a specific method *k* relative to use of the base method K. The comparison category *k* takes on three categories including condom use, pill use, and highly effective method use, while the reference category *K* is use of least effective methods in a given week. Here, $\overline{x_{i\cdot\cdot}}$, and $\overline{x_{ij\cdot}} - \overline{x_{i\cdot\cdot}}$ and $x_{ijk} - \overline{x_{ij\cdot}}$ indicate the decomposed measures of overall proportion of weeks sexually active for each woman (woman-level sexual activity), partnership-level sexual activity and week-level sexual activity respectively. For the models results reported in tables, partnership-level and woman-level sexual activity measures were scaled by a factor of ten, such that estimates reflect the effect of a 10% increase in the proportion of weeks sexually active at each level. Models were also estimated with unscaled measures of partnership-level and woman-level sexual activity. Using results from these unscaled models we compared woman-level effects and partnership-level effects to the week-level effects using postestimation Wald tests.

We conducted sensitivity analyses altering the method of imputation for condom use in non sexually active weeks when the next reported method was something other than condoms (a method switch) and when the last week of sexually active condom use was followed only by sexually inactive weeks and censoring due to

the study end or loss to follow-up. For these two scenarios, we used two alternative scenarios for imputation. For the first sensitivity analysis we carried forward condom use only halfway up (for the first half of weeks of sexual inactivity within a period of sexual inactivity) to a method switch or end of study. For the second sensitivity analysis we did not carry forward condom use at all in the case of a method switch or end of study (in those cases weekly contraceptive use is coded as non use in the absence of any non coital method reported during these weeks). In both of these sensitivity analyses, as in the primary analyses, condom use was carried forward into sexually inactive weeks if condom use was reported as the next method used when sexual activity resumed. In a third sensitivity analysis, we categorized condom use weeks together with the least effective methods for a three-category specific method use variable. All analyses were conducted using StataMP 14.2.

4.3 Results

Sample description

The 737 women contributed an average of 33 weeks of data for this analysis (SD=32; range: 1-145). Women reported data on a total of 2,004 partners with an average of 2.7 partners per woman (SD=2.6; range: 1-20), with each partnership contributing an average of 12 weeks of data (SD=22; range: 1-145). Overall use of specific contraceptive methods varied between women, but individual women also changed their contraceptive behaviors over time (Figure 4.1). At the week level, the most frequently used method was the pill, which accounted for a total of 42% of weeks

of the study, followed by condoms (25%) and least effective methods (26%) (Table 4.1). At the partnership level, the distribution of methods used was similar to the week level, although condoms were used for a greater percentage of weeks and pills were used less frequently on average. Average woman-level method use was similar to partnership-level method use, with a slightly higher average percentage of weeks of highly effective methods. At the woman level, pills were used for an average of 33% (SD=38%) of each woman's total weeks in the analytic sample. Condoms were the next most prevalent method used, accounting for an average of 30% (SD=34%) of weeks, closely followed by the least effective methods, which accounted for an average of 29% (SD=32%) of women's weeks (this category included both no method, which was used for an average of 12% (SD=22%) of weeks and less effective methods, which were used for an average of 17% (SD=26%) of weeks). Longer acting methods were least frequently used, on average accounting for only 9% (SD=22%) of women's weeks (this category included the injectable, which was used for an average of 5% (SD=17%) of weeks and all other highly effect methods that were used for an average of 3% (SD=15%) of weeks).

Sexual activity also varied both between women and for individual women over time (Figure 4.2). The proportion of partnered weeks that were sexually active for each woman ranged from 3% to 100%, with an average of 69% (SD=27%) of weeks sexually active (Table 4.1). At the partnership level, 60% (SD=39%) of weeks were sexually active on average within a partnership. Overall, 65% of weeks in the study were sexually active.

The sample was socially and demographically diverse (Table 4.2). Race and ethnicity varied across participants, with 59% white, 30% black, 9% Hispanic, and 2% with other race/ethnic identities. Mean high school grade point average (GPA) was 3.1 (SD=0.62) and 55% were enrolled in post-secondary education at baseline. Just over half of participants (56%) identified as highly religious and 28% had ever received public assistance. About one in three participants (35%) reported having sex by age 15 and 28% had ever been pregnant. Two thirds of participants (68%) reported more than one sexual partner prior to enrolment.

Weekly partnership characteristics provide insight into young women's relationships in this sample (Table 4.3). One third of weeks were spent in exclusive dating relationships. About one in five weeks were spent in cohabiting (18%), long distance (18%) and married or engaged (17%) relationships respectively. A smaller percentage of weeks were spent in casual (8%) and nonexclusive dating (6%) relationships. One in five weeks were spent in relationships that had dissolved and subsequently reformed, and 17% of weeks were spent in relationships where the participant had reported a pregnancy with the current partner. About one in four weeks were spent with a partner who was at least three years older than the participant and only 13% of weeks were spent with a partner who was more highly educated than the participant. Fewer than one in ten weeks were spent with a partner who already had children from a previous relationship. Participants reported that their partners had fertility desires that were not entirely anticonception in only 6% of weeks.

Effect of weekly sexual activity

Generally, weekly sexually activity is associated with weekly use of more effective methods (Table 4.4). Sexual activity in a given week is associated with an 83% increased chance of being a condom user in that week compared to being a user of a least effective method (RRR=1.83, 95% CI: 1.64-2.10). This effect is similar for pill use relative to use of the least effective methods (RRR=1.86, 95%CI: 1.66-2.13). For use of highly effective methods, the effect of weekly sexual activity is even greater, with a more than two-fold increase in the risk of highly effective method use relative to use of the least effective methods in sexually active weeks compared to sexually inactive weeks (RRR=2.17, 95% CI: 1.74-3.51).

Comparing between use of the more effective methods–condoms, pill, and highly effective methods–relative to each other there were no significant effects of weekly sexual activity (p=0.51). For example, the effect of weekly sexual activity on weekly use of pills relative to condoms was not statistically significant (RRR=1.01, 95% CI: 0.92-1.12), nor was the effect of weekly sexual activity on use of the highly effective methods relative to pills (RRR=1.17, 95% CI: 0.88-1.55).

Effect of partnership-level sexual activity

Similar to findings at the week level, at the partnership level, use of each specific more effective method was increased relative to the least effective methods as the proportion of sexually active weeks within a partnership increased. Specifically, for each 10% increase in the proportion of sexually active weeks within a specific partnership,

there was a corresponding 5% increase in the chance of condom use relative to use of least effective methods (RRR=1.05, 95% CI: 1.01-1.11). For this same increase in partnership-level sexual activity there was a 9% increased chance of pill use (RRR=1.09, 95% CI: 1.04-1.14) and 10% increased chance of highly effective method use (RRR=1.10, 95% CI: 1.02-1.18) relative to least effective method use.

Relative selection between the more effective methods does not relate to partnership-level sexual activity (p=0.18). For example, there was no statistically significant effect of partnership-level sexual activity on use of pills relative to condoms (RRR=1.04, 95% CI: 1.00-1.08) nor on use of highly effective methods relative to pills (RRR=1.00, 95% CI: 0.92-1.12).

Effect of woman-level sexual activity

The woman-level effects of sexual activity on specific method use diverged from the week-level and partnership-level findings, particularly for condom use. Whereas at the week-level and partnership-level sexual activity was associated with greater condom use relative to least effective/no method use, at the woman level the overall proportion of sexually active weeks was associated with less condom use relative to less effective methods. Specifically, a 10% increase in the proportion of weeks that a woman was sexually active would be associated with an overall 8% decrease in her probability of using condoms (RRR=0.92, 95% CI: 0.86-0.99). The woman-level effect of sexual activity on pill use relative to the least effective methods was similar to the partnership-level positive effect, but attenuated and not statistically significant (RRR=1.07, 95% CI: 0.98-

1.15). The woman-level effect of sexual activity on use of highly effective methods relative to the least effective methods paralleled the effects at the other levels, with a 21% increase in the probability of highly effective method use relative to the least effective methods per 10% increase in a woman's proportion of weeks sexually active (RRR=1.21, 95% CI: 1.06-1.36).

In contrast to the week-level and partnership-level effects, there were significant effects of woman-level sexual activity on relative use of various more effective methods ($p<0.001$). Specifically, each 10% increase in a woman's overall proportion of weeks sexually active was associated with a 16% increased probability of using the pill relative to using condoms (RRR=1.16, 95% CI: 1.07-1.25) and a 31% increased probability of using a highly effective method relative to using condoms (RRR=1.31, 95% CI: 1.16-1.48). There was no significant effect of woman-level sexual activity on use of highly effective methods relative to the pill (RRR=1.13, 95% CI: 1.00-1.28), although this effect approached statistical significance.

Comparison of effects across levels

Comparisons between the week-level, partnership-level, and woman-level effects indicate no significant differences between the magnitude of these effects for pill use relative to the least effective methods (p=0.54) or for longer acting methods relative to the least effective methods (p=0.22). These results suggest that the average between-women effects provide an accurate approximation of the week-to-week effects for these methods. Comparisons of the effects on condom use at the three

levels, however, indicate significant differences among the effect sizes (p<0.001). Specifically, the negative effect between women differed significantly from the positive week-level (p<0.001) and partnership-level (p=0.002) effects, while the week- and partnership-level effects were similar to each other (p=0.70).

Adjusted model

Adjusting for individual-level and partnership-level confounders resulted in some changes to the effects of sexual activity at the woman-level, but not at the week-level or partnership level (Table 4.5). Across all methods, at the week level, the effect of sexual activity on method use remained positive and statistically significant. So too, at the partnership level, effects of sexual activity on specific method use were virtually unchanged. At the woman-level, however, there were changes in the effect of sexual activity on condom use and pill use relative to use of the least effective methods. Specifically, the effect of woman-level sexual activity of condom use relative to the least effective methods was attenuated and not statistically significant (aRRR=0.98, 95% CI: 0.91-1.06). The effect of woman-level sexual activity on pill use relative to the least effective methods was strengthened, and became statistically significant (aRRR=1.12, 95% CI: 1.03-1.21).

Sensitivity Analyses

Sensitivity analyses were generally consistent with findings from main analyses (Table 4.S5). For the first sensitivity analysis in which condom use was carried forward

only halfway up to a method switch, and the second in which condom use was not carried forward at all before a method switch, effects in the adjusted three-level model were consistent with primary analyses. In fact, the magnitudes of the effects were larger in the sensitivity analyses, suggesting that the chosen imputation approach was the most conservative for these specific main analyses. In the third sensitivity analysis we combined condom use with use of the least effective methods, obviating the need for imputation. In the adjusted three-level model for this third sensitivity analysis, findings were consistent with the main analysis for effects on pill use and longer acting method use, except that the partnership-level effect of increased sexual activity on use of longer acting methods relative to use of condom or less effective methods was no longer statistically significant (aRRR=1.07; 95%CI: 0.99-1.17).

4.4 Discussion

Our analyses provide evidence that sexual activity is associated with use of effective contraceptive methods. For hormonal and longer acting methods, our findings are clear and consistent. The positive and significant woman-level effects that we find for use of the pill and highly effective methods are consistent with prior cross sectional literature that indicates an association between sexual activity and contraceptive use (Frost & Darroch, 2008; Kusunoki & Upchurch, 2011). Furthermore, we find that these woman-level effects are mirrored in similarly positive effects at the partnership level and at the week level. Thus, cross-sectional analyses of summary measures for the association between sexual activity and use of hormonal and highly effective methods

appear to approximate the more granular dynamic of the associations for individual women over time.

The dynamics of sexual activity and condom use, however, appear to be more complex. We found that the expected positive week-level association between sexual activity and condom use was not reflected in an analogous woman-level effect. While the situational week-level effect indicated increased probability of using condoms as opposed to using less effective methods or no method during sexually active weeks, on average women who were more sexually active were actually less likely to use condoms relative to a least effective method in unadjusted models. In adjusted models this between-women effect was attenuated, possibly reflecting confounding by factors that change over the course of relationships. The qualitatively different results at the week level and partnership level compared to the woman level suggest that sexual activity may influence method use decisions differently for condom use than for use of more effective non-coital methods. Specifically, these condom use results may reflect that women factor only very recent sexual experiences into their decision-making about coital methods, without taking into account more distant past and expected future sexual activity. An important implication of these findings is that cross-sectional studies summarizing measures of sexual activity and condom may not adequately reflect the dynamics of condom use behavior over time. In fact, our findings may explain in part why prior studies have resulted in conflicting results (Frost et al., 2007a; Wildsmith et al., 2015; Wilson & Koo, 2008; Wu et al., 2008).

Our primary findings were not substantially confounded by individual and partnership characteristics or by partnership-level effects. In fact, week-level and partnership-level effects of sexual activity on contraceptive method use increase somewhat in magnitude after adjusting for potential confounders, an indicator of conservative confounding. This finding is not unexpected, as many of the potential confounders that are related to decreased contraceptive method use may also be related to increased sexual activity, thus making it unlikely that the positive association between sexual activity and contraceptive use is largely due to confounding.

Understanding how women's patterns of sexual activity influence their contraceptive behaviors is important for contraceptive users, healthcare providers, and researchers. For example, our subsequent analyses of how sexual activity influences the two components of contraceptive use, method discontinuation and method selection, may help guide individualized contraceptive counseling.

Additionally, a better understanding of the association between sexual activity and contraceptive use may be useful when analyzing user-group-specific failure rates and creating strategies around reducing failure of specific methods. Annual failure rates depend on frequency of sexual activity, as women who have sex more often are more often at risk of event-level method failure. Part of the differences in specific method failure rates could consequently be in part due to differences in frequency of sexual activity while women are using those methods. Furthermore, differences in specific method failure rates between groups of people according to characteristics such as age and relationship type may be in part due to variation in frequency of sexual activity

(Kost et al., 2008). Removing this potential confounding by frequency of sexual activity from failure rate analyses may provide more useful information about other modifiable and non-modifiable factors that contribute to increased method failure on the population-level.

The population from which our sample was drawn is specific such that our findings may not be generalizable to other populations. Our study focuses on young women ages 18-22 specifically because these are the women most are risk of unintended pregnancy in the United States (Finer & Zolna, 2014), and the majority are unmarried and non-cohabitating. The dynamics of sexual activity and contraceptive use, however, may differ among older women and particularly among those who are in longer-term, stable relationships. While additional research may be needed to generalize specific findings to broader populations, our analyses do provide lessons of broader importance to longitudinal research on sexual and reproductive health behaviors.

Our analyses are preliminary and provide a foundation for future study of a possibly causal association between sexual activity and contraceptive use by assessing the exposure and outcome in a timescale that likely corresponds to how health behavior decisions are made. By showing associations between sexual activity and contraceptive method use at the level of weekly observation, including for condom use where woman-level effects are not consistent with week-level effects, this study goes beyond prior research in this area. Same week ascertainments of sexual activity and contraceptive outcomes were analyzed in this study, such that no conclusions should be made about

the direction of causality. Women may adapt their contraceptive behavior in response to recent sexual activity; they may adapt their sexual activity in response to recent contraceptive behaviors; or they may do both. Furthermore, this analysis of weekly contraceptive behaviors does not differentiate between continuation of contraceptive use and selection and initiation of a new method, which may be influenced differently by patterns of sexual activity. These dynamics are explored in greater detail in the next two chapters.

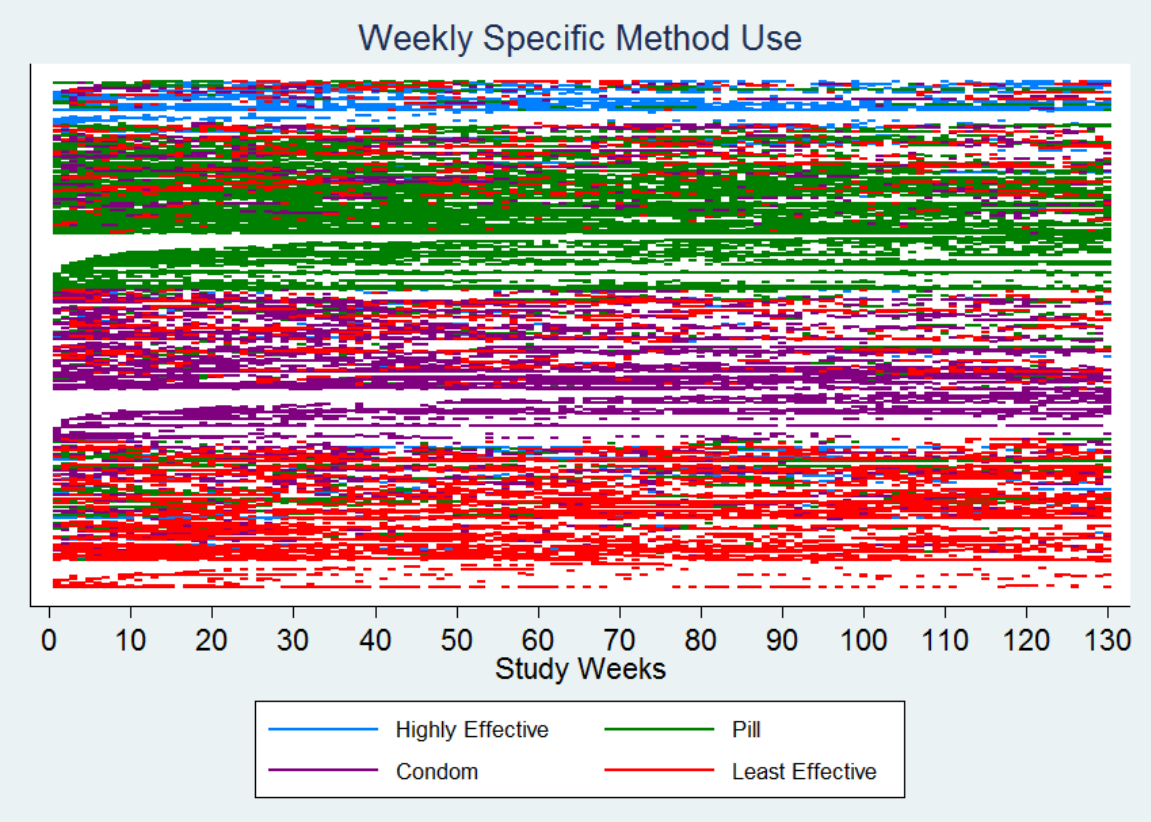

Figure 4.1. Lasagna plot of weekly specific contraceptive method use. Each horizontal line on the plot represents one woman in the study and each colored line segment represents a week of a certain specific method. White areas indicate a week not in the analytic sample because of missing data or not at risk of unintended pregnancy.

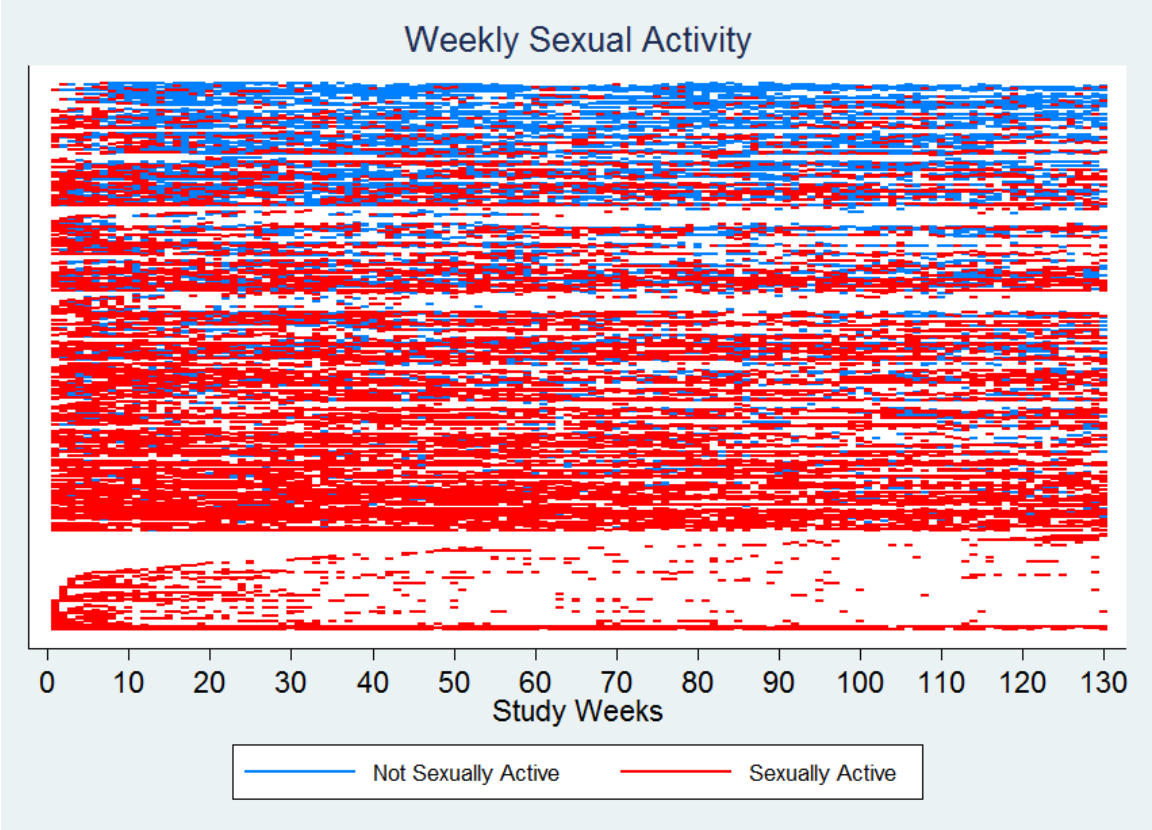

Figure 4.2. Lasagna plot showing each woman's reported weekly sexual activity over time during the study. Each horizontal line on the plot represents one woman in the study and each red or blue segment of the line represents a sexually active or inactive week respectively. White areas indicate a week not in the analytic sample because of missing data or not at risk of unintended pregnancy.

Table 4.1. Aim 1: Week-level, partnership-level, and woman-level sexual activity and contraceptive use

Measure	**Week Level** (n=24,533) %	**Partnership Level** (n=2,004) mean (SD)	**Woman Level** (n=737) mean (SD)
Sexual Activity	64.9%	60.4% (39.1%)	69.2% (26.5%)
Contraceptive Use			
Least Effective	6.9%	29.4% (29.6%)	28.7% (31.9%)
Condoms	41.8%	32.9% (42.0%)	29.6% (34.3%)
Pills	25.0%	31.3% (42.3%)	33.1% (38.0%)
Highly Effective	26.4%	6.3% (21.1%)	8.6% (22.0%)

Table 4.2. Aim 1: Baseline characteristics of women (n=737) during the study

Characteristic	Baseline Prevalence % (n) or mean (SD)
Age	19.2 (0.57)
Race/Ethnicity	
White	59.0 (435)
Black	30.1 (222)
Hispanic	8.8 (65)
Other	2.0 (15)
HS GPA	3.1 (0.62)
Post-Sec Enrollment	
No	45.2 (333)
Yes	54.8 (404)
Highly Religious	
No	44.5 (328)
Yes	55.5 (409)
Ever Public Assistance	
No	72.0 (531)
Yes	28.0 (206)
First Sex <=15	
No	64.6 (476)
Yes	35.4 (261)
Ever Pregnant	
No	72.2 (532)
Yes	27.8 (205)
Multiple Past Partners	
No	32.0 (236)
Yes	68.0 (501)

Table 4.3. Aim 1: Weekly partnership characteristics (n=24,533 weeks)

Characteristic	Prevalence % (n) or mean (SD)
Relationship type	
Casual	8.2 (2,013)
Nonexclusive dating	5.6 (1,374)
Long distance	17.5 (4,294)
Exclusive dating	33.0 (8,085)
Cohabiting	18.4 (4,526)
Married/engaged	17.3 (4,241)
Ever broken up	
No	80.2 (19,670)
Yes	19.8 (4,863)
Relationship duration in months	20 (20)
Ever pregnant with current partner	
No	83.2 (20,420)
Yes	16.8 (4,113)
Partner 3+ years older	
No	74.2 (18,194)
Yes	25.8 (6,339)
Partner more educated	
No	87.0 (21,343)
Yes	13.0 (3,190)
Partner has prior children	
No	91.3 (22,398)
Yes	8.7 (2,135)
Partner may want a pregnancy right now	
No	93.8 (22,973)
Yes	6.2 (1,520)

Table 4.4. Aim 1: Unadjusted multinomial logistic regression model for the probability of specific method use in relation to sexual activity (N=737 women; n=24,464 weeks)

	RRR [95% BCa CI] [a]			
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	*p*-value for differences between methods
Week-level sexual activity	1.83 [1.64-2.10]***	1.86 [1.66-2.13]***	2.17 [1.74-3.51]***	0.51
Partnership-level sexual activity [b]	1.05 [1.01-1.11]*	1.09 [1.04-1.14]***	1.10 [1.02-1.18]*	0.18
Between-women sexual activity [b]	0.92 [0.86-0.99]*	1.07 [0.98-1.15]	1.21 [1.06-1.36]***	<0.001
p-value for differences between levels [c]	<0.001 [d]	0.54	0.22	

*p<0.05 **p<0.01 ***p<0.001

[a] Bootstrapped bias corrected and accelerated confidence intervals

[b] Proportion of partnership weeks sexually active is scaled by 10 so that RRR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

[c] Test for equality of unscaled week-level, partnership-level and between-women effects

[d] Pairwise comparisons indicated significant differences between week-level and between-women effect (p<0.001) and between-women and partnership-level effect (p=0.002), but no difference in week-level and partnership-level effects (p=0.70)

Table 4.5. Aim 1: Adjusted multinomial logistic regression models for the probability of specific method use in relation to sexual activity (N=737 women; n=24,433 weeks)

	RRR [95% BCa CI] [a]			
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	*p*-value for differences between methods
Week-level sexual activity	2.00 [1.73-2.31]***	2.00 [1.71-2.32]***	2.49 [1.90-3.82]***	0.43
Partnership-level sexual activity [b]	1.06 [1.02-1.11]**	1.11 [1.04-1.16]***	1.11 [1.02-1.21]*	0.23
Between-women sexual activity [b]	0.98 [0.91-1.06]	1.12 [1.03-1.21]*	1.24 [1.09-1.41]***	<0.001
Age (years)	0.97 [0.82-1.15]	0.90 [0.76-1.08]	0.95 [0.71-1.25]	
Race/Ethnicity				
White	ref	ref	ref	
African-American	0.79 [0.49-1.23]	0.43 [0.24-0.69]***	1.15 [0.44-2.07]	
Other	0.63 [0.29-1.38]	0.99 [0.53-1.83]	0.48 [0.17-1.44]	
Post-Sec Enrollment	0.93 [0.62-1.36]	1.20 [0.80-1.78]	1.28 [0.73-2.34]	
HS GPA (points)	1.55 [1.11-2.09]**	2.73 [1.86-3.83]***	1.38 [0.91-2.50]	
Highly Religious	1.08 [0.73-1.56]	0.99 [0.68-1.55]	0.50 [0.26-1.05]	
Ever Public Assistance	1.19 [0.80-1.75]	0.85 [0.53-1.25]	2.74 [1.52-5.57]***	
Multiple Past Partners	0.60 [0.42-0.91]*	0.86 [0.56-1.31]	0.88 [0.33-2.23]	
Sex before age 16	0.91 [0.59-1.37]	0.99 [0.65-1.58]	1.02 [0.51-1.99]	
Relationship Type				
Casual	ref	ref	ref	
Non-exclusive dating	0.76 [0.58-0.99]	1.00 [0.73-1.37]	1.03 [0.48-1.99]	
Long distance	1.16 [0.76-1.76]	1.05 [0.72-1.52]	1.85 [0.94-3.86]	
Exclusive dating	1.06 [0.70-1.53]	1.15 [0.78-1.68]	1.35 [0.66-2.73]	
Cohabiting	0.80 [0.45-1.31]	0.95 [0.61-1.56]	1.04 [0.45-2.27]	
Married/Engaged	0.61 [0.34-1.14]	0.65 [0.38-1.07]	1.33 [0.53-3.62]	
Relationship duration (per month)				
0-12 months	0.98 [0.94-1.01]	1.03 [1.00-1.07]	1.01 [0.95-1.06]	
>12 months	1.02 [0.98-1.07]	0.97 [0.93-1.01]	1.00 [0.95-1.08]	
Ever pregnant with current partner	0.62 [0.42-0.98]*	0.66 [0.43-1.05]	0.57 [0.27-1.03]	
Partner is older	0.67 [0.48-0.99]*	0.81 [0.54-1.24]	0.83 [0.41-1.41]	
Partner more educated	0.83 [0.57-1.23]	0.82 [0.52-1.30]	0.88 [0.47-1.76]	
Partner has prior kids	1.05 [0.69-1.70]	0.86 [0.55-1.44]	1.68 [0.96-3.04]	
Partner does not want pregnancy	1.46 [0.95-2.04]	1.28 [0.65-2.06]	1.90 [0.94-3.47]	

*p<0.05 **p<0.01 ***p<0.001

[a] Bootstrapped bias corrected and accelerated confidence intervals

[b] Proportion of partnership weeks sexually active is scaled by 10 so that RRR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

Table 4.S1. Aim 1: Weekly specific method use by baseline characteristics of women (n=737)

Characteristic	Proportion Weeks Used Less Effective Methods mean (SD)	Proportion Weeks Used Condoms mean (SD)	Proportion Weeks Used Pill mean (SD)	Proportion Weeks Used Highly Effective Methods mean (SD)	*p*-value [a]
Age	–	–	–	–	0.52
Race/Ethnicity					<0.001
White	0.27 (0.32)	0.27 (0.33)	0.39 (0.39)	0.06 (0.18)	
Black	0.30 (0.31)	0.36 (0.36)	0.20 (0.31)	0.13 (0.28)	
Hispanic	0.30 (0.34)	0.25 (0.32)	0.39 (0.39)	0.07 (0.23)	
Other	0.39 (0.38)	0.19 (0.30)	0.34 (0.44)	0.08 (0.17)	
HS GPA	–	–	–	–	<0.001
Post-Sec Enrollment					0.001
No	0.32 (0.34)	0.31 (0.34)	0.27 (0.36)	0.10 (0.24)	
Yes	0.30 (0.30)	0.29 (0.34)	0.38 (0.39)	0.07 (0.20)	
Highly Religious					0.06
No	0.27 (0.32)	0.27 (0.34)	0.37 (0.39)	0.09 (0.22)	
Yes	0.30 (0.32)	0.31 (0.35)	0.30 (0.37)	0.09 (0.22)	
Ever Public Assistance					<0.001
No	0.27 (0.32)	0.29 (0.35)	0.38 (0.39)	0.06 (0.18)	
Yes	0.32 (0.33)	0.31 (0.34)	0.21 (0.31)	0.15 (0.28)	
First Sex <=15					0.008
No	0.27 (0.31)	0.31 (0.35)	0.35 (0.39)	0.06 (0.18)	
Yes	0.32 (0.33)	0.26 (0.32)	0.29 (0.36)	0.13 (0.27)	
Ever Pregnant					<0.001
No	0.26 (0.31)	0.31 (0.35)	0.38 (0.39)	0.06 (0.18)	
Yes	0.35 (0.33)	0.27 (0.31)	0.21 (0.31)	0.16 (0.28)	
Multiple Past Partners					0.001
No	0.24 (0.30)	0.35 (0.37)	0.36 (0.40)	0.05 (0.17)	
Yes	0.31 (0.33)	0.27 (0.33)	0.32 (0.37)	0.10 (0.24)	

[a] Wald test of significance from bivariable multinomial logistic model with cluster robust standard errors for independent variable coefficients across all three method-specific equations.

Table 4.S2. Aim 1: Weekly specific method use by weekly partnership characteristics (n=24,479 weeks)

Characteristic	Weeks Used Less Effective Methods % (n)	Weeks Used Condoms % (n)	Weeks Used Pill % (n)	Weeks Used Highly Effective Methods % (n)	*p*-value [a]
Relationship type					<0.001
Casual	28.6 (573)	33.8 (657)	34.4 (689)	4.3 (86)	
Nonexclusive dating	28.7 (393)	27.2 (373)	38.8 (532)	5.3 (72)	
Long distance	24.0 (1,027)	30.4 (1,304)	39.6 (1,697)	6.0 (259)	
Exclusive dating	20.9 (1,688)	25.8 (2,081)	47.3 (3,809)	6.0 (482)	
Cohabiting	28.6 (1,292)	19.9 (899)	44.1 (1,993)	7.5 (339)	
Married/engaged	35.0 (1,481)	18.9 (801)	35.5 (1,504)	10.6 (448)	
Ever broken up					0.03
No	25.0 (4,916)	24.9 (4,893)	42.7 (8,394)	7.4 (1,449)	
Yes	31.9 (1,538)	25.3 (1,222)	37.9 (1,830)	4.9 (237)	
Relationship duration in months	–	–	–	–	0.01[b]
Ever pregnant with current partner					<0.001
No	23.9 (4,867)	26.1 (5,323)	43.7 (8,909)	6.2 (1,272)	
Yes	38.6 (1,587)	19.3 (792)	32.0 (1,315)	10.1 (414)	
Partner 3+ years older					0.007
No	24.3 (4,405)	26.5 (4,819)	42,8 (7,774)	6.4 (1,161)	
Yes	32.4 (2,049)	20.5 (1,296)	38.8 (2,450)	8.3 (525)	
Partner more educated					<0.001
No	24.6 (5,230)	25.1 (5,347)	43.6 (9,299)	6.7 (1,428)	
Yes	38.6 (1,224)	24.2 (768)	29.1 (925)	8.1 (258)	
Partner has prior children					0.001
No	25.7 (5,742)	24.8 (5,546)	43.2 (9,651)	6.4 (1,425)	
Yes	33.7 (6,454)	26.9 (569)	27.1 (573)	12.3 (261)	
Partner may want a pregnancy right now					<0.001
No	25.3 (5,802)	25.1 (5,764)	42.6 (9,771)	6.9 (1,591)	
Yes	41.9 (635)	22.7 (344)	29.1 (440)	6.3 (95)	

[a] Wald test of significance from bivariable multinomial logistic model with cluster robust standard errors for independent variable coefficients across all three method-specific equations.

[b] Model includes a spline knot at one year of duration, to allow a different effect beyond one year of duration in order to best fit the data. The odds of condom use relative to less effective methods decline over the course of the first year of a relationship (p=0.01), while significant effect was found beyond the first year or for other methods.

Table 4.S3. Aim 1: Sexual activity by baseline characteristics of women (n=737)

Characteristic	Proportion Weeks Sexually Active mean (SD)	*p*-value [a]
Age	–	<0.001
Race/Ethnicity		<0.001
White	0.71 (0.26)	
Black	0.65 (0.27)	
Hispanic	0.64 (0.30)	
Other	0.84 (0.19)	
HS GPA	–	0.03
Post-Sec Enrollment		0.009
No	0.72 (0.26)	
Yes	0.67 (0.27)	
Highly Religious		0.01
No	0.72 (0.26)	
Yes	0.67 (0.27)	
Ever Public Assistance		0.64
No	0.68 (0.27)	
Yes	0.72 (0.25)	
First Sex <=15		<0.001
No	0.66 (0.27)	
Yes	0.74 (0.24)	
Ever Pregnant		0.03
No	0.68 (0.27)	
Yes	0.73 (0.23)	
Multiple Past Partners		<0.001
No	0.61 (0.28)	
Yes	0.73 (0.24)	

[a] Wald test of significance from bivariable multinomial logistic model with cluster robust standard errors for all independent variable coefficients across all three method-specific equations.

Table 4.S4. Aim 1: Weekly sexual activity by partnership characteristics (n=24,533 weeks)

Characteristic	Weeks Sexually Active % (n)	*p*-value [a]
Relationship type		<0.001
Casual	46.8 (938)	
Nonexclusive dating	62.9 (860)	
Long distance	38.4 (1,647)	
Exclusive dating	77.1 (6,223)	
Cohabiting	73.4 (3,323)	
Married/engaged	68.8 (2,914)	
Ever broken up		0.26
No	65.9 (12,943)	
Yes	61.2 (2,962)	
Relationship duration in months	–	<0.001[b]
Ever pregnant with current partner		0.001
No	62.7 (12,787)	
Yes	75.8 (3,118)	
Partner 3+ years older		0.87
No	63.9 (11,600)	
Yes	68.0 (4,305)	
Partner more educated		0.25
No	63.9 (13,616)	
Yes	72.0 (2,289)	
Partner has prior children		0.26
No	64.3 (14,388)	
Yes	71.2 (1,517)	
Partner may want a pregnancy right now		<0.001
No	64.4 (14,766)	
Yes	73.7 (1,119)	

[a] Wald test of significance from bivariable multinomial logistic model with cluster robust standard errors for all independent variable coefficients across all three method-specific equations.

[b] Model includes a spline knot at one year of duration, to allow a different effect beyond one year of duration in order to best fit the data. In the first year of a relationship, duration is not significantly associated with sexual activity (p=0.30); after the first year of a relationship there is a significant decline over time in the odds of sexual activity (p<0.001).

Table 4.S5. Aim 1: Sensitivity analyses for three-level multinomial logistic regression models for the relative risk of specific method use in relation to sexual activity

	Model S1: Adjusted [b] Partitioned Effect RRR [95% BCa CI] [c]			Model S2: Adjusted [b] Partitioned Effect RRR [95% BCa CI] [c]			Model S3: Adjusted [b] Partitioned Effect RRR [95% BCa CI] [c]	
	Condom vs. Least Effective	Pill vs. Least Effective	Longer Acting vs. Least Effective	Condom vs. Least Effective	Pill vs. Least Effective	Longer Acting vs. Least Effective	Pill vs. Less Effective	Longer Acting vs. Less Effective
Week-level sexual activity	3.49 [2.95-4.03]	2.43 [2.07-2.82]	2.97 [2.25-4.59]	2.59 [2.23-2.97]	2.21 [1.89-2.54]	2.72 [2.06-4.19]	1.39 [1.22-1.56]	1.78 [1.39-2.80]
Partnership-level sexual activity [a]	1.13 [1.08-1.18]	1.13 [1.07-1.19]	1.13 [1.04-1.23]	1.09 [1.05-1.15]	1.12 [1.05-1.18]	1.12 [1.03-1.22]	1.07 [1.02-1.12]	1.07 [0.99-1.17]
Between-women sexual activity [a]	1.07 [0.99-1.14]	1.17 [1.07-1.26]	1.28 [1.14-1.45]	1.02 [0.94-1.08]	1.14 [1.05-1.23]	1.26 [1.11-1.43]	1.13 [1.05-1.22]	1.25 [1.11-1.42]

S1: Condom use not carried forward before a method switch; S2: Condom use carried forward halfway before a method switch; S3: Condom use and less effective/no method use combine into a single category.

[a] Proportion of partnership weeks sexually active is scaled by 10 so that OR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

[b] Adjusted for race/ethnicity, age, HS GPA, post-secondary enrollment, religiosity, receipt of public assistance, sex at or before age 15, prior pregnancies, multiple prior sex partners at enrollment, relationship type, relationship duration, relationship instability, prior pregnancies with current partner, partner age and education differences, and partner's pregnancy intentions.

[c] Bootstrapped bias corrected and accelerated confidence intervals.

5 Aim 2: Recent sexual activity and contraceptive discontinuation

5.1 Background

Almost half of pregnancies in the United States are unintended and young adults have the highest unintended pregnancy rate (Finer & Zolna, 2016). Reducing unintended pregnancies and increasing contraceptive use are national public health priorities (U.S. Department of Health and Human Services. Office of Disease Prevention and Health Promotion.). Prior research suggests that while a majority of unintended pregnancies occur when women are not using contraception (Mosher et al., 2012), most of these women have used a contraceptive method in the past, as recently as six months prior to becoming pregnant (R. K. Jones et al., 2002). Contraceptive discontinuation is a very common experience in the United States (Moreau, Cleland, & Trussell, 2007; Vaughan, Trussell, Kost, Singh, & Jones, 2008), and contributes globally to unmet need for contraception (Jain, Obare, RamaRao, & Askew, 2013). Identifying and understanding when and why women discontinue contraceptive methods may have a sizable impact on reducing unintended pregnancy.

Patterns of sexual activity are inextricably linked to patterns of contraceptive use, yet it is not yet fully understood how exactly recent sexual behavior influences women's subsequent contraceptive behaviors. Infrequent sexual activity or not expecting to have sex is one of the most common reasons that women at risk of unintended pregnancy give for not using a method of contraception (Frost et al., 2007b; Mosher et al., 2012). These reasons are also frequently given among women

experiencing unintended pregnancies (R. K. Jones et al., 2002). While there is some evidence that reduced sexual activity is related overall to less contraceptive use (Frost et al., 2007a; Wu et al., 2008), and to use of less effective methods (Frost & Darroch, 2008; Kusunoki & Upchurch, 2011; Wildsmith et al., 2015), not all studies are in agreement (Wilson & Koo, 2008).

The theoretical framework through which sexual activity and contraceptive behavior interact may be complex. Generally, changes in sexual activity may influence contraceptive behavior via changes in perceived risk of unintended pregnancy, as conceptualized in multiple health behavior theories (Brewer & Rimer, 2008). The literature on sexual activity and contraceptive use, however, does not distinguish the potentially differential influence of sexual activity on contraceptive method selection and contraceptive continuation. The behavioral processes for initiating a health behavior, such as method selection, are likely distinct from the processes for maintaining a health behavior, such as contraceptive continuation and discontinuation (Rothman, 2000). The link between changes in sexual activity and discontinuation of specific contraceptive methods has been acknowledged in the literature, but not studied systematically. For example, some studies have conceptualized reduced frequency of sexual activity as a potential libido-related side effect of hormonal methods that may contribute to discontinuation, where as other studies consider that women who discontinue because of temporary sexual inactivity to be no longer at risk of unintended pregnancy and not in need of contraception (Inoue, Barratt, & Richters, 2015). Additional studies, however, have shown that women clearly acknowledge

changes in frequency of sexual activity as a reason for discontinuing or switching contraceptive methods (Huber et al., 2006; Jaccard et al., 1995; Rosenberg & Waugh, 1998). Furthermore, two studies have shown a direct association between lower frequency of sexual activity and discontinuation of specific methods including the pill and condoms (Huber et al., 2006; Sanders et al., 2001).

The dynamics of contraceptive discontinuation vary across types of method. Longer acting methods, including the IUD and implant, tend to have lower discontinuation rates, with only about 20% of women discontinuing use in the first year, compared to more than 30% of pill users (Trussell, 2011). Discontinuation of the injectable and condoms are even higher (Trussell, 2011). Method-specific characteristics, such as convenience and side effects, influence discontinuation (Moreau et al., 2007), likely contributing to much of the differential in duration of use between methods. Thus, the influence of patterns of sexual activity on discontinuation may vary in magnitude across types of methods.

Changes in partners and relationships account for one of the important situational factors that contribute to changes in both sexual activity and contraceptive behaviors over time. Patterns of sexual activity, for example, change over the course of relationships (Rao & Demaris, 1995), and vary across different types of relationships (Wildsmith et al., 2015). These same factors have also been found to influence contraceptive use (Frost & Darroch, 2008; Manlove et al., 2007; Manlove et al., 2011), and risk of contraceptive discontinuation also appears to vary by marital status (Grady, Billy, & Klepinger, 2002; Trussell & Vaughan, 1999). Furthermore, events such as a

break-up may precipitate contraceptive discontinuation and increase risk of a subsequent unintended pregnancy and abortion (Bajos et al., 2006; Moreau, Beltzer, Bozon, & Bajos, 2011). While the saliency of partners and relationships to understanding how sexual activity relates to contraceptive discontinuation is clear, prior studies have not fully described this dynamic.

This study addresses the dearth of research on the influence of patterns of sexual activity on discontinuation of specific methods. We use a longitudinal population-based sample of young adult women, acknowledging the dynamic nature of sexual and contraceptive behaviors. The role of partners and relationships are also considered. Specifically, we investigate whether frequency of sexual activity in the recent past is associated with discontinuation of specific method types, accounting for the dynamics and characteristics of partnerships. We also compare the influence of recent sexual activity on discontinuation across types of methods.

5.2 Methods

We used data from the Relationship Dynamics and Social Life Study (RDSL), a population-based sample of one county in Michigan. Women ages 18-19 were randomly sampled at baseline and were followed longitudinally for up to two and a half years. Interviewer-administered baseline surveys were conducted in 2008/2009 and women completed brief weekly follow-up surveys online or by phone. The baseline survey included 1,003 women and had a response rate of 83%. Weekly follow-up surveys were completed by 95% of all women enrolled in the study. Most women remained in the

study, with high retention rates at six months (84%), one year (79%) and 18 months of follow-up (75%) (Barber et al., 2011). This analysis was limited to sexually active weeks where women were not pregnant, and indicated clearly not wanting to become pregnant, resulting in an analytic sample of 664 women and 14,300 weeks. Additional weeks of data, including non-sexually active weeks, were also used to calculate recent and overall sexual activity variables. The RDSL received ethical approval from the University of Michigan Institutional Review Board and by the National Institutes of Health. This secondary analysis was exempted from full review by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

The main exposure that we considered was recent sexual activity. Any vaginal sexual activity was assessed dichotomously each week. For a measure of recent sexual activity, we calculated the proportion of sexually active weeks in the past month. Because of missed weekly surveys and late weekly surveys, we used up to four most recent prior weeks of data reported in the 60 days prior to any given week of observation. Weeks with fewer than two prior weeks of data in the past 60 days were excluded (n=1,575 weeks). We conducted sensitivity analyses requiring at least three weeks of data in the past 60 days (n=2,272 weeks excluded) and at least four weeks of data (n=3,059 weeks excluded). Results from these sensitivity analyses were consistent with our main results.

To decompose information into partnership- and woman-level effects, we also calculated the overall proportion of sexually active weeks within each reported partnership and for each woman overall in the study using all available weeks of data.

To decompose these respective effects, past month and partnership-level measures of sexual activity were centered on partnership-level and woman-level measures of sexual activity respectively as appropriate for the given statistical models (Begg & Parides, 2003). This centering, or subtraction of the mean measure for the next level up, allows us to estimate the effect of sexual activity at a given level independent of sexual activity at another level. This approach has been taken for other similar analyses (Harvey et al., 2016; Weir & Latkin, 2015).

The outcome that we examined was weekly discontinuation of a specific method type. Weekly contraceptive method use was classified into four method type categories according to the most effective method reported that week: highly effective methods, including the injectable, implant, IUD, and a very few weeks in which women reported a partner vasectomy (n=17 weeks); the pill, patch, and ring (referred to as the pill for simplicity); condoms; and all less effective methods, including no method. Of the weeks in the less effective method category, 65% were withdrawal (2,116/3,243 weeks) and 33% were no method (1,067/3,243). The remaining weeks of method use in this category included rhythm (<1%), spermicides (<1%), emergency contraception (<1%) and other unspecified methods (1%). A method type discontinuation was identified if the reported type of method for a specific week was different than the method type reported in the most recent sexually active week in the analysis. Thus, discontinuations included both switches to different types of effective methods as well as switches to the least effective methods or no method when women were still at risk of unintended pregnancy. Because periods of least effective method use were included in this analysis,

the discontinuation of that contraceptive state represents an initiation of a more effective method.

We also considered a series of potential individual-level confounders in our analyses. Individual sociodemographic characteristics that we considered included age, race/ethnicity, high school GPA, enrollment in post-secondary education at baseline, ever receipt of public assistance prior to enrollment, and religiosity. Sexual and reproductive health characteristics that we considered included sexual debut by age 15, more than one prior lifetime sexual partner at enrollment, and any pregnancies prior to enrollment.

Relationship qualities that we considered included relationship type. Using information about seriousness and time intensity, relationships were classified as casual, nonexclusive dating, long distance, exclusive dating, cohabiting, and married or engaged. Stability was assessed according to whether the relationship had experienced a previous breakup and reconciliation. We also considered prior pregnancies with the current partner. Demographic characteristics of partners that we included were age difference of three or more years, education differential, partners' prior children, and partners' current fertility desires.

We used three-level logistic regression models to assess the association of recent and longer-term sexual activity with method type discontinuation. These models included measures of past month sexual activity as well as partnership-level and woman-level sexual activity, all specified as proportion weeks sexually active. Models were estimated with random intercepts to account for correlation between weekly data

reported within partnership, and the correlation of partnership-level data within women. These models allow us to ascertain the effect of past month sexual activity on weekly discontinuation, regardless of overall partnership-level and woman-level sexual activity. We included a main effect for specific method type in each model because of the known differences in discontinuation between different types of methods (Trussell, 2011) and assessed modification of the effect of past month sexual activity on discontinuation by specific method type, because of the potential that recent sexual activity may have a different effect on discontinuation depending on the method that a woman is using. Interaction coefficients were multiplied by main effects to obtain the effects of recent sexual activity on discontinuation for each specific contraceptive category. We estimated unadjusted models as well as models adjusting for potential individual-level and partnership-level confounders as appropriate.

We conducted a sensitivity analysis to test certain assumptions about the analytic sample. In the sensitivity analysis we removed weeks of no method and emergency contraception use from the least effective method category, as discontinuing these methods would necessarily reflect uptake of a more effective method. We also exclude weeks in which women report partner vasectomy. They were no substantial differences in model results in the sensitivity analyses (Table 5.S1).

5.3 Results

Sample description

The sample included 664 women who contributed a total of 14,300 weeks to the analysis. Women's total number of weeks in the sample ranged from 1 to 123 and averaged 22 (SD=24). A total of 1,379 partnerships were included in the analysis, with an average of 2.1 (SD=1.8) partnerships per woman (range: 1-13). On average (Table 5.1), women were sexually active in 68% (SD=26%) of weeks and partnerships were sexually active for an average of 74% of weeks (SD=27.4). For weeks in the analysis, the average percentage of weeks sexually active in the past month was 74% (SD=33%), or about three out of four weeks.

Women reported discontinuing their current type of method in 14% of weeks overall (Table 5.1). At the partnership level discontinuations occurred in an average of 20% (SD=31%) of weeks and at the woman level in an average of 18% (SD=21%) of weeks. Out of all weeks in the sample, women reported using highly effective methods in 8% of weeks (the injectable accounted for 66% of these highly effective method weeks), pills in 47% of weeks, condoms in 23% of weeks, and less effective methods (including no method in 8% of all weeks) in 23% of weeks.

Baseline characteristics of women in the analysis are summarized in Table 5.2. The average age at enrollment was 19.2 years (SD=0.58). While the majority (60%) of women were white, almost one in three (30%) were black, while Hispanic women and those of other race/ethnicities made up 9% and 2% of the sample respectively. Just over half of women in the sample were enrolled in post-secondary education (57%) and reported being highly religious (57%). Approximately one in four women (28%) reported ever receiving public assistance. While few women reported sexual debut at age 15 or

earlier (36%) or ever having been pregnant (26%) at baseline, the majority of women had more than one prior sexual partner at baseline (68%).

Weekly partnership characteristics are summarized in Table 5.3. The greatest proportion of weeks was spent in exclusive dating relationships (39%), followed by cohabiting (21%) and married or engaged (18%) relationships. Long distance, nonexclusive dating, and casual relationships were less frequent. Just under 20% of weeks were spent in relationships that had previously had a break up and in relationships where the woman had ever been pregnant with the current partner. A minority of weeks were spent with partners who were more than three years older (26%), where the partner was more educated (14%), or with a partner who had children from other relationships (9%). In only 6% of weeks did women report that their partner did not have strong anticonception pregnancy intentions.

Effect of recent sexual activity on discontinuation

Our first unadjusted model suggests that recent sexual activity decreases subsequent method discontinuation (Table 5.4, Model 1). Each additional sexually active week in the past month was associated with a 21% reduction in the odds of discontinuing a method (OR=0.79, 95% CI: 0.76-0.83). This effect is relatively unchanged when the weeks of no method use (n=1,067) are removed from the least effective method category (Table 5.S1, Model 1), with each additional sexually active week in the past month corresponding to a 17% reduction in the weekly odds of discontinuation (OR=0.83, 95% CI: 0.79-0.88).

Effect of partnership-level sexual activity on discontinuation

The effect of partnership-level sexual activity on method discontinuation mirrored the effect of recent sexual activity. Each 10% increase in the proportion of sexually active weeks within a partnership was associated with a 10% reduction in the odds of method discontinuation (OR=0.90, 95% CI: 0.85-0.95).

Effect of woman-level sexual activity on discontinuation

Woman-level sexual activity also had an inverse effect on method discontinuation. A 10% increase in a woman's overall proportion of weeks sexually active was associated with a 4% reduced odds of method discontinuation, an effect that was not statistically significant in the unadjusted model (OR=0.96, 95% CI: 0.92-1.01).

Comparison of effects across levels

Comparison of the effects of sexual activity on discontinuation at each of the three levels indicates no significant differences in effects sizes. The past-month and partnership-level effects on discontinuation are significantly negative while the woman-level effect is negative but not statistically significant (p=0.10). Comparing the sizes of the effects for unscaled measures of sexual activity at each of the three levels indicates no statistically significant variation (p=0.07).

Effects of method type on discontinuation

Each model, including the unadjusted model, included a variable for the type of method that women were using at the time of discontinuation. In the unadjusted model, we found that discontinuation was lowest when women were using the pill relative to each of the other three types of methods. For example, the odds of discontinuing a highly effective method were twice that of discontinuing the pill in any given week (OR=2.01, 95% CI: 1.54-2.61). The odds of discontinuing condoms were more than three times the odds of discontinuing the pill (OR=3.23, 95% CI: 2.73-3.82), as were the odds of discontinuing a least effective method (OR=3.19, 95% CI: 2.70-3.77). In the sensitivity analysis where weeks of no method use were excluded from the least effective method category (Table 5.S1, Model 1), the odds of discontinuing least effective methods relative to the odds of discontinuing the pill increased (OR=4.90, 95% CI: 4.06-5.92).

Effect of recent sexual activity on discontinuation by method type

Effect modification analyses indicated that the effect of recent sexual activity on method discontinuation varied depending on the type of method that women were using (Table 5.4, Model 2; Figure 5.1). Specifically, for condom use the effect of past month sexual activity on discontinuation was attenuated to a 9% decline in odds of discontinuation per additional sexually active week (OR=0.91, 95% CI: 0.84-0.99). The effects for the other three types of methods, however, were stronger, reflecting approximately 25% decline in odds of discontinuation per additional sexually active week (highly effective OR=0.71, 95% CI: 0.60-0.83; pill OR=0.77, 95% CI: 0.70-0.84; least

effective OR=0.72, 95% CI: 0.66-0.78). Introducing the method-specific interaction terms into the model did not substantially alter estimates on partnership-level and woman-level effects of sexual activity on discontinuation.

In the sensitivity analysis where weeks of nonuse were excluded from the least effective method category, results were similar to the overall results with some small differences (Table 5.S1, Model 2). The effect of recent sexual activity on discontinuation of condoms was attenuated and no longer statistically significant (OR=0.94, 95% CI: 0.86-1.02). The effects of recent sexual activity on discontinuation of highly effective methods and pills were relatively unchanged (highly effective OR=0.69, 95% CI: 0.58-0.82; pill OR=0.78, 95% CI: 0.71-0.85). The effect of recent sexual activity on discontinuation of the least effective methods was attenuated but still statistically significant (OR: 0.80, 95% CI: 0.72-0.88).

Adjusted model

Adjusting the effect modification model for potential confounders resulted in some small differences in the effects of recent sexual activity on discontinuation of specific methods (Table 5.5). Specifically, we find that each of the method-specific effects of recent sexual activity on discontinuation is slightly attenuated. The effect for condom discontinuation is attenuated to the point of becoming not statistically significant (aOR=0.94, 95% CI: 0.87-1.02). Each of the effects of discontinuation on the other three methods remains highly statistically significant (p<0.001).

Adjusting for confounders results in only small changes in other effect estimates. The partnership-level effect of sexual activity (aOR=0.90, 95% CI: 0.85-0.95) is similar to the effect in the unadjusted effect modification model and in the original unadjusted model. The women-level effect becomes more negative and statistically significant, reflecting a 5% decreased odds of discontinuation per 10% increase in a woman's level of sexual activity (aOR=0.95, 95% CI: 0.91-1.00). The effect of specific method type on discontinuation are somewhat attenuated, but all remain highly statistically significant (p<0.001).

5.4 Discussion

In these analyses we show that recent frequency of sexual activity is associated with subsequent contraceptive discontinuation. Specifically, more frequent sexual activity in the prior month is associated with less discontinuation. Furthermore, we show that this overall association holds for each individual specific type of method, though magnitudes vary.

Our study findings are in line with prior research and provide additional detail that has not been previously described on how sexual activity relates to discontinuation of specific methods. For example, our overall findings that greater recent sexual activity is associated with lower odds of switching method types is in line with prior studies where women have reported changes in sexual activity as a reason for switching methods or discontinuing.(Huber et al., 2006; Jaccard et al., 1995; Rosenberg & Waugh, 1998) Furthermore, our findings are consistent with prior studies that have shown

specific associations between reduced frequency of sexual activity and discontinuation of the pill and condoms (Huber et al., 2006; Sanders et al., 2001). We add to this prior literature, however, by also examining the least effective methods and the most effective methods. While it may come as a surprise that in our sample discontinuation of highly effective methods was greater than other types of methods, this finding should be considered in light of the mix of methods in the category, which consisted primarily of the injectable (66% of highly effective method weeks). The injectable actually has been reported to have a higher discontinuation rate than pills, even though the IUD and implant, which also fall into this category, typically have lower discontinuation rates (Trussell, 2011). We found a similar effect, that greater frequency of recent sexual activity was related to less discontinuation, for both longer acting methods and for the least effective methods.

While we have framed our understanding of the influence of frequency of sexual activity on contraceptive use as relating to changes in perceived risk of unintended pregnancy, there are additional complexities to consider. Some prior research has suggested that women may experience changes in sexual activity while using a contraceptive method that they understand as a type of side effect of the method itself. For example, use of hormonal methods have a biologically plausible mechanism for interfering with female libido, which may in turn lead to changes in patterns of sexual activity that could compel women to try a different method. This pathway is not limited to hormonal methods, as some condom users may find that the difficulty or bother of

using a condom leads them to avoid having sex, and thus eventually search for a new method of contraception (Fennell, 2014).

Our research indicates a dynamic association between recent sexual activity and contraceptive discontinuation. Our findings can inform how clinicians and health educators counsel women on ongoing management of a current contraceptive method. Healthcare providers should recognize that contraceptive suitability is dynamic and that contraceptive needs change over time. Taking a sexual history, as recommended in the Centers for Disease Control and Prevention guidelines (Gavin et al., 2014), is important and should be integrated into conversations about characteristics of contraceptive methods and how to minimize risk of unintended pregnancy when switching methods in the future. Furthermore, our findings underscore the importance of routine counseling for women who are currently using a contraceptive method to ensure that the current method continues to meet women's needs.

We acknowledge that there are several limitations to our analysis. First, data on contraceptive use and sexual activity were collected at the weekly level and not at the event level. Thus, we do not have specific information about coital frequency within a given week, merely whether or not any sexual activity occurred. Furthermore, in our analysis we do not distinguish discontinuation from gaps in use, as any weekly discontinuation is counted, regardless of subsequent resumption of use. Some short term discontinuations may not reflect substantial unintended pregnancy risk. For example, women may report nonuse of the pill during every fourth off week. Alternatively, women may discontinue use of coital methods during days of the

menstrual cycle when she perceives a low risk of pregnancy. Information about the timing of menstruation was not collected in the weekly journal instrument, so this could not be accounted for in our analysis. Finally, while we recognize that discontinuation rates vary substantially between the injectable and other longer-acting methods, such as the IUD and implant, we were not able to examine the influence of sexual activity on discontinuation of these methods separately because of small numbers of weeks of IUD and implant use.

Our analysis furthers a more complete understanding of how patterns of sexual activity interact with the dynamics of contraceptive behavior by investigating contraceptive discontinuation. Specifically, these findings demonstrate that less frequent recent sexual activity is associated with discontinuing and switching to a different type of contraceptive method. This analysis, however, does not consider how patterns of sexual activity influence what happens after women discontinue their current type of method. Subsequent analyses will assess how patterns of sexual activity influence women's contraceptive behavior after method discontinuation.

Table 5.1. Aim 2: Short term, partnership-level, and woman-level sexual activity and contraceptive discontinuation

Measure	Short Term* %	Partnership Level mean (SD)	Woman Level mean (SD)
Sexual Activity	73.8% (32.6%)	74.4% (27.4%)	68.1% (26.0%)
Contraceptive Discontinuation	13.6%	20.3% (31.0%)	17.5% (21.3%)

*Short term is past month for sexual activity and week level for contraceptive discontinuation.

Table 5.2. Aim 2: Baseline characteristics of women (n=664) during the study

Characteristic	Baseline Prevalence % (n) or mean (SD)
Age	19.2 (0.58)
Race/Ethnicity	
White	59.9 (398)
Black	28.9 (192)
Hispanic	8.9 (59)
Other	2.3 (15)
HS GPA	3.1 (0.62)
Post-Sec Enrollment	
No	42.6 (283)
Yes	57.4 (381)
Highly Religious	
No	45.2 (300)
Yes	54.8 (364)
Ever Public Assistance	
No	72.0 (531)
Yes	28.0 (206)
First Sex <=15	
No	64.5 (428)
Yes	35.5 (236)
Ever Pregnant	
No	73.6 (489)
Yes	26.4 (175)
Multiple Past Partners	
No	32.5 (216)
Yes	67.5 (448)

Table 5.3. Aim 2: Weekly partnership characteristics (n=14,300 weeks)

Characteristic	Prevalence % (n) or mean (SD)
Relationship type	
Casual	6.0 (860)
Nonexclusive dating	5.4 (768)
Long distance	10.6 (1,523)
Exclusive dating	39.2 (5,610)
Cohabiting	20.6 (2,947)
Married/engaged	18.1 (2,592)
Ever broken up	
No	80.6 (11,526)
Yes	19.4 (2,774)
Relationship duration in months	20 (20)
Ever pregnant with current partner	
No	80.6 (11,525)
Yes	19.4 (2,775)
Partner 3+ years older	
No	73.7 (18,194)
Yes	26.3 (3,762)
Partner more educated	
No	86.3 (12,344)
Yes	13.7 (1,956)
Partner has prior children	
No	91.2 (13,041)
Yes	8.8 (1,259)
Partner may want a pregnancy right now	
No	93.6 (13,370)
Yes	6.4 (912)

Table 5.4. Aim 2: Three-level logistic models for weekly odds of discontinuing method among sexually active weeks (N=664 women; N= 1,379 partnerships; n=14,300 weeks)

	Model 1: Partitioned effect adjusted for method	Model 2: …with effect modification by method type
	OR [95% CI]	OR [95% CI]
Past month sexual activity [a]	0.79 [0.76-0.83]***	
Among users of…		
Highly Effective		0.71 [0.60-0.83]***
Pill		0.77 [0.70-0.84]***
Condom		0.91 [0.84-0.99]*
Least Effective		0.72 [0.66-0.78]***
Partnership-level sexual activity [a]	0.90 [0.85-0.95]***	0.91 [0.86-0.96]**
Woman-level sexual activity [a]	0.96 [0.92-1.01]	0.96 [0.92-1.01]
Method using		
Highly Effective	2.01 [1.54-2.61]***	1.95 [1.48-2.56]***
Pill	ref	ref
Condom	3.23 [2.73-3.82]***	3.57 [3.00-4.26]***
Least Effective	3.19 [2.70-3.77]***	3.12 [2.62-3.71]***

*p<0.05 **p<0.01 ***p<0.001

[a] Past month sexual activity is scaled by 4 so that OR estimates refer to relative increases per additional week sexually active. Proportion of partnership and woman weeks sexually active are scaled by 10 so that OR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

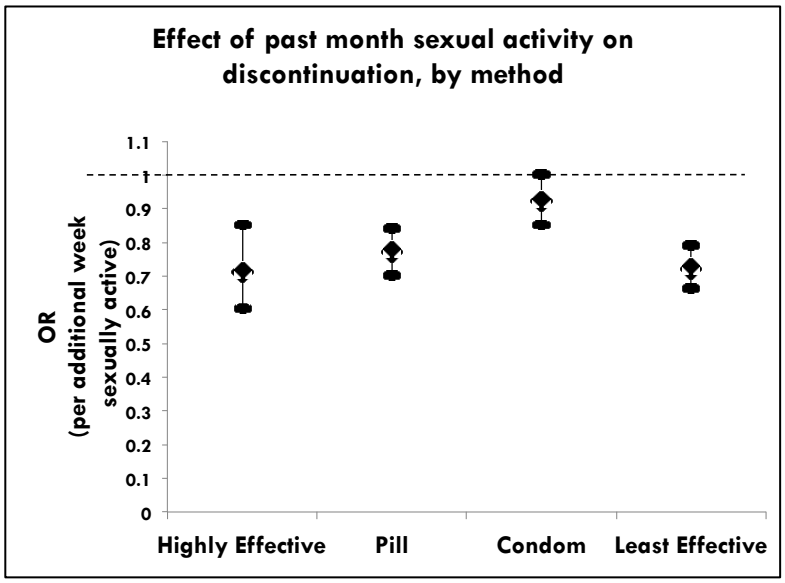

Figure 5.1. Aim 2: Effect modification analyses for the effect of past month sexual activity on method discontinuation by specific method type.

Table 5.5. Aim 2: Adjusted multi-level logistic model for weekly odds of discontinuing a method among sexually active weeks (N=664 women; N= 1,379 partnerships; n=14,300 weeks)

	Discontinuation aOR [95% CI]
Past month sexual activity [a]	
Among users of…	
Highly Effective	0.73 [0.62-0.86]***
Pill	0.79 [0.72-0.86]***
Condom	0.94 [0.87-1.02]
Least Effective	0.73 [0.67-0.80]***
Partnership-level sexual activity [b]	0.90 [0.85-0.95]***
Woman-level sexual activity [b]	0.95 [0.91-1.00]*
Method using	
Highly Effective	1.73 [1.32-2.27]***
Pill	ref
Condom	3.33 [2.79-3.97]***
Least Effective	2.85 [2.39-3.39]***
Age (years)	0.96 [0.88-1.05]
Race/Ethnicity	
White	ref
African-American	1.30 [0.99-1.70]
Other	0.85 [0.59-1.22]
Post-Sec Enrollment	0.87 [0.68-1.09]
HS GPA (points)	0.94 [0.78-1.14]
Highly Religious	1.05 [0.83-1.32]
Ever Public Assistance	1.25 [1.02-1.53]*
Multiple Past Partners	1.33 [1.03-1.73]*
Sex before age 16	0.89 [0.70-1.14]
Never pregnant at enrollment	0.92 [0.70-1.22]
Relationship Type	
Casual	ref
Non-exclusive dating	0.99 [0.74-1.32]
Long distance	0.71 [0.53-0.94]*
Exclusive dating	0.72 [0.56-0.92]**
Cohabiting	0.71 [0.53-0.95]*
Married/Engaged	0.74 [0.53-1.03]
Relationship duration (per month)	
0-12 months	0.99 [0.96-1.01]
>12 months	1.01 [0.99-1.04]
Instability	1.06 [0.88-1.27]
Ever pregnant with current partner	1.71 [1.32-2.21]***
Partner is older	1.08 [0.87-1.33]
Partner has prior kids	1.14 [0.86-1.50]

*p<0.05 **p<0.01 ***p<0.001

[a] Past month sexual activity is scaled by 4 so that OR estimates refer to relative increases per additional week sexually active. Method-specific odds ratios for past month sexual activity are the product of category-specific interaction terms and the odds ratio for the base category.

[b] Proportion of partnership and woman weeks sexually active are scaled by 10 so that OR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

Table 5.S1. Aim 2: Sensitivity analysis three-level logistic models for weekly odds of discontinuing method among sexually active weeks with no method weeks excluded (N=649 women; N= 1,329 partnerships; n=13,243 weeks)

	Model 1: Partitioned effect adjusted for method	Model 2: …with effect modification by method type	Model 3: …adjusted for individual and partnership characteristics [b]
	OR [95% CI]	OR [95% CI]	OR [95% CI]
Past month sexual activity [a]	0.83 [0.79-0.88]***		
Among users of…			
Highly Effective		0.69 [0.58-0.82]***	0.72 [0.61-0.86]***
Pill		0.78 [0.71-0.85]***	0.81 [0.74-0.89]***
Condom		0.94 [0.86-1.02]	0.98 [0.89-1.06]
Other less effective methods		0.80 [0.72-0.88]***	0.82 [0.74-0.91]***
Partnership-level sexual activity [a]	0.93 [0.87-0.99]*	0.93 [0.88-0.99]*	0.93 [0.87-0.99]*
Woman-level sexual activity [a]	0.98 [0.93-1.04]	0.99 [0.94-1.04]	0.97 [0.92-1.02]
Method using			
Highly Effective	1.82 [1.38-2.40]***	1.74 [1.30-2.32]***	1.51 [1.14-2.01]**
Pill	ref	ref	ref
Condom	3.17 [2.66-3.77]***	3.48 [2.91-4.18]***	3.20 [2.67-3.83]***
Other less effective methods	4.90 [4.06-5.92]***	4.96 [4.09-6.02]***	4.47 [3.68-5.42]***

*p<0.05 **p<0.01 ***p<0.001

[a] Past month sexual activity is scaled by 4 so that OR estimates refer to relative increases per additional week sexually active. Proportion of partnership and woman weeks sexually active are scaled by 10 so that OR estimates refer to relative increases per 10% increase in proportion of weeks sexually active.

[b] See Table 5.4 for specific individual and partnership confounders that were included in the model.

6 Aim 3: Sexual Activity and Contraceptive Method Selection

6.1 Background

About 60% of women in the United States with unintended births report using no contraceptive method at the time of conception (Mosher et al., 2012). The other 40% of women with unintended births were using a method at the time of conception, and thus experienced method failure. Women who get abortions often report contraceptive use around the time of conception, although this contraceptive use is likely to be inconsistent and of less effective methods (R. K. Jones et al., 2002). While all contraceptive methods substantially reduce the risk of unintended pregnancy, methods vary substantially in their effectiveness, with 13% of condom users becoming unintentionally pregnant in the first year of use, compared to only 7% of pill users and less than 1% of IUD users (Sundaram et al., 2017; Trussell, 2011). Choosing to use a contraceptive method, therefore, greatly influences a woman's risk of unintended pregnancy, as does the specific method that she selects.

There is a moderate amount of evidence for an association between various patterns of sexual activity and patterns of contraceptive use. Several past studies, for example, identify greater frequency of sexual activity as associated with use of more effective contraceptive methods (Frost & Darroch, 2008; Kusunoki & Upchurch, 2011; Wildsmith et al., 2015). In the Aim 1 of this dissertation, we also find that weekly sexual activity is associated with use of more effective methods. Prior research is somewhat heterogeneous, however, with not all studies confirming this same association (Wilson & Koo, 2008).

One of the difficulties in understanding factors that influence contraceptive protection is that method use at any given time is a function of both which method women select and how long they use that method. Many prior studies on how sexual activity influences contraceptive behavior assess contraceptive use as a single measure, rather than considering selection and continuation (or discontinuation) separately. Health behavior theorists have suggested that while some of the same factors may influence both initiation of a health behavior and maintenance of a health behavior, the relative importance of various factors may be different (Rothman, 2000). Sexual activity, therefore, likely influences both method selection and method continuation, but may influence these two components of contraceptive use to different extents.

There are several major limitations to the prior research in this area. First, the research specifically on how sexual activity influences selection of a new contraceptive method is limited, with prior studies focusing on contraceptive method use more generally. Furthermore, these studies are largely based on cross-sectional data, and often use measures of sexual activity and contraceptive use that summarize behaviors over substantially large periods of time.

The goal of this analysis is to evaluate how recent sexual activity relates to what women do after they discontinue a method–whether they switch to a new method (and which method they select) or whether they stop using any method. We compare the effect of recent sexual activity across selection of four specific categories of contraceptive methods, expecting that when women are more sexually active they are more likely to select more effective methods. We also compare the effect of sexual

activity on method selection at three different time scales (past month, partnership level, and woman level). We expect that the effect of sexual activity will be greater at the most proximal past month level, while the effects of overall partnership-level sexual activity and woman-level sexual activity will be less intense because they are more distal to the time point at which women decide which contraceptive method to select.

6.2 Methods

Data for this analysis come from the Relationship Dynamics and Social Life Study (RDSL), which was conducted by the University of Michigan (Barber et al., 2015). The RDSL consisted of a population-based random sample of women ages 18-19 from a single county in Michigan. Women were interviewed in person at enrollment and were subsequently followed longitudinally with weekly surveys for up to two and a half years. The baseline survey collected a wide array of information of sociodemographic characteristics and reproductive health variables. Weekly surveys were completed online or by phone, and included a brief questionnaire on recent partnership-related events and characteristics, as well as recent sexual and reproductive health behaviors.

The analytic sample for this analysis was limited to weeks in which women made a new contraceptive method selection and were at risk of an unintended pregnancy. Specifically, in these weeks women were sexually active, not pregnant, and indicated that they did not want to become pregnant. Contraceptive method selections were defined as occurring in sexually active weeks where the contraceptive method type reported was different from the method type reported in the prior sexually active week.

Weeks were excluded if there were insufficient data to calculate past month sexual activity (n=286 weeks).

The main outcome for this analysis is a categorical indicator of a new contraceptive behavior. Data on contraceptive use were collected in each weekly survey. Contraceptive behaviors were categorized as (1) least effective methods, including no method, withdrawal, and all other methods less effective than condoms; (2) condoms; (3) pill, patch, and ring (referred henceforth as pill); and (4) highly effective, including the injectable, implant, IUD and sterilization. When women reported using more than one type of method in a week, she was categorized according to the most effective method that she reported. Switches from dual method use (i.e. condoms and a more effective method) to condom use only were not considered selection of a new method, even though the overall effectiveness category of weekly method use changed due to discontinuation of the more effective method. These cases were excluded from this analysis. We conducted a sensitivity analysis in which we excluded weeks where women discontinued a prior method and switched using no method and the results were unchanged (Table 6.S1).

The key exposure of interest was sexual activity in the past month. Sexual activity was assessed weekly as a dichotomous variable in weekly journal surveys. Past month sexual activity was calculated as a proportion of sexually active weeks for the four weeks prior to the index week. These four weeks could occur up to 60 days prior to the index week. If there were fewer than four responses in the 60 days prior to the index week, the proportion of sexual active weeks was calculated using as few as two

weeks of sexual activity data in the prior 60 days. If there were no responses or only one weekly response in the prior 60 days, the index week was excluded from the analysis (n=286 weeks). This flexible definition was crafted to account for late and missed survey responses. We conducted sensitivity analyses using definitions that required at least three (392 weeks dropped) and four weeks (512 weeks dropped) of past month data respectively. Model results from these two sensitivity analyses were in line with our primary findings, although power was somewhat reduced due to smaller sample sizes (Tables 6.S2 and 6.S3). In analytic models, past month sexual activity was scaled by a factor of four, so regression coefficients correspond to the effect of each additional week of sexual activity.

To account for potential confounding by partnership- and woman-level sexual activity, we also calculated proportion of weeks sexually active within each partnership as well as the overall proportion of weeks sexually active during the study for each woman. The past month effect of sexual activity was decomposed from these partnership- and women-level measures using a centering technique. Subtracting the mean value for sexual activity at the next level up allows estimation of the effect of sexual activity at a given level regardless of sexual activity at the next level up (Begg & Parides, 2003; Harvey et al., 2016; Weir & Latkin, 2015). These partnership- and week-level estimates were scaled by a factor of ten such that regression coefficients correspond to the effect of a 10% increase in the proportion of weeks sexually activity for a woman or within a partnership.

We also considered a series of potential confounders at the individual and

partnership levels in adjusted models. Individual-level confounders included age, race/ethnicity, post-secondary school enrollment at baseline, ever having received public assistance, and reporting multiple prior sex partners at baseline. Due to small cell sizes, for multivariable models race/ethnicity categories were collapsed to compare women identifying as African American to all others. We took this approach because contraceptive use patters were most different among African American women than among all other race/ethnic groups. Partnership-level confounders include relationship type, duration, and any pregnancy with current partner. In multivariable models casual and non-exclusive dating relationship weeks were collapsed into a single category because of small cell sizes. Relationship duration was modeled as a continuous variable in months, with a spline knot at one year of duration to allow for a different association with method selection beyond the first year of a relationship.

Descriptive analyses were conducted for weekly measures and for partnership- and woman-level summary measures of variables as appropriate. Multinomial logistic regression models were estimated, with bootstrapped bias-corrected and accelerated confidence intervals to account for the correlation of weekly observations within partnerships and within individual women. Unadjusted models were estimated with specific new contraceptive behavior as the outcome and past month sexual activity as a continuous predictor. Adjusted models were then estimated with potential individual- and partnership-level confounders. Least effective methods were selected as the reference group for all models, and the three resulting estimates for the effect of past month sexual activity on the relative risk of specific method selection were compared

using post-estimation Wald tests. To compare the effect of recent sexual activity to the partnership-level and woman-level effects of sexual activity on method selection, the effect sizes across the three levels were compared within each method using post-estimation Wald tests. A significant *p*-value indicated that at least one of the three effects differed, and subsequent pairwise comparisons indicated specific differences. Regression coefficients from models that were estimated using the unscaled measures of sexual activity were used for these cross-level comparisons. All analyses were conducted in Stata 14.

6.3 Results

Sample description

The analytic sample included a total of 430 women (Table 6.1). Just under one third (29%) of women in the sample were African-American and more than half (56%) were enrolled in post-secondary education at baseline. Just over half of women (54%) identified as highly religious and about one in three women (33%) had received public assistance. At baseline, about one in three reported sex by age 15 (36%) and had ever been pregnant (28%) at the beginning of the study.

The sample included 1,799 new method behaviors, with an average of 4.2 starts per woman (SD=4.1; range 1 to 27) over the 2.5 years of observation. Method selections occurred in the context of 640 reported partnerships, with an average of 2.8 method selections in each partnership (SD=3.2, range 1 to 27). The mean proportion of weeks sexually active in the month prior to a switch (Table 6.2) was 0.65 (SD=0.35; range 0 to

1). Partnerships in the analysis were sexually active for an average of 74% (SD=25.1%) of weeks and women were sexually active for an average of 69% of weeks (SD=24%).

Of the new method selections that occurred during the study, 9% were highly effective methods, while 25% were pills, 27% were condoms, and 40% were the least effective methods, including no method (Table 6.2). At the partnership level the distribution of method selections was similar to the week level. At the woman level, the average percentage of method selections that were the more effective methods (pills and highly effective methods) were slightly higher than at the week and partnership levels, while selection of the less effective methods was slightly lower.

Effect of past month sexual activity

Overall, we find that greater frequency of sexual activity in the past month is associated with a lower probability of selecting condoms relative to selecting each of the other specific methods (Table 6.3). Specifically, the risk ratio of selecting condoms relative to the least effective methods was 23% reduced for each additional week sexually active in the past month (RRR=0.77, 95% CI: 0.71-0.84). This risk ratio for selecting condoms was similar relative to the risk ratio for choosing pills (RRR=0.80, 95% CI: 0.70-0.90) or highly effective methods (RRR=0.81, 95% CI: 0.70-0.95).

Relative selection between the non-barrier methods (i.e. methods other than condoms) did not relate to past month sexual activity. Specifically, there was no significant difference in selection of the pill relative to the least effective methods (RRR=0.96, 95% CI: 0.87-1.08), selection of highly effective methods relative to least

effective methods (RRR=0.95, 95% CI: 0.81-1.09) or selection of highly effective methods relative to the pill (RRR=0.98, 95% CI: 0.84-1.15) per additional week sexually active in the past month.

Effect of partnership-level sexual activity

There was no significant effect of average partnership-level frequency of sexual activity on method selection within that partnership. Specifically, there was no difference in the risk of condom selection relative to selection of a least effective method per 10% increase in the proportion of weeks sexually active in a partnership (RRR=0.98, 95% CI: 0.93-1.03). Similarly, the effects for selection of the other specific methods relative to the least effective methods were not significant, and there were no overall differences between these null effects (p=0.95).

Effect of woman-level sexual activity

Women's overall frequency of sexual activity had an effect on condom selection, but not on selection of other specific methods. Each 10% increase in a woman's overall frequency of sexual activity was associated with a 4% decrease in the risk of selecting condoms relative to selecting a least effective method (RRR=0.92, 95% CI: 0.92-1.00). The effect of woman-level sexual activity on selecting pills relative to least effective methods was null (RRR=1.01, 95% CI: 0.95-1.08) as was the effect on selection of highly effective methods relative to least effective methods (RRR=1.04, 95% CI: 0.93-1.16).

Comparison of effects across levels

A comparison of the effect of sexual activity at each of the three levels (past month, partnership-level, and woman-level) on method selection revealed significant differences only for condom selection. The effect of sexual activity on selection of condoms relative to the least effective methods varied significantly across the three levels (p<0.001), with significant inverse effects at the past month and woman levels and no effect at the partnership level. There were no variations in effects across the different levels for pill selection relative to the least effective methods (p=0.62) or for selection of highly effective methods relative to the least effective methods (p=0.60).

Adjusted model

Adjusting for potential individual- and partnership-level confounders left the effects of sexual activity on method selection almost entirely unchanged (Table 6.4). The only change in significance or direction of effect was for the effect of woman-level sexual activity on selection of condoms relative to least effective methods, which was just attenuated (aRRR=0.96, 95% CI: 0.93-1.01). Significant differences in the effects on sexual activity on condom use across the three levels remain (p<0.001).

In the sensitivity analysis where weeks in which women discontinued to no method were excluded from the least effective method category, results were unchanged from the main adjusted results (Table 6.S1). As in the main results, the only significant effect of sexual activity on method selection was in the past month on selection of condoms relative to the least effective methods (aRRR=0.81, 95% CI: 0.73-

0.90).

6.4 Discussion

We find that sexual activity does not influence selection between highly effective methods, pills, or least effective methods for any time scale. We do, however, find that when women have sex more often, they are subsequently less likely to select condoms as a new method relative to each of the other methods. Furthermore, the effects of sexual activity on selection of condoms were not the same at different time scales. Specifically, there was no partnership-level effect, suggesting that measuring average sexual activity over the course of a partnership would be insufficient. An analogous effect at the woman level was present in the unadjusted model, but after adjusting for potential confounders this effect also was attenuated, further emphasizing the need to measure short term changes in sexual activity rather than relying on summary measures. The differences in the woman-level effect in the unadjusted and adjusted models also underline the importance of socioeconomic status and relationship qualities as confounders.

Our findings of no effect of sexual activity on selection of methods other than condoms suggests that the mechanism through which sexual activity affects overall use of these methods may be through its effect on discontinuation, rather than through its effect on selection. This result suggests that women may largely not take into account how their coital frequency influences their risk of pregnancy when choosing between contraceptive methods. The Centers for Disease Control and Prevention (CDC)

guidelines for provision of contraceptive methods suggests that withdrawal may be a more suitable method for women who have sex infrequently (Division of Reproductive et al., 2010). This suggestion largely does not appear to play out in our data. While it is of no concern that women who do not have sex very often might be using highly effective methods, it is of greater concern that women who have sex frequently and wish to avoid pregnancy might be using the least effective methods, and thus be at additional risk of unintended pregnancy.

Other unmeasured factors may be influencing the lack of association between sexual activity and contraceptive method selection. Prior research has suggested that numeracy, as measured by accuracy of risk perceptions, is linked to contraceptive risk taking, including nonuse, gaps in use, and use of least effective methods (Ela, 2016). Thus, the confounding effect of ability to accurately perceive risk on method selection may attenuate the effect that we would expect to see in a situation of rational risk-aware behavior. These findings may also be an indication of the other characteristics of contraceptive methods besides the effectiveness of a method at preventing pregnancy that women take into account when making a selection.

Condom use, however, appears to have different influences, potentially reflecting the interplay of both pregnancy risk perceptions and STI risk perceptions in the decision to use condoms. Specifically, we find that women who have sex more often are less likely to choose condoms. This dynamic may be a reflection of unmeasured partnership dynamics, reflecting greater trust and a perception of fewer outside partners. Our analysis should not be used to make inferences about STI protective

behaviors, however, as we have categorized method use through a pregnancy risk lens rather than through an STI risk lens. We are limited in that women are classified according to the most effective contraceptive method they use, and those who are dual users of condoms and hormonal contraceptive methods are not classified as condom users. While we have removed instances when women switched from dual use to condom only use from our analysis (n=164 switches), we are limited by our sample size from increasing the number of outcome categories.

There are additional limitations to this study that should also be acknowledged. While this is a randomly selected population-based sample, the target population is narrow, reflecting young women in a single county in Michigan. These findings may not apply to older women (particularly those in longer term partnerships) and those in other geographic settings. Additionally, our measures of sexual activity are limited to a dichotomous weekly measure, designed to reduce the weekly burden of response and increase retention rates. While a more detailed account of coital frequency within a specific week would add valuable information to this type of analysis, the loss to follow up due to burdensome weekly surveys would likely not be worth the gained information.

Results of this final aim, illustrating how sexual activity relates to new contraceptive behaviors, completes a dynamic exploration of how patterns of sexual activity relate to contraceptive behaviors. The findings of each of these three results chapters will be synthesized and discussed in the following final discussion chapter.

Table 6.1. Aim 3: Baseline characteristics of women (n=430)

Characteristic	Baseline Prevalence % (n) or mean (SD)
Age	19.2 (0.58)
Race/Ethnicity	
White	60.9 (262)
Black	28.6 (123)
Hispanic	8.6 (37)
Other	1.9 (8)
HS GPA	3.1 (0.62)
Post-Sec Enrollment	
No	43.7 (188)
Yes	56.3 (242)
Highly Religious	
No	46.0 (198)
Yes	54.0 (232)
Ever Public Assistance	
No	67.0 (288)
Yes	33.0 (142)
First Sex <=15	
No	63.5 (273)
Yes	36.5 (157)
Ever Pregnant	
No	72.1 (310)
Yes	27.9 (120)
Multiple Past Partners	
No	28.6 (123)
Yes	71.4 (307)

Table 6.2. Aim 3: Short term, partnership-level, and woman-level sexual activity and contraceptive use

Measure	**Short Term*** (n=1,799) %	**Partnership Level** (n=640) mean (SD)	**Woman Level** (n=430) mean (SD)
Sexual Activity	64.9% (35%)	74.2% (25.1%)	69.0% (24.0%)
Method Selected			
Least Effective	39.7%	37.5% (36.4%)	36.2% (29.2%)
Condoms	26.8%	27.5% (35.5%)	24.6% (27.6%)
Pills	24.6%	26.7% (36.6%)	29.8% (34.9%)
Highly Effective	8.8%	8.3% (22.7%)	9.3% (21.8%)

*Short term is past month for sexual activity and week level for method selected.

Table 6.3. Aim 3: Unadjusted multinomial logistic models for new contraceptive behaviors (n=1,799 switches; N=430 women)

	RRR [95% CI] [a]			*p*-value for differences between methods
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	
Past month sexual activity [b]	0.77 [0.71-0.84]***	0.96 [0.87-1.08]	0.95 [0.81-1.09]	<0.001
Partnership-level sexual activity [c]	0.98 [0.93-1.03]	0.97 [0.89-1.03]	0.97 [0.88-1.07]	0.95
Woman-level sexual activity [c]	0.96 [0.92-1.00]*	1.01 [0.95-1.08]	1.04 [0.93-1.16]	0.21
p-value for differences between levels [d]	<0.001	0.62	0.60	

[a] Bootstrapped bias corrected and accelerated confidence intervals

[b] Past month sexual activity is scaled by 4 so that RRR estimates refer to relative increases per additional week sexually active in prior month

[c] Scaled by 10 so that RRR estimates refer to relative increase per additional 10% of weeks sexually active

[d] Calculated for unscaled effects at all three levels

Table 6.4. Aim 3: Adjusted multinomial logistic models for new contraceptive behaviors (n=1,941 switches; N=439 women)

	RRR [95% CI] [a]			*p*-value for differences between methods
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	
Past month sexual activity [b]	0.78 [0.71-0.85]***	0.92 [0.83-1.03]	0.94 [0.81-1.01]	0.01
Partnership-level sexual activity [c]	0.96 [0.91-1.02]	1.00 [0.90-1.08]	1.01 [0.90-1.14]	0.71
Woman-level sexual activity [c]	0.97 [0.93-1.01]	1.01 [0.94-1.07]	1.02 [0.92-1.14]	0.49
Age (years)	1.07 [0.81-1.22]	0.93 [0.76-1.07]	1.04 [0.80-1.34]	
African-American	1.01 [0.87-1.32]	0.70 [0.50-1.07]	1.87 [1.09-3.47]*	
Post-Sec Enrollment	1.08 [0.87-1.32]	1.43 [1.07-1.93]*	1.10 [0.67-1.73]	
Highly Religious	1.07 [0.89-1.33]	0.92 [0.69-1.23]	1.00 [0.59-1.73]	
Ever Public Assistance	1.04 [0.83-1.28]	0.91 [0.68-1.31]	2.39 [1.38-3.54]***	
Multiple Past Partners	0.85 [0.68-1.05]	0.93 [0.69-1.28]	1.27 [0.65-2.57]	
Relationship Type				
Casual/Non-exclusive dating	ref	ref	ref	
Long distance	0.91 [0.56-1.41]	1.23 [0.75-2.09]	2.24 [0.99-5.69]	
Exclusive dating	0.99 [0.69-1.39]	1.54 [1.01-2.28]*	2.29 [1.06-5.03]*	
Cohabiting	0.93 [0.63-1.35]	1.19 [0.76-1.87]	2.05 [0.88-5.24]	
Married/Engaged	0.85 [0.58-1.34]	0.87 [0.48-1.51]	2.48 [1.00-5.95]*	
Relationship duration (per month)				
0-12 months	0.99 [0.96-1.01]	1.04 [1.00-1.07]	0.99 [0.93-1.04]	
>12 months	1.02 [0.99-1.05]	0.97 [0.93-1.01]	1.02 [0.96-1.69]	
Ever pregnant with current partner	0.97 [0.75-1.21]	1.08 [0.83-1.51]	1.04 [0.67-1.69]	

[a] Bootstrapped bias corrected and accelerated confidence intervals

[b] Past month sexual activity is scaled by 4 so that RRR estimates refer to relative increases per additional week sexually active in prior month

[c] Scaled by 10 so that RRR estimates refer to relative increase per additional 10% of weeks sexually active

Table 6.S1. Aim 3: Sensitivity analysis adjusted multinomial logistic models for new contraceptive behaviors excluding no method weeks (n=1,533 switches; N=418 women)

	aRRR [95% CI] [a]			*p*-value for differences between methods
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	
Past month sexual activity [b]	0.81 [0.73-0.90]	0.96 [0.86-1.06]	0.99 [0.84-1.15]	0.008
Partnership-level sexual activity [c]	1.02 [0.94-1.12]	1.06 [0.98-1.15]	1.05 [0.92-1.19]	0.74
Woman-level sexual activity [c]	0.99 [0.94-1.05]	1.03 [0.95-1.12]	1.05 [0.94-1.17]	0.47

[a] Bootstrapped bias corrected and accelerated confidence intervals, adjusted for individual and partnership confounders in Table 6.3

[b] Past month sexual activity is scaled by 4 so that RRR estimates refer to relative increases per additional week sexually active in prior month

[c] Scaled by 10 so that RRR estimates refer to relative increase per additional 10% of weeks sexually active

Table 6.S2. Aim 3: Sensitivity analysis adjusted multinomial logistic models for new contraceptive behaviors restricting at least three weeks of past month data (n=1,693 switches; N=406 women)

	aRRR [95% CI] [a]			*p*-value for differences between methods
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	
Past month sexual activity [b]	0.77 [0.70-0.85]	0.91 [0.82-1.03]	0.90 [0.75-1.06]	0.03
Partnership-level sexual activity [c]	0.98 [0.93-1.04]	1.01 [0.92-1.08]	1.01 [0.90-1.15]	0.83
Woman-level sexual activity [c]	0.96 [0.92-1.01]	1.00 [0.94-1.08]	1.03 [0.93-1.17]	0.43

[a] Bootstrapped bias corrected and accelerated confidence intervals, adjusted for individual and partnership confounders in Table 6.3

[b] Past month sexual activity is scaled by 4 so that RRR estimates refer to relative increases per additional week sexually active in prior month

[c] Scaled by 10 so that RRR estimates refer to relative increase per additional 10% of weeks sexually active

Table 6.S3. Aim 3: Sensitivity analysis adjusted multinomial logistic models for new contraceptive behaviors restricting at least four weeks of past month data (n=1,573 switches; N=376 women)

	aRRR [95% CI] [a]			*p*-value for differences between methods
	Condom vs. Least Effective	Pill vs. Least Effective	Highly Effective vs. Least Effective	
Past month sexual activity [b]	0.79 [0.72-0.88]	0.93 [0.83-1.04]	0.89 [0.74-1.06]	0.06
Partnership-level sexual activity [c]	0.96 [0.89-1.03]	1.00 [0.90-1.08]	0.97 [0.85-1.11]	0.75
Woman-level sexual activity [c]	0.96 [0.92-1.00]	0.99 [0.92-1.06]	1.02 [0.91-1.16]	0.62

[a] Bootstrapped bias corrected and accelerated confidence intervals, adjusted for individual and partnership confounders in Table 6.3

[b] Past month sexual activity is scaled by 4 so that RRR estimates refer to relative increases per additional week sexually active in prior month

[c] Scaled by 10 so that RRR estimates refer to relative increase per additional 10% of weeks sexually active

7 Discussion

Patterns of sexual activity have a complex influence on contraceptive behaviors. In Aim 1 we show a deceptively straightforward association between sexual activity and increased weekly use of each specific method according to effectiveness. In Aims 2 and 3 we demonstrate the compositional complexity of these associations. In Aim 3 our findings suggest that women take into account their recent sexual activity when deciding whether or not to select condoms as their primary contraceptive method. On the other hand, findings from Aim 2 suggest that sexual activity exerts its influence on use of hormonal contraceptive methods through an association with method discontinuation, rather than through an influence on initial selection of these methods. These dimensions of the interplay between sexual activity and contraceptive behaviors have important implications for research and practice and have not previously been fully described.

As we note in Aim 3, women appear to take into account their recent sexual activity when deciding whether to select condoms as their contraceptive method or to select some other method. Specifically, women who have recently been less sexually active tend to select condoms. This finding is generally consistent with prior research that suggests an association between less frequent sexual activity and greater condom use, including a 1999 meta-analysis (Sheeran et al., 1999), as well as several more recent individual studies (Katz et al., 2000; Marshall et al., 2016; Sayegh et al., 2006).

Several characteristics of our analysis, however, are unique from this prior literature on sexual activity and condom use. First, these studies approach condom use

as an STI-protective behavior rather than as a pregnancy-protective behavior. Condom nonusers, therefore, could include women who are using no contraceptive method as well as women using highly effective contraceptive methods. Additionally women who are using only condoms are not distinguished from women using condoms in addition to more effective contraceptive methods. Studies that have considered sexual activity and condom use through a pregnancy prevention lens have found additional complexity to the association (Frost & Darroch, 2008; Wildsmith et al., 2015) (Kusunoki & Upchurch, 2011).

What is to our knowledge lacking in this prior literature is a distinction between how sexual activity influences *selection* of condoms as a new contraceptive method versus how sexual activity influences *continuation* of condom use. The variety of measures of condom use, such as condom use at last sex (Marshall et al., 2016) or the number of condom unprotected sex acts (Sayegh et al., 2006) do not distinguish between the decision to start using condoms and the decision to continue using condoms. These two types of cognitive processes may differ substantially in how they are influenced by a variety of factors, including sexual activity (Rothman, 2000). Accordingly, we find in our study that sexual activity is inversely associated with selection of condoms as a new contraceptive method but is not associated with continued use of condoms.

Our overarching finding that greater frequency of sexual activity is associated with greater use of hormonal contraception and other highly effective methods is in line with some of the prior literature in this area (Frost & Darroch, 2008; Kusunoki &

Upchurch, 2011). We find that the mechanism for influence on sexual activity on hormonal contraceptive use is different than the mechanism for condom use. Specifically, The influence of sexual activity on use of effective methods appears to be through its influence on method discontinuation, rather than through an association with initial method selection. These findings on the effects on selection and discontinuation of effective methods may explain in part some of the heterogeneity in prior studies (Wildsmith et al., 2015; Wilson & Koo, 2008). Furthermore, our findings on the association between sexual activity and contraceptive discontinuation are corroborated by reasons that women have given for switching methods in prior studies (Huber et al., 2006; Jaccard et al., 1995; Rosenberg & Waugh, 1998).

There are several possible reasons that the mechanisms through which sexual activity influences method use may differ between condoms and hormonal methods. The influence of sexual activity on method selection, which appears to most greatly influence condom use, may relate to specific characteristics of condoms that do not apply to hormonal methods. When selecting a new method and deciding whether or not to choose condoms, women may be taking into consideration their risk of STIs and HIV in addition to their risk of pregnancy (O'Leary, 2011). While pregnancy risk increases directly with respect to the number of unprotected coital events, it is possible that women who have sex with a partner less frequently may actually have a perception of increased risk of acquiring an STI because of the increased chance that her partner may have had additional partners between sexual encounters.

Additional reasons that may contribute to the association between sexual activity and condom selection include both cost and convenience. Unlike hormonal methods, the cost of being a condom user increases according to frequency of sexual activity. Condoms may therefore be a more appealing economic option when women are having sex less frequently and less appealing when women are having sex more frequently. In addition to the financial cost, a coital method such as the condom, also has a cost of convenience that relates to frequency of sexual activity, whereas the mechanisms of using hormonal methods or the IUD do not depend on frequency of sexual activity.

Future research into life events that can cause changes in the frequency of sexual activity may also provide insight into times when women are at risk of discontinuing a contraceptive method. Preliminary research, for example, has identified housing instability and residential moves as times when women are at risk of not using contraception (Clark, Kusunoki, & Barber, 2017). There is also evidence that partnership instability, which could result in disrupted patterns of sexual activity, may increase the risk of unintended pregnancy (Moreau et al., 2011).

Our findings with respect to the least effective methods may appear somewhat surprising. The overall trends, with respect to selection and discontinuation, appear to track most closely with the pill and the highly effective methods, rather than with condoms. Prior research has suggested that poor numeracy, or the inability to accurately understand risk and cumulative risk, may relate to use of less effective methods of contraceptive (Ela, 2016). Because our conceptual framework predicates the

short-term association between sexual activity and contraceptive behavior on perceptions of unintended pregnancy risk, the effect of sexual activity may be differentially attenuated among women using the least effective methods due to low numeracy. Additionally, through the lens of the transtheoretical model for health behavior change (Prochaska, Redding, & Evers, 2008), women using no method may not be making an active decision about their contraceptive state. In fact, they may be in the "precontemplation" stage, and may simply not be perceiving or thinking about pregnancy risk.

We found no independent effects of partnership-level or woman-level sexual activity on method selection, although greater sexual activity at each of these levels did relate to less discontinuation. What is important about these partnership-level and woman-level findings is that they do not reflect the full dynamic of how sexual activity influences contraceptive behavior over time. For example, without repeated measures over time, the effect of recent month sexual activity on condom selection would not have been detected. These findings underscore the critical importance of longitudinal studies with frequent data collection for understanding the dynamics of sexual and reproductive health behaviors

There are several limitations to our research that may impact the generalizability of our findings. The RDSL is a population-based sample that is representative of its target population, but this target population of women ages 18-22 in a single county of Michigan is relatively narrow, despite some racial and socioeconomic diversity. Our study findings may not be applicable to older women and particularly to women in

longer term stable partnerships. The RDSL target population, however, was selected because young adult women are the population most at risk of unintended pregnancy in the United States (Finer & Zolna, 2014).

The focus of our study and of the RDSL is on fertility and the prevention of unintended pregnancy and as such our analysis does not fully account for STI and HIV risk perceptions and preventive behaviors. Our analysis of the influence of sexual activity on condom behaviors is potentially susceptible to this omission, as condoms are highly effective for STI prevention but only moderately effective for pregnancy prevention compared to other contraceptive methods (Sundaram et al., 2017). Furthermore, there is evidence to suggest that dual method use relative to use of condoms only or hormonal methods only depends on the salience of STI risk perceptions relative to pregnancy risk perceptions (Ott, Adler, Millstein, Tschann, & Ellen, 2002). We categorize weeks in which multiple methods were reported according to the method used that is most effective at preventing pregnancy. Thus, weeks in which condoms were used in addition to a more effective method were classified as pill or highly effective method weeks. Through an STI prevention lens, the condom use element of these dual use weeks would be important, and potentially influenced by patterns of sexual activity. While the RDSL contains data on all methods used in a given week, expanding our outcome measures to include additional dual use categories would have increased the complexity of our study to the detriment of power of the analyses.

As this study was a secondary data analysis, the RDSL was not designed to address our specific research question and we were limited to the available measures.

The weekly questionnaire did not include information specifically about coital frequency within a given week and women were not asked about contraceptive use with respect to specific coital events. Furthermore, women were not asked about menstruation, which could affect both sexual activity as well as contraceptive use due to perceptions about susceptibility to pregnancy. The brevity of the weekly journal instrument, however, was critical in ensuring the unusually high retention rate of a study that asked participants to complete weekly surveys for more than two years (Barber et al., 2011). Thus, additional measures in the weekly instrument would likely have added to the burden of response and increased loss to follow-up.

We have investigated in our research a certain level of complexity beyond prior studies of sexual activity and contraceptive use. It is likely, however, that there are additional complexities to this association that are beyond the scope of our study. For example, it is possible that some of the effects of sexual activity on contraceptive behaviors are modified by other characteristics. A prior study, for example, that found no association between sexual activity and contraceptive use was conducted specifically among low-income women (Wilson & Koo, 2008), raising the possibility of effect modification by socioeconomic status. The associations between partnership characteristics and contraceptive use are also complex (Kusunoki, 2014), and there are likely additional interactions between these characteristics and the effects of sexual activity on contraceptive behaviors. Despite the large sample size of weeks of data, the additional comparisons that would be required to test these interactions, particularly in

multilevel multinomial method-specific models were beyond the scope of the power of our secondary analyses.

There are several important conclusions from our research that have direct implications for the prevention of unintended pregnancy and the promotion of reproductive autonomy in public health practice. Our research may be particularly useful in understanding adolescent and young adult risk of unintended pregnancy, as these populations tend to have sex less frequently and more sporadically than older women in more established partnerships. The effect of infrequent sex on method discontinuation may in part explain the high rates of unintended pregnancies among young adults (Finer & Zolna, 2016).

The short-term effect of sexual activity poses a particular challenge to health educators, clinicians, and others providing contraceptive counseling and guidance. It is already recommended in the Center for Disease Control and Prevention's guidelines for provision of family planning services that a medical history be taken regarding information that may be relevant to selection of a contraceptive method, including taking a history of recent sexual activity (Gavin et al., 2014). There is not, however, specific guidance on how to use this sexual history in the context of contraceptive counseling beyond a note in the medical eligibility criteria for contraceptive use specific only to the use of withdrawal, which the criteria state, "might be appropriate for couples … who have intercourse infrequently" (Division of Reproductive et al., 2010). While clinicians and counselors are in a position to discuss contraceptive use and sexual activity, they need guidance on what to discuss.

Contraceptive counseling frequently occurs in the context of new method selection, but in our study we find that this is not where the greatest influence of sexual activity occurs. Counselors need to be equipped to provide anticipatory guidance to women about how method discontinuation can occur in the context of future major life events and more gradual changes over time in life circumstances that result in changes in sexual activity. Counselors can support women who make changes in their contraceptive behavior when they are out of clinical contact by equipping women in advance with the resources to make safe transitions between contraceptive methods.

This anticipatory approach has been better developed for advance provision of emergency contraception. A study published in 2000 demonstrated that providing emergency contraception in advance significantly increased its use after unprotected sex (Raine, Harper, Leon, & Darney, 2000). A later meta-analysis provided additional evidence that advance provision of emergency contraception increases use without adverse effects on potentially risk sexual behavior (Polis et al., 2007). Changes in the regulation of emergency contraception eventually ensued and the drug became available over the counter in pharmacies (Cleland, Bass, Doci, & Foster, 2016).

Advance provision of emergency contraception is important but not sufficient to address women's pregnancy prevention needs outside of the clinical setting, as evidenced by research suggesting little effect of advance provision of emergency contraception on pregnancy rates (Polis et al., 2007). A similar approach to increasing access to ongoing hormonal contraceptive methods outside of the clinical setting is needed. While some have advocated for over-the-counter access for the contraceptive

pill, these efforts have not yet been successful in the United States (Grossman, Cackovic, & Paidas, 2008). Recent state-level policy changes in several states including Oregon have made the pill more accessible in pharmacies without having to visit a physician or other advance practice clinician for a prescription (Rodriguez, Anderson, & Edelman, 2016). This approach could provide additional needed support for women to continue or switch contraceptive methods with minimal pregnancy risk when they are not in contact with the clinical care system.

There are several ways that clinicians and health educators could better equip women to handle changes in sexual activity and contraceptive behaviors once they are beyond clinical contact. First, our study findings on the dynamics of these behaviors underscore the need to provide women with information on the full range of contraceptive methods, including and beyond the method that they select that day. The goal of contraceptive counseling should not be to urge women to choose a specific method, but to enable them to make an informed and autonomous decision about what method to select (Gomez, Fuentes, & Allina, 2014; Gubrium et al., 2016). Taking into account our study findings, we suggest that an additional goal of contraceptive counseling should be to enable women to make future informed decisions about contraceptive continuation and selection.

Beyond providing high quality counseling, clinicians and counselors can also provide material support to women in advance of future method discontinuations and selections. Contraceptive counseling should include information about the risk of pregnancy associated with discontinuing or switching methods. Furthermore, depending

on the method that women select, they could be provided with materials to reduce the risk of unintended pregnancy upon method discontinuation. For example, a woman who selects the pill could be provided with a supply of condoms, emergency contraception and a referral card with information about how to make an appointment to obtain another type of method, such as the IUD or implant, in case she decides to discontinue the pill. Similarly, a woman who selects condoms could be provided with emergency contraception, a pack of pills in case she decides to discontinue using condoms, and information about how to obtain other types of methods. Having alternate methods on hand in case of discontinuation could reduce unintended pregnancies that result from recent method discontinuations.

Additional approaches to supporting women's contraceptive use when they are outside the clinical setting may include building the capacity of community-based professionals who work with adolescents and young adults in other capacities on a day-to-day basis to provide supportive pregnancy prevention resources. Prior research suggests that in a broad range of community-based organizations, professionals who work with youth already have conversations about relationships and sexual health (Fisher et al., 2012). Success of a recent intervention to develop the capacity of youth-serving professions to discuss sexual health issues with young men and refer them to clinical sexual and reproductive healthcare services (Marcell et al., 2016) could be translated to improving community-based contraceptive supports for young men and women.

Our study on the multidimensional association between sexual activity and contraceptive use underscores the importance of investing in detailed longitudinal research projects. Rich data sources, such as the RDSL allow us to more fully understand women's sexual and reproductive health behaviors. This study findings provide the basis for improving sexual and reproductive health services, formulating supportive policies, and supporting women's reproductive right to decide if and when to become pregnant.

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Wildsmith, E., Manlove, J., & Steward-Streng, N. (2015). Relationship characteristics and contraceptive use among dating and cohabiting young adult couples. *Perspect Sex Reprod Health, 47*(1), 27-36.

Wilson, E. K., & Koo, H. P. (2008). Associations between low-income women's relationship characteristics and their contraceptive use. *Perspect Sex Reprod Health, 40*(3), 171-179.

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SUSANNAH E. GIBBS
229 Hallie Ford Center, Corvallis, OR 97331
Phone: (971)-998-3913
Email: susannah.gibbs@oregonstate.edu

EDUCATION

2017 **PhD**, Population, Family & Reproductive Health, Johns Hopkins Bloomberg School of Public Health
2013 **MSPH**, Population, Family & Reproductive Health, Johns Hopkins Bloomberg School of Public Health
2011 **BA**, Public Policy Analysis/Biology, Pomona College

POSITIONS

Oregon State University, College of Public Health and Human Sciences
2017- Research Analyst
2016- Courtesy Faculty Research Assistant

University of California, San Francisco, Bixby Center for Global Reproductive Health
2013-14 Research Analyst

TEACHING EXPERIENCE

Johns Hopkins Bloomberg School of Public Health
Teaching Assistant: Child Health and Development (Fall 2016)
Guest Lecturer: Abortion from a Public Health Perspective (Spring 2016)
Teaching Assistant: Life Course Perspectives on Health (Fall 2014)

PUBLICATIONS

Peer-Reviewed Publications

Marcell AV, **Gibbs S**, Pilgrim NA, Page KR, Sanders R, Jennings JM, Loosier PS, Dittus PJ. (in press). Sexual and reproductive health care receipt among young males aged 15-24. *Journal of Adolescent Health*.

Mmari K, **Gibbs S**, Moreau C, Naranjo-Rivera G, de Meyer S, El Gibaly O, Al-Attar G, Kabiru C, Maina B, Bello B, Xiayun Z, Chahua L. (in press). 'Yea, I've grown; I can't go out anymore': perceived risks for girls and boys entering adolescence. *Culture, Health & Sexuality.*

Gibbs S, Moreau C. (2017). Discordance of fertility desires with perceived partner fertility desires and association with contraceptive use. *European Journal of Contraception & Reproductive Health Care*. 22(4):310-315.

Marcell AV, **Gibbs S**, Howard SR, Pilgrim NA, Jennings JM, Sanders R, Page KR, Loosier PS, Dittus PJ. (2017). Do nonclinical community-based youth-serving professionals talk with young men about sexual and reproductive health and intend to refer them for care? *American Journal of Men's Health*. 11(4):1046-1054.

Gibbs S, Rocca C, Bednarek P, Thompson K, Darney P, Harper CC. (2016). Long acting reversible contraception counseling and use for older adolescents and nulliparous women. *Journal of Adolescent Health.* 59(6):703-709.

Kågesten A, **Gibbs S**, Blum RW, Moreau C, Chandra-Mouli V, Herbert A, Amin A. (2016). Understanding factors that shape gender attitudes in early adolescence globally: A mixed-methods systematic review. *PLoS One*. 11(6): e0157805.

Marcell AV, **Gibbs S,** Choiriyyah I, Sonenstein FL, Astone NM, Pleck JH, Dariotis JK. (2016) National needs of family planning among US men ages 15 to 44 years. *American Journal of Public Health*. 106(4):733-739.

Rafie S, Kelly S, Gray EK, Wong M, **Gibbs S**, Harper CC. (2016). Provider opinions regarding expanding access to hormonal contraception in pharmacies. *Women's Health Issues*. 26(3):153-160.

Marcell AV**, Gibbs S**, Lehmann HP (2016) Brief condom interventions targeting males in clinical settings: a meta-analysis. *Contraception*. 93(1):153-163.

Chandra-Mouli V, **Gibbs S**, Badiani R, Quinhas F, Svanemyr J. (2015). Programa Geração Biz, Mozambique: How did this adolescent health initiative grow from a pilot to a national programme, and what did it achieve? *Reproductive Health.* 12.

Tomori C, Risher K, Limaye RJ, Van Lith L, **Gibbs S**, Smelyanskaya M, Celentano DD. (2014). A Role for health communication in the continuum of HIV care, treatment, and prevention. *JAIDS.* 66(S3):S306-S310.

Gibbs S, Le LC, Dao, HB, Blum R. (2014). Peer and community influences on the acceptance of premarital sex among Vietnamese adolescents. *Journal of Paediatrics and Child Health.* 50(6):438-443.

Chandra-Mouli V, Mapella E, John T, **Gibbs S**, Hanna C, Kampatibe N, Bloem P. (2013). Standardizing and scaling up quality adolescent friendly health services in Tanzania. *BMC Public Health*. 13(1):579.

Lee A & **Gibbs S.** (2013) Neurobiology of food addiction and adolescent obesity prevention in low and middle income countries. *Journal of Adolescent Health*. 52(S2):S39-S42.

Medina-Mora M, **Gibbs S.** (2013) Implications of science on illicit drug use policies for adolescents in low- and middle-income countries. *Journal of Adolescent Health.* 52(S2):S33-S35.

Christiansen C, **Gibbs S**, Chandra-Mouli V. (2013) Preventing early pregnancy and pregnancy-related mortality and morbidity in adolescents in developing countries: The place of interventions in the pre-pregnancy period. *Journal of Pregnancy.* 2013.

Conference Presentations

Gibbs S, Kusunoki Y, Moreau C. "Sexual Activity and Contraceptive Method Selection in Young Adult Women." International Union for the Scientific Study of Population, International Population Conference. Cape town, South Africa. November 2017.

Gibbs S, Strobino D, Harvey SM. "Planned Out of Hospital Birth and Medicaid Policy Changes in Oregon." Annual Meeting of the Society for Pediatric and Perinatal Epidemiologic Research. Seattle, WA. June 2017.

Gibbs S, Kusunoki Y, Moreau C. "Sexual Activity and Weekly Contraceptive Use in Young Adult Women." Population Association of America Annual Meeting. Chicago, IL. April 2017.

Marcell AV, Perin J, **Gibbs S**, Howard S, Heuklom S, Pilgrim N, Jennings J, Sanders R, Page K, Loosier P, Dittus P. "Did a brief intervention increase community-based youth-serving professionals' sexual healthcare discussions and referrals with young men?" STD Prevention Conference. Atlanta, GA. September 2016.

Gibbs S, Moreau C. "Discordance of fertility desires with perceived partner fertility desires and association with contraceptive use" Population Association of America Annual Meeting. Washington, DC. April 2016.

Mmari K, **Gibbs S**, Moreau C, Naranjo-Rivera G, de Meyer S, El Gibaly O, Al-Attar G, Kabiru C, Maina B, Bello B, Xiayun Z, Chahua L. "'Yea, I've grown; I can't go out anymore': perceived risks for girls and boys entering adolescence." Population Association of America Annual Meeting. Washington, DC. April 2016.

Marcell AV, **Gibbs S**, Howard SR, Pilgrim NA, Jennings JM, Sanders R, Page KR, Loosier PS, Dittus PJ. "Are youth-serving professionals in community organizations providing young men with sexual and reproductive health information and referring them to care?" Society for Adolescent Health and Medicine Annual Meeting. Washington, DC. March 2016.

Gibbs S, Rocca CH, Henderson JT, Westhoff C, Darney PD, Harper CC. "Attitudes of young women in reproductive health clinics toward pelvic examinations by race/ethnicity" ACOG Annual Clinical and Scientific Meeting. San Francisco, CA. May 2015.

Gibbs S, Rocca C, Thompson KMJ, Darney P, Bednarek P, Speidel J, Harper CC. "Access to long-acting reversible contraception for nulliparous women: Results from a cluster randomized trial." American Public Health Association Annual Meeting. New Orleans, LA. November 2014.

Harper CC, Rocca CH, Thompson KM, Patel A, **Gibbs S**, Speidel J, Darney PD. "STI history and IUD provision: results from a cluster randomized trial." North American Forum. Miami, FL. October 2014.

Van Lith LM, Limaye RJ, **Gibbs S**, Roush S. "Combination prevention for HIV: evidence for the role of health communication in stemming the epidemic." International Conference on AIDS and STIs in Africa. Cape Town, South Africa. December 2013.

Kamala B, **Gibbs S**, Mlangwa S, Kauffman M, David G. "HIV risk behaviors and relationship characteristics associated with concurrent sexual partnerships in Tanzania." National Institute for Medical Research Annual Joint Scientific Conference and One Health Conference in Africa. Arusha, Tanzania. April 2013.

FUNDING

Pending

NICHD F32 HD095554-01 (PI). Evaluating pharmacist prescription of hormonal contraception among low-income women in Oregon. 4/2018-3/2021. $172,890.

Consortium of Universities for Global Health (PI). Developing and piloting an economically empowering comprehensive sexual and reproductive health education program for adolescents in Tanzania. 1/2018-12/2018. $5,000.

Current

Save the Children (Consultant). Developing a manuscript for evaluation of the Choices, Voices, Promises gender transformative intervention for 10-14 year-olds in Nepal. 5/2017-9/2017. $2,450.

Completed

HRSA T03MC07645 MCH Epidemiology Doctoral Training (Predoctoral Fellow). Planned out of hospital birth and Medicaid policy changes in Oregon. 9/2016-8/2017. $26,860.

University of California, San Francisco, Advancing New Standards in Reproductive Health (Consultant). Reviewing the literature on clinical facility requirements and access to healthcare services. 5/2017-8/2017. $1,480.

Georgetown University, Institute for Reproductive Health (Consultant). Developing indicators to use in the evaluation of gender transformative interventions for 10-14 year-olds. 2/2017-4/2017. $3,480.

ADDITIONAL RESEARCH EXPERIENCE

Johns Hopkins Bloomberg School of Public Health, Department of Population, Family & Reproductive Health

2016-17 Graduate Research Assistant: Building a new healthcare provider tool to tailor predictions of contraceptive outcomes to patient sub-populations; PI: Caroline Moreau

2015-16 Graduate Research Assistant: Project Connect: Evaluating community-based methods to engage males in clinical sexual and reproductive healthcare; PI: Arik Marcell

2014-15 Graduate Research Assistant: Global Early Adolescent Study; PI: Robert Blum

World Health Organization, Department of Reproductive Health and Research

2012 Research Intern: Establishing recommendations for violence screening in HIV testing and for addressing violence against sex workers

Johns Hopkins Bloomberg School of Public Health

2011-13 Graduate Research Assistant: Center for Communication Programs**,** Tanzania and Malawi Teams, Baltimore, MD & Dar es Salaam, Tanzania

HONORS AND AWARDS

2016-17 Maternal and Child Health Training Grant (tuition support)
2016-17 Fellowship in Family Planning and Reproductive Health (stipend support)
2015-16 Award from the Fund in Recognition of Laurie Schwab Zabin for Population and Family Planning Students (tuition & stipend support)
2014-15 Robertson Endowment Award (tuition support)
2011-12 Robertson Endowment Award (tuition support)
2011 Russell M. Story Prize in Public Policy Analysis, Pomona College

ACADEMIC AND UNIVERSITY SERVICE

Doctoral Admissions Committee Member (2015-2016), Johns Hopkins Bloomberg School of Public Health, Department of Population, Family & Reproductive Health
Alumni Admissions Interviewer (2015-present), Pomona College
Reviewer: *Journal of Women's Health*

PROFESSIONAL MEMBERSHIPS

Population Association of America (PAA)
Oregon Public Health Association (OPHA)
Society for Pediatric and Perinatal Epidemiologic Research (SPER)
International Union for the Scientific Study of Population (IUSSP)
Delta Omega Honorary Society in Public Health, Alpha Chapter