# Identifying peer effects using spatial analysis: the role of peers on risky sexual behavior

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## Abstract

This paper explores the role of peer effects on early sexual debut for a sample of adolescents using data from the National Longitudinal Study on Adolescent Health (Add Health). Most studies analyzing peer influences ignore the "reflection" problem that occurs with studying peer effects. To address the reflection problem, this paper employs a spatial econometric approach to estimate a social interactions model. This is the first study in the literature on adolescent risky sexual behavior to use this approach to estimate peer effects. Similar to other research on peer effects and adolescent risky sexual behavior, this paper finds the existence of peer effects. However, the more vital outcome from this study is that older and male peers increase the likelihood of adolescent early sexual debut, while peers whose mothers are more open about sexual activity decrease adolescent risky sexual behavior. This methodology can help further our knowledge about the social context that influences adolescent sexual behavior.

### Keywords

Peer effects; Early sexual debut; Risky sexual behavior; Social interactions model; Spatial durbin probit model

## 1 Introduction

Early initiation of sexual behavior is associated with adverse health and educational outcomes such as sexually transmitted diseases (STDs), unintended pregnancies (Davis and Friel 2001), poor mental health (Sabia and Rees 2008) and lower grade-point averages (Sabia 2007). This is of particular concern for adolescents since risky sexual behavior not only adversely affects outcomes in the short-run but also has important long-run ramifications (Gruber 2001; O' Donoghue and Rabin 2001). There is a vast literature that studies the factors that influence adolescent risky sexual behavior (Buhi and Goodson 2007; Kotchick et al. 2001; Zimmer-Gembeck and Helfand 2008). These factors include intentions to have sex, environmental constraints, and social norms. One factor that has been the subject of much study is the role of an adolescent's peers (Kinsman et al. 1998). Peers can influence individual behavior through several mechanisms. Individuals can engage in behavior because they believe engaging in this behavior will enhance their popularity, it

matches the social norms of a desired group, it is reinforced by peers, or the behavior contributes to a favorable self-identity (Brechwald and Prinstein 2011). Peers also influence sexual activity through dissemination of information and the formation of intention to engage in sexual activity. The study of peer effects in health behaviors has flourished because of the realization while individuals make choices based on individual preferences, their decisions can be influenced by others (Blume and Durlauf 2005; Cawley and Ruhm 2011).

This paper estimates how an adolescent's peer group affects sexual debut and risky sexual behavior. While the analysis of peer influence on sexual activity is well researched, there are noted methodological issues with the estimation of peer effects (Manski 1993). Current methods do not properly disentangle the effect of peers. Many studies on peer effects do not account for these issues and in the studies that try to correct for these issues, most scholars use either peer group fixed effects or instrumental variable regression techniques to estimate the endogenous peer effects (Fletcher 2012). However, recent advances in spatial econometrics have been shown to be useful in estimating social interaction models that can correct these issues (Blume et al. 2011). Lee (2007) argues that using spatial analysis brings the model closer to standard social interactions model by explicitly modeling the contextual effects. This methodology has been applied to studies of student achievement (Calvó-Armengol et al. 2009; Lin 2010). This paper is the first to apply spatial methodology to the estimation of peer effects on adolescent risky sexual behavior. Data are taken from the National Longitudinal Survey of Adolescent Health (Add Health) dataset to estimate the model. The results show that older and male peers increase the likelihood of adolescent early sexual debut, while peers whose mothers are more open about sexual activity decrease adolescent risky sexual behavior. This methodology along with the LeSage and Pace (2009) approach to obtaining marginal effects can help to further our understanding of the social context that influences adolescent sexual behavior.

## 2 The reflection problem

The theoretical framework for analyzing peer effects comes from the social interactions literature. Social interaction models study the relationship between interactions among individuals and collective behavior. Akerlof (1997) explains, "As a consequence, the impact of my choices on my interactions with other members of my social network may be the primary determinant of my decision, with the ordinary determinants of choice of only secondary importance". These models can help explain the observation that individuals within the same group tend to exhibit the same behavior. This explains the popularity of social interaction models for the exploration of peer group effects. Peer groups can influence adolescent decision-making through three mechanisms: endogenous interactions, contextual interactions, and correlated effects (Manski 2000). Endogenous interactions occur when the behavior of the group affects the behavior of the individual, contextual interactions occur the individual's behavior varies with the characteristics of the group like age, race or gender, and correlated effects occur when the environment plays a role in the behavior of individuals within a group. Several authors have sought to empirically test these interactions and effects, mostly the endogenous interactions (Blume and Durlauf 2005; Fowler and Christakis 2008).

A problem with the estimation of social interaction models is the "reflection" problem (Manski 1993). While peers' outcome affects the individual's decision, the individual's decision could influence the peers' outcome. In the reduced form of the social interaction framework, the endogenous effect and the contextual effects cannot be separated (Durlauf and Ioannides 2010). The key question in the literature has been how to disentangle these effects and properly identify the model. Soetevent (2006) outlines the problems and the methods to estimate social interaction models. One method is to use data where groups are randomly assigned (Sacerdote 2001; Zimmerman 2003; Kang 2007). Some criticisms of this method is that these randomly assigned peers do not reflect true peers and may underestimate peer effects (Stinebrickner and Stinebrickner 2006). A second method is the use of instrumental variables and group-level fixed effects, which has been used extensively in the literature (Case and Katz 1991; Gaviria and Raphael 2001; Fletcher 2007; Ali and Dwyer 2011). This method requires having suitable instruments which can prove to be problematic.

A new method that is slowly gaining traction in the literature is the application of spatial econometrics using social networks. This method has been shown to be an improvement on identification (Bramoulle et al. 2009; Lee 2007; Lee et al. 2010). Blume et al. (2011) argue, "Social network models provide further focus on the microstructure of interactions among agents and allow for heterogeneity of interactions across pairs of agents". Lin (2010) argues that the spatial autoregressive (SAR) model can utilize network information to identify the endogenous and contextual effects, thus solving the reflection problem. The equation for a SAR model, which takes this impact into account, follows:

$$y = \lambda Wy + X\beta + u, \quad (1)$$

where y is a function of the neighboring regions' y, and a series of Xs. W represents the spatial weight matrix that quantifies the relationship between the observations. If $\lambda$ is significantly different from zero, then the data exhibit spatial dependence, indicating that the actions in one region impact those of a neighboring region. There are a variety of methods for specifying the weight matrix W, including using the relationship between observations based on Euclidean distances (a nearest-neighbors matrix) or assigning values of 1 if regions are adjacent and 0 otherwise (first-order contiguity matrix). In the social interactions literature, W represents a social network weight matrix where individuals who are assigned a 1 if they are in the same peer group and a 0 otherwise. The endogenous peer effect is represented by $\lambda$ in (1). To fully incorporate all the mechanisms in a social interactions model we outline a generalized version of the Cliff–Ord spatial model[1] that allows for spatial interactions in the dependent variable and the explanatory variables.

## 3 Empirical framework

### 3.1 Data

The data are taken from Wave 1 of the In-Home Survey of the National Longitudinal Study of Adolescent Health (Add Health). Beginning with an in-school questionnaire administered

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[1]Cliff and Ord (1981).

to a nationally representative sample of students in grades 7 through 12 in 1994–1995 (Wave I), the study follows up with a series of in-home interviews of respondents approximately 1 year (Wave 2; 1996), 6 years (Wave 3; 2001–2002), and 13 years later (Wave 4; 2007–2008). While the In-School Survey is preferred, that survey does not contain questions on sexual activity. Friendship nomination data are available in the In-School survey and the first wave of the In-Home survey. However, only a limited set of friendship data are available in the In-Home survey. There are sixteen schools that have complete nomination data[2] which reduced the sample size. The total number of observations is 1,873.

The primary dependent variable is early sexual debut, defined as whether the respondent has ever had sexual intercourse by the age of fifteen. Three other dependent variables relate to risky sexual behaviors like pregnancy and sexually transmitted diseases that could lead to adverse outcomes. The first dependent variable is casual sex, defined as whether the respondent has engaged in sexual activity with a non-romantic partner. The second dependent variable is multiple partners, defined as whether the respondent has been with more than three non-romantic partners in the past year. Finally, unprotected sex is defined as if the respondent did not use any contraception during their most recent sex.

The explanatory variables are categorized into individual and family factors. Individual factors include basic demographics like gender, age, grade, and ethnicity. Also included are measures of knowledge and religiosity. The measure of knowledge is cognitive competence, measured by the Peabody Picture Vocabulary Test. I include whether the respondent attends religious services at least once a week. Adamczyk and Felson (2006) show that peers' religiosity has an influence on sexual initiation, which is mediated by the denseness of the friendship network. Family factors include family structure and characteristics of the parents (Kincaid et al. 2012). Whether the respondent lives in a household with both biological parents or with a single mother are included as separate explanatory variables. Family structure has been shown to be an important factor in adolescent sexual behavior (Ali and Ajilore 2011; Davis and Friel 2001; Sturgeon 2008). Other parent characteristics, focusing primarily on the mother, include the level of education, level of religiosity, public assistance receipt, whether the mother approves of the respondent engaging in sexual activity and whether the mother approves of the respondent's use of birth control. The approval measures are scales that go from one, where the mother strongly disapproves of behavior, to five, where the parent strongly approves of behavior. Parental communication has been shown to influence risky sexual behavior so an index is created that asks about the degree to which the parent communicates about specific issues relating to sexual activity.[3] A higher value signifies the parent often discusses these issues. Table 1 provides the variable means

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[2]"The In-School Questionnaire yields full social network data for most students in 140 schools. Students were asked to identify up to five male and five female friends, to locate and record their student numbers, and to indicate which of five activities they had done with each of these friends during the past week. Because friends' student numbers were recorded, friendship networks can be determined and a respondent's peer group, as well as his or her position within it, can be described in detail. Multiple measures of the strength of friendship ties are available. Patterns of association within the school community, the density and centralization of the social network, and the degree to which it is fractured on lines of race, gender, or behaviors can be computed. In-home interviews of adolescents in the saturation sample (i.e. adolescents who attended schools in which all students were solicited for in-home interviews) elicited nominations of the five closest opposite-sex and five closest same sex friends who, it is likely, were also interviewed. The remainder of the in-home sample was asked about only one male and one female friend". (Source: http://www.cpc.unc.edu/projects/addhealth/design/contexts).

[3]However, Averett and Estelle (2013) find estimates on parental communication tend to be overstated.

for the full sample, their peers' means, and by gender. The respondents on average have 3.4 peers.

One thing to note in Table 1, boys are more likely to lose their virginity by the age of fifteen and they are more likely to engage in certain types of risky sexual behavior.

### 3.2 Methodology

This study estimates the effect of peers on sexual debut using a social interactions model. This model includes the endogenous peer effect and contextual effects. There are two issues with estimating this type of model. The first issue is the dependent variable is a binary variable whether the respondent has lost their virginity by the age of fifteen. Thus, the appropriate procedure is a probit model. The second issue is the reflection problem as described earlier. We need a methodology that can disentangle the endogenous peer effect from the contextual effects. Spatial econometrics can solve this identification problem. Due to the dichotomous nature of the dependent variable, we estimate a spatial probit model.[4] The conventional probit model would attempt to explain the variation in the binary vector y using a matrix of explanatory variables X. LeSage and Pace (2009) set forth a spatial autoregressive variant, shown in (2).

$$y = \lambda Wy + \alpha i_n + X\beta + \varepsilon \quad (2)$$

In their model, $\lambda Wy$ consists of the average of neighboring regions' utility, creating a mechanism for modeling interdependence in region-specific outcomes. In our model, $\lambda Wy$ models interdependence of peer-specific outcomes, namely the peers' decision to have sex. In (2), if there is independence in the decision to have sex among peers, the parameter $\lambda$ will be zero and the model reduces to the standard probit model. We expand the model to fit the social interactions framework by including the spatial lags of the explanatory variables. This model, shown below in (3), is called the spatial durbin probit model.[5]

$$y = \lambda Wy + \alpha i_n + X\beta + WX\theta + \varepsilon \quad (3)$$

This model incorporates the endogenous peer effect ($\lambda Wy$) and the contextual effects ($WX\theta$). It is the convention within the literature to use a Bayesian approach to estimate (3). This approach treats the binary observations in y as latent unobserved $y^*$ utility associated with initiating sexual activity or abstaining. If the utility of losing their virginity exceeds the utility from maintaining their virginity, then the individual chooses to have sex. However, we do not observe the utilities from this decision therefore the Bayesian econometric approach is to replace the unobserved latent utility with parameters, $\lambda$, $\beta$, and $\theta$ to be estimated. Following LeSage and Pace (2009), I implement the Markov Chain Monte Carlo (MCMC) estimation procedure.

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[4]Programs to estimate the models in MATLAB were provided through James LeSage's Spatial Econometrics toolbox. The specific programs to carry out the MCMC estimation (sarpx_g.m) and calculate the confidence intervals (cr_interval.m) were downloaded from the Journal of the Royal Statistical Society: Series A website, available at the following link: http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-985X/homepage/174_4.htm.
[5]See Lacombe and LeSage (2013).

The specification of the weight matrix, W, is based on the definition of the peer group. Peer groups can be defined as broadly as individuals in the same grade or as narrowly as close friends (see Halliday and Kwak 2012). Those individuals that are a part of an adolescent's peer group receive a one, and everyone else receives a zero. Peer effect studies using spatial analysis normally do not differentiate between unidirectional and bidirectional ties. These studies assume peer effects exist as long as one person nominates another person. The argument is the individual that nominates a person as a friend, looks to that person as a guide for behavior. Therefore, the peer group of a given student A is comprised of all the individuals student A nominates. If student B is nominated by student A as a friend but does not reciprocate, student A is not part of student B's peer group. I make the assumption that reciprocity is not necessary for peer effects because the influence of peers does not need reciprocity. Peer influence can occur through peer pressure, modeling of behaviors, setting of norms, and providing opportunities to engage in behavior. If we think of peer influence as only occurring through peer pressure, reciprocity would be needed but that is not the case here.

Lee (2007) shows that the model is identified when there is variation in group size. Thus, if the peer group is comprised of grade-level peers, as long as each group varies in size, the model is identified. Bramoulle et al. (2009) show that the model is identified in the case of networks through intransitive triads. That is, using friends of friends that are not connected to the individual can serve as instruments in the model. Weight matrices in spatial models are usually row-normalized such that the sum of each row in the matrix sums to one. Thus, the model estimates the average outcomes of peers on an individual's outcome.

### 3.3 Marginal effects

Caution must be exercised when interpreting the results and the significance of the parameters in any spatial model. LeSage and Pace (2009) discuss the interpretation of results from the estimation of spatial models. Inferences from the coefficients reported cannot be made in the standard fashion like that of ordinary least squares (OLS) regressions, since the $\beta$s in spatial regressions are not equal to the partial derivatives. To see why this is case, let's go back to estimating Eq. (3):

$$y = \lambda W y + \alpha i_n + X\beta + WX\theta + \varepsilon \quad (3)$$

Re-arranging (3) to get the dependent variable on the left hand side and pre-multiplying by $(I_n - \lambda W)^{-1}$:

$$y = (I_n - \lambda W)^{-1}[\alpha i_n + X\beta + WX\theta + \varepsilon] \quad (3')$$

Taking the partial derivative with respect to an explanatory variable for individual i, we arrive at (3″).

$$\delta y / \delta x_i = (I_n - \lambda W)^{-1}(I_n \beta_i + W\theta_i) \quad (3'')$$

This expression is a matrix, not a scalar like that from an OLS regression. The question then is how to interpret this matrix to make inferences. LeSage and Pace (2009) average the

elements of the matrix to create both direct effects and indirect effects. They take averages of the main diagonal of (3″) which represent the average direct effects that arise from a change in the explanatory variables. To arrive at the average indirect effects, they average the elements from the off-diagonal of the matrix in (3″). Summing these two averages together gives the average total effect of an explanatory variable.[6]

Conceptually, the average direct effect of an explanatory variable on the dependent variable is similar to coefficients that come from an OLS regression. The difference occurs due to the feedback effect of the respondent's influence in their peer group. The average indirect effects are the spatial spillovers from neighbors. Since the neighbors in our study refer to the peers, the average indirect effects represent the peer effects. The interpretation of the average indirect effects is the cumulative effect of each peers' behavior on the likelihood the individual engaging in sexual activity, i.e. the influence of friends on the individual's decision to engage in sexual activity.

One additional complication with calculating the marginal effects is that the dependent variable is dichotomous. We know that marginal effects from probit models do not have the same interpretation as the marginal effects from a linear model. These same issues are present with the interpretation from spatial autoregressive probit models. One concern is how valid the summary measures calculated are given the non-linearities present in probit models. LeSage et al. (2011) address these issues and calculate new effects for these models. [7]

## 4 Results

### 4.1 Early sexual debut

The Add Health dataset gathers data on specific friendship networks in the Wave I and Wave II In-Home Survey and the Wave I In-School Survey. Students were asked to name up to five male friends and five female friends. Not all of the friends were located in the same school.[8] This network of nominated friends comprises the peer group. Table 2 provides the results of peer effects on whether the respondent lost their virginity by the age of fifteen. The endogenous peer effect measures whether sexual activity by individuals in the peer group influences an individual's decision to engage in sexual activity and the contextual effects measure how the characteristics of those in the network influence an individual's decision to engage in sexual activity at an early age.

The endogenous peer effect is significant and positive for those who had their sexual debut by the age of fifteen. There is a direct peer influence with respect to early sexual debut, which fits within the literature on sexual debut. As outlined by Manski (1993), there is more than a direct peer effect. Peers can have an influence on behavior in other ways, as measured by the contextual effects. However, we cannot use the results of Table 2 for inference because the coefficients do not represent the marginal effects.

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[6]In the case where $\lambda$ is zero, the model collapses into a conventional probit model. For the SDM, the marginal effects would be $I_n\beta_i + W\theta_i$.

[7]The calculation of these effects is applicable for the spatial durbin probit models (see footnote 4 for a link to the code).

[8]Friends who attended different schools were omitted from the sample.

Table 3 provides the scalar summary measures for the three effects. Our focus is on the average direct effect and the average indirect effect, which represents the peer effect.

The direct effects show that adolescents who are older and live in a two biological parent household are less likely to engage in sex by the age of fifteen. Adolescents whose mother approves of birth control and talks about sex are more likely to engage in sexual activity at an early age.

The indirect effects show the influence of peers on early sexual debut. Peers who are older and who are male increase the likelihood that the respondent will have an earlier sexual debut. Peers who live in intact households and who parents are religious also have a positive effect on an adolescent's sexual debut. Peers whose mother approve of sexual activity and whose mother talks about sex have a negative effect on an adolescent's sexual debut. Peers whose parents attend religious services increase the likelihood the respondent will have an earlier sexual debut. The final column of Table 3 shows that the direct and indirect effects cancel each other out while with other factors, only the total effect is significant. White adolescents and those who live in a single mother household are less likely to have an early sexual debut, while individuals whose mother is on public assistance are more likely to have an early sexual debut.

### 4.2 Gender differences in early sexual debut

Studies show that sexual activity differs by gender with boys being more sexually active than girls (CDC 2011). Lavy and Schlosser (2007) show the importance of estimating differences in behavior by gender. Kincaid et al. (2012) call for more gender specific policies because of how the various factors work for young men and young women. In this section, the analysis is broken down by gender to account for the potential differential effects of the explanatory variables on sexual activity.

The coefficient for the endogenous peer effect for young males is 0.035 with a standard deviation of 0.06.[9] The coefficient for the endogenous peer effect for young females is 0.041 with a standard error of 0.07. Both parameters are insignificant. Therefore, the model just collapses into the conventional probit model with the contextual effects.[10] Table 4 provides the marginal effects.

Other than age, there are differences in how the factors affect early sexual debut for boys and girls. White males are less likely to lose their virginity by the age of 15, while girls in higher grades and who attend religious services are more likely to lose their virginity early. The contextual effects show that boys are influenced by the male peers to lose their virginity and by their peers whose mothers approve of sexual activity. Girls whose peers attend religious services influence them not lose their virginity.

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[9]Full results are available upon request from the author.
[10]The reported marginal effects are just the partial derivatives calculated for probit models in STATA using the command dprobit, since X and WX are both exogenous explanatory variables (see footnote 6).

### 4.3 Peer effects and risky sexual behavior

One of the major concerns with early sexual debut is that it is a gateway to what are considered risky sexual behaviors like unprotected sex and non-romantic sex. These risky behaviors can lead to unintended pregnancies and the transmission of sexually transmitted infections. In this section, I estimate the role of peers on risky sexual behaviors. Specifically, I look at whether the respondent engages in non-romantic sex (casual sex), whether the respondent has had sex with more than three non-romantic partners, and whether they did have unprotected sex during their most recent sexual encounter.[11]

The coefficient on the endogenous peer effect for casual sex is 0.085 with a standard error of 0.057, for unprotected sex is 0.093 with a standard error of 0.045, and for multiple partners is –0.049 with a standard error of 0.069. The spatial parameters for casual sex and unprotected sex are both significant at the 5 % level, while the spatial parameter for multiple partners is insignificant. Recent work has shown that looking at peer influence as occurring through social norms can explain the significant effects (Coley et al. 2013; Wisnieski et al. 2013). The following tables provide the results of the marginal effects of peer influences.

The results show that family structure matters, as both types of family structure lower the prevalence of casual sex. Maternal permissiveness leads to a greater prevalence of casual sex. Male peers decrease the likelihood of the respondent engaging in casual sex. The peer effects negate some of the direct effects. However, with maternal approval of sexual activity, the peer effect is much larger than the direct effect. Since the indirect effect is a cumulative effect of all the peers on the respondent, this result shows that the peer effect of this specific characteristic can mitigate the effect of the maternal approval of sex on the respondent engaging in casual sex (Table 5).

Older and Black respondents are less likely to engage in sexual activity without protection. Maternal permissive decreases the likelihood the respondent will engage in sexual activity without protection. Male peers increase the prevalence of unprotected sexual activity. An interesting result is that respondents whose parents who attend religious are more likely to engage in unprotected sexual activity. Further research is needed to understand the ethnic differences in sexual activity (Table 6).

Boys are more likely to have multiple partners and living in an intact household decreases the likelihood of the respondent engaging in sexual activity with multiple partners. Maternal approval of birth control use is the only significant contextual effect and it increases the likelihood that the respondent will have multiple partners (Table 7).

## 5 Discussion

This study estimates the role of peers on sexual debut and several types of risky sexual behavior using Add Health. The results show that endogenous peer effects exist for early sexual debut and several types of risky sexual behavior. Several authors have shown that youth are more likely to engage in sexual activity with increased activity by those in their

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[11] I also estimated models for condom use and different specifications of sex with multiple partners.

peer group (Ali and Dwyer 2011; Potard et al. 2008; Gardner and Steinberg 2005). While the existence of peer effects is important to assess, the more vital outcomes center on the characteristics and peer characteristics. In terms of the individual factors, the only consistently significant measure was gender. Boys are more likely to lose their virginity by the age of fifteen, more likely to have unprotected sex, and more likely to have multiple partners. Boys, however, are less likely to engage in casual sex. Male peers have a strong influence on sexual activity. Male peers increase the likelihood adolescents engage in early sexual activity and engage in unprotected sex. Male peers have a noticeable influence on early sexual debut for boys. Male peers, however, decrease the likelihood adolescents engage in casual sex. Separating by gender did not show the existence of endogenous peer effects but there were differences. Boys are more influenced by maternal attitudes on sexual activity and their same sex peers.

In terms of family factors, living in an intact household lowers the likelihood adolescents lose their virginity early and engage in risky sexual behavior. Ali and Ajilore (2011) find the lowest prevalence of sexual activity in intact family households. The argument is that being in an intact household provides a proper role model for sexual activity. Another consistent result is the effect of maternal approval of sexual activity and birth control use. The more permissive the mother's attitude towards sex, the more likely the respondent engages in sexual activity. Yet, the respondent is less likely to engage in unprotected sex. This provides a conundrum on the implications of maternal permissiveness. While the direct effects of maternal permissiveness may lead to more sexual activity, the indirect effects provide a different conclusion. Peers whose mothers have more permissive attitudes about sexual activity decrease the likelihood of early sexual debut and casual sex. Also, peers whose parents attend religious services increase the likelihood of early sexual debut. These results may speak to adolescents being in a more open environment may lower overall sexual activity and lower risky sexual behavior.

## 6 Conclusion

Adolescent sexual activity is a concern because of the negative outcomes associated with this behavior like unintended pregnancies and sexually transmitted infections. There are a variety of theories as to the causes including parental factors, peer effects, and neighborhood effects (Buhi and Goodson 2007). The role of peer effects and risky sexual behavior has been studied in a variety of literatures (Ali and Dwyer 2011; Fletcher 2007; Metzler et al. 1994; Romer et al. 1994; Sieving et al. 2006). There is a consensus that an individual's friends play a large role in their decision to engage in sexual activity (Bearman and Brückner 1999; Buhi and Goodson 2007). However, the analysis of peer effects has limited within the existing empirical research by focusing solely on the endogenous peer effect. There are several mechanisms into which peers influence an adolescent's behavior and there needs to be an appropriate methodology to properly estimate these mechanisms (Manski 2000).

This study uses a social interaction framework to estimate the influence of peers on sexual initiation using the Add Health dataset. Using spatial analysis to estimate the social interaction model solves the "reflection" problem that plagues many studies of peer effects.

There are two key findings from this study. The first finding is the existence of peer effects with early sexual debut, casual sex, and unprotected sex within the friendship network. A second finding is that the characteristics of peers have an influence on sexual activity. Older and male peers increase the likelihood of early sexual debut, but peers whose mothers have more permissive attitudes about sexual activity decrease the likelihood of early sexual debut and casual sex. This study contributes to the literature by detailing an approach to estimating peer effects that provides magnitudes of the full effect of an adolescent's peers on risky sexual behavior. Future work will explore gender and ethnic-based differences in risky sexual behavior. Another avenue for future research is to link risky sexual behavior to the contraction of sexually transmitted diseases.

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**Table 1**

Descriptive statistics (N = 1,873)

| | **Full sample** | **Peers** | **Male** | **Female** |
|---|---|---|---|---|
| *Dependent variables* | | | | |
| Sexual debut | 0.19 | 0.10 | 0.23 | 0.16 |
| Casual sex | 0.56 | 0.37 | 0.55 | 0.57 |
| Unprotected sex | 0.65 | 0.60 | 0.28 | 0.21 |
| Multiple partners | 0.09 | 0.06 | 0.11 | 0.07 |
| *Independent variables* | | | | |
| Gender (male = 1) | 0.50 | 0.51 | | |
| Age | 15.9 | 15.8 | 16.1 | 15.6 |
| Grade | 10.01 | 9.99 | 10.13 | 9.89 |
| White | 0.58 | 0.60 | 0.58 | 0.58 |
| Black | 0.14 | 0.13 | 0.12 | 0.15 |
| Hispanic | 0.18 | 0.17 | 0.18 | 0.17 |
| Attend religious services | 0.44 | 0.44 | 0.43 | 0.46 |
| PVT score | 101.0 | 101.4 | 102.2 | 99.9 |
| Two biological parent household | 0.63 | 0.64 | 0.64 | 0.63 |
| Single mother household | 0.18 | 0.18 | 0.17 | 0.19 |
| Mother approves of sex | 1.67 | 1.64 | 1.82 | 1.53 |
| Mother approves birth control use | 2.90 | 2.86 | 3.23 | 2.56 |
| Mother is on welfare | 0.06 | 0.05 | 0.04 | 0.07 |
| Mother's level of education | 5.41 | 5.45 | 5.44 | 5.38 |
| Parent communicates about sexual activity | 0.00 | 0.01 | −0.12 | 0.13 |
| Parents are religious | 0.81 | 0.82 | 0.81 | 0.81 |

The summary means for the dependent variables are given the respondent has had sex

**Table 2**

Estimation of peer effects on early sexual debut (N = 1,873)

| Variable | Coefficient | SE | Coefficient | SE |
|---|---|---|---|---|
| **Endogenous peer effect** | **0.135**<sup></sup>** | **0.064** | | |
| | **Own characteristics** | | **Contextual effects** | |
| Male | 0.007 | 0.118 | 0.129 | 0.181 |
| Age | −0.875*** | 0.105 | 0.154 | 0.101 |
| White | −0.053 | 0.310 | −0.320 | 0.361 |
| Black | −0.126 | 0.338 | −0.293 | 0.396 |
| Hispanic | 0.252 | 0.319 | −0.635 | 0.407 |
| Grade | 0.202** | 0.106 | 0.029 | 0.150 |
| Attend religious services | 0.275*** | 0.121 | −0.341** | 0.176 |
| PVT score | −0.003 | 0.005 | −0.009 | 0.006 |
| Two biological parent household | −0.214 | 0.140 | −0.447** | 0.234 |
| Single mother household | −0.148 | 0.166 | −0.378 | 0.278 |
| Mother approves of sex | 0.245*** | 0.071 | −0.072 | 0.120 |
| Mother approves birth control use | 0.172*** | 0.044 | 0.081 | 0.069 |
| Mother is on welfare | −0.272 | 0.244 | 0.092 | 0.327 |
| Mother's level of education | −0.013 | 0.026 | −0.017 | 0.039 |
| Parent communicates about sexual activity | 0.272*** | 0.073 | 0.240** | 0.107 |
| Parents are religious | −0.079 | 0.141 | −0.196 | 0.238 |
| Constant | 8.836*** | 1.196 | | |

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Significance at the 1 % level,

**
significance at the 5 % level

**Table 3**

Marginal effects of peers on early sexual debut (N = 1,873)

|  | Direct | Indirect | Total |
|---|---|---|---|
| Gender (male = 1) | 0.013 | 0.979*** | 0.992*** |
| Age | −0.071*** | 0.085*** | 0.015 |
| Grade | 0.021 | −0.063 | −0.042 |
| White | −0.037 | −0.044 | −0.080*** |
| Black | −0.037 | −0.005 | −0.042 |
| Hispanic | −0.037 | −0.005 | −0.042 |
| PVT score | −0.010 | 0.034 | 0.024 |
| Attend religious services | −0.001 | −0.011 | −0.012 |
| Two biological parent household | −0.064*** | 0.063** | −0.001 |
| Single mother household | −0.054 | −0.018 | −0.073*** |
| Mother approves of sex | 0.017 | −0.078** | −0.062 |
| Mother approves birth control use | 0.026*** | −0.007 | 0.019 |
| Mother is on welfare | −0.019 | 0.049 | 0.030*** |
| Mother's level of education | −0.003 | −0.019 | −0.022 |
| Parent communicates about sexual activity | 0.050*** | −0.054*** | −0.003 |
| Parents are religious | −0.028 | 0.085*** | 0.057*** |

***Significance at the 1 % level,

**significance at the 5 % level

**Table 4**

Marginal effects (total effects) of peers on early sexual debut by gender (N = 1,873)

| | Male | SE | Female | SE |
|---|---|---|---|---|
| Age | −0.0107*** | 0.003 | −0.0241*** | 0.005 |
| White | −0.0232*** | 0.012 | 0.0040 | 0.010 |
| Black | −0.0078 | 0.003 | 0.0056 | 0.015 |
| Hispanic | −0.0033 | 0.005 | 0.0149 | 0.020 |
| Grade | 0.0007 | 0.002 | 0.0122*** | 0.004 |
| Attend religious services | 0.0012 | 0.003 | 0.0084** | 0.005 |
| PVT score | 0.0001 | 0.0001 | −0.0002 | 0.0002 |
| Two biological parent household | −0.0039 | 0.004 | −0.0065 | 0.005 |
| Single mother household | −0.0006 | 0.004 | −0.0055 | 0.004 |
| Mother approves of sex | 0.0059*** | 0.002 | 0.0027 | 0.002 |
| Mother approves birth control use | 0.0045*** | 0.001 | 0.0027 | 0.001 |
| Mother is on welfare | −0.0008 | 0.001 | −0.0002 | 0.001 |
| Mother's level of education | −0.0062 | 0.003 | 0.0044 | 0.009 |
| Parent communicates about sexual activity | 0.0015 | 0.002 | 0.0108*** | 0.003 |
| Parents are religious | −0.00002 | 0.004 | −0.0064 | 0.006 |
| *Contextual effects* | | | | |
| Male | 0.0037** | 0.002 | −0.0022 | 0.002 |
| Age | 0.0012 | 0.001 | 0.0007 | 0.001 |
| White | 0.0001 | 0.002 | 0.0000 | 0.003 |
| Black | 0.0013 | 0.003 | −0.0001 | 0.004 |
| Hispanic | −0.0047 | 0.003 | −0.0015 | 0.004 |
| Grade | −0.0015 | 0.001 | −0.0005 | 0.001 |
| Attend religious services | 0.0018 | 0.001 | −0.0045** | 0.002 |
| PVT score | −0.0001 | 0.00005 | −0.00002 | 0.0001 |
| Two biological parent household | 0.0002 | 0.002 | −0.0027 | 0.002 |
| Single mother household | 0.0008 | 0.002 | −0.0037 | 0.003 |
| Mother approves of sex | 0.0023** | 0.001 | 0.0007 | 0.001 |
| Mother approves birth control use | −0.0007 | 0.001 | 0.0001 | 0.001 |
| Mother is on welfare | −0.0004 | 0.0003 | 0.0002 | 0.0004 |
| Mother's level of education | 0.0004 | 0.003 | 0.0019 | 0.004 |
| Parent communicates about sexual activity | 0.0009 | 0.001 | 0.0016 | 0.001 |
| Parents are religious | −0.0006 | 0.002 | 0.0005 | 0.003 |

***
Significance at the 1 % level,

**
significance at the 5 % level

**Table 5**

Marginal effect of peers on casual sex (N = 1,873)

|  | Direct | Indirect | Total |
|---|---|---|---|
| Male | 0.0293 | −0.6380*** | −0.6086*** |
| Age | 0.0174 | 0.0143 | 0.0317 |
| White | −0.0424 | 0.0611 | 0.0188 |
| Black | 0.0171 | −0.0628 | −0.0457 |
| Hispanic | −0.0953** | 0.1137** | 0.0184 |
| Grade | 0.0115 | −0.1143** | −0.1028** |
| Attend religious services | −0.0139 | 0.0263 | 0.0124 |
| PVT score | −0.0021 | −0.0129 | −0.0150 |
| Two biological parent household | −0.1018** | 0.0996** | −0.0023 |
| Single mother household | −0.1189** | 0.0092 | −0.1098** |
| Mother approves of sex | 0.0869*** | −0.2150*** | −0.1281** |
| Mother approves birth control use | 0.0522*** | 0.0415 | 0.0937*** |
| Mother is on welfare | 0.0120 | 0.0443 | 0.0563*** |
| Mother's level of education | −0.0025 | 0.0157 | 0.0132 |
| Parent communicates about sexual activity | 0.0849*** | −0.0876*** | −0.0027 |
| Parents are religious | 0.0306 | 0.0611 | 0.0916*** |

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Significance at the 1 % level,

**
significance at the 5 % level

**Table 6**

Marginal effect of peers on unprotected sex (N = 1,873)

|  | Direct | Indirect | Total |
|---|---|---|---|
| Male | −0.0516 | 1.1926*** | 1.1410*** |
| Age | −0.0435** | −0.0126 | −0.0561 |
| White | −0.0114 | −0.0359 | −0.0474** |
| Black | −0.0839** | 0.0716 | −0.0123 |
| Hispanic | −0.0066 | −0.0844 | −0.0910** |
| Grade | 0.0091 | −0.0163 | −0.0072 |
| Attend religious services | 0.0289 | −0.0189 | 0.0100 |
| PVT score | 0.0000 | 0.0314 | 0.0314 |
| Two biological parent household | 0.0708 | −0.0708 | 0.0001 |
| Single mother household | −0.0169 | 0.0937 | 0.0768 |
| Mother approves of sex | −0.0820*** | 0.0634 | −0.0185 |
| Mother approves birth control use | −0.0636*** | −0.0254 | −0.0890*** |
| Mother is on welfare | 0.0650 | −0.1341** | −0.0691*** |
| Mother's level of education | 0.0061 | 0.0643 | 0.0705 |
| Parent communicates about sexual activity | −0.0684*** | 0.0751*** | 0.0067 |
| Parents are religious | 0.0227 | −0.0970 | −0.0744*** |

***
Significance at the 1 % level,

**
significance at the 5 % level

**Table 7**

Marginal effect (total effects) of peers on multiple partners (N = 1,873)

| Variable | Own characteristics | | Contextual effects | |
|---|---|---|---|---|
| | Coefficient | SE | Coefficient | SE |
| Male | 0.0150** | 0.007 | 0.0003 | 0.003 |
| Age | −0.0054 | 0.004 | 0.0015 | 0.002 |
| White | 0.0091 | 0.005 | −0.0071 | 0.005 |
| Black | 0.0070 | 0.012 | −0.0054 | 0.006 |
| Hispanic | 0.0101 | 0.019 | −0.0107 | 0.006 |
| Grade | 0.0360 | 0.026 | −0.0016 | 0.002 |
| Attend religious services | 0.0003 | 0.006 | 0.0020 | 0.003 |
| PVT score | −0.0003 | 0.0003 | 0.000003 | 0.0001 |
| Two biological parent household | −0.0186** | 0.009 | −0.0042 | 0.004 |
| Single mother household | −0.0108 | 0.006 | −0.0038 | 0.005 |
| Mother approves of sex | 0.0048 | 0.003 | −0.0001 | 0.002 |
| Mother approves birth control use | 0.0031 | 0.002 | 0.0030** | 0.001 |
| Mother is on welfare | 0.0027 | 0.001 | −0.0013 | 0.001 |
| Mother's level of education | −0.0056 | 0.010 | 0.0101 | 0.006 |
| Parent communicates about sexual activity | 0.0049 | 0.004 | 0.0030 | 0.002 |
| Parents are religious | −0.0017 | 0.008 | −0.0029 | 0.004 |

***
Significance at the 1 % level,

**
significance at the 5 % level