

Dynamics of Social Networks Following Adolescent Pregnancy

Elizabeth Humberstone*

Johns Hopkins University, 2800 North Charles Street, Baltimore, MD, 21218,
ehumber3@jhu.edu

Abstract

Adolescents who experience a pregnancy often face educational and economical difficulties later in life. One factor that has been found to improve outcomes for pregnant teens is access to social supports. Inopportunately, teen pregnancy presents social obstacles, and cross-sectional analysis has found pregnant teens have fewer friendships than their non-pregnant counterparts. However, longitudinal work has yet to explore network change after a pregnancy. This study uses multiple network modeling techniques to follow the social networks of a group of girls who become pregnant between waves of the Add Health survey. Pregnant teens were found to maintain fewer friendships between time points than peers. Whole school network maps suggest that in some schools teens move to more peripheral network positions following pregnancy. These preliminary findings suggest that the relationship between social network change and pregnancy may vary depending on school environment; future work is needed to better understand how school contexts may change the social outcomes of pregnant girls.

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Introduction

Despite a downward trend in adolescent pregnancy since the 1990's, pregnancy is still a relatively common occurrence among American teenagers. Approximately one in ten sexually active girls experience a pregnancy sometime during their teenage years – about 5% of adolescent females nationally (Guttmacher Institute, 2016). This prevalence makes the United States the leader in adolescent pregnancies amongst industrialized nations (Kearney & Levine, 2012). High incidence of teenage pregnancy is a public policy concern as teens experiencing pregnancy complete less schooling than their peers (Kane, Morgan, Harris, & Guilkey, 2013) and are more likely to struggle financially later in life (Assini-Meytin & Green, 2015). The pregnancy-related challenges faced by these girls often thwart regular school-going, leaving those who cut their education short vulnerable to employment and economic struggles in adulthood.

The support pregnant teens receive can help mitigate the negative repercussions of becoming pregnant. Pregnant teens have been found to rely on social supports more than older women experiencing pregnancies (Letourneau, Stewart, & Barnfather, 2004). Pregnant girls with broad social support networks report less stress and depression, and higher levels of contentedness and parenting abilities (Letourneau et al., 2004). Social connectedness is also an important factor in retaining teens in schools (Rumberger, 2011). As a population more at risk of drop out, pregnant teens may particularly benefit from school-based social support networks that encourage educational persistence. Indeed, a teen's level of connectedness prior to pregnancy has been found to relate to her post-pregnancy educational attainment (Humberstone, 2018b).

Many of the obstacles that arise with a pregnancy can also impede one's social interactions. Following pregnancy, teens may experience stigmatization, new educational environments and added responsibilities – all of which can alter the friendships they held prior to pregnancy. Past work has found that pregnant teens have less reciprocated friendships, and are less likely to be considered a friend by their peers than non-pregnant girls (Humberstone, 2018a). While this work elucidates friendship differences between pregnant and non-pregnant teens, its cross-sectional design looks only at social networks held after a pregnancy occurrence. Cross-sectional networks only capture information of the presence or absence of ties and position in the greater social network at one time. It is unable to account for the greater social tendencies within a school network that may drive change, or assess friendship stability across time. Further, as both friendship- and pregnancy-related challenges likely evolve over time, cross-sectional work may underestimate the extent of social disturbance pregnant teens face. More work is needed to understand how an individual's network evolves following a pregnancy, and how this evolution may vary across different school environments within which pregnant girls are socially embedded.

Using data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), this study follows the social networks of a group of girls who experience their first pregnancy between data collection time points using a number of strategies. While the sample used in this study is not representative and has a small pregnant population, it is unique in its longitudinal whole school social network data. I take advantage of three analytic strategies in an effort to identify possible relationships between pregnancy, social change and school environments within the limited available data. I map and describe sociometric (i.e. whole) school networks at different time points to visualize how pregnant teens' positions within their schools' social networks change. While

graphing networks provides descriptive information on overall networks across time, it cannot account for possible drivers of any observed network change. To better take into account the influence of the whole network structure on friendship and behavioral decisions, I explore network evolution of select schools using stochastic actor oriented models (SAOM), which simultaneously model changes in actors' network positions and attributes (e.g. pregnancy) across time (Snijders, van de Bunt, & Steglich, 2010). Although this strategy is able to control for network influences, which are not accounted for in other modeling techniques, the models presented here are likely underpowered given the small number of girls experiencing a pregnancy. Multilevel models were used as an alternative as they adjust for differences across schools and possible background characteristics in a way that network graphs cannot, but do not control for network tendencies. Here multilevel models were used to evaluate whether the magnitude of change in network characteristics, such as change in number of friends reported before and after pregnancy, is larger for pregnant girls than comparable peers. Comparing these groups serves as a robustness check to assess if any downward trends in network variables are artifacts of overall network change instead of pregnancy. I find that pregnancy is associated with greater decreases in being considered a friend by peers, and fewer maintained friendships across time points. The network maps further suggest that in some schools, pregnant teens move to more peripheral positions in their school networks following pregnancy. While each method has limitations given the available data, they generally suggest a possible relationship between school context, pregnancy, and social disturbance that warrants further investigation.

Background

Friendships and Social Change

Friends are an important part of adolescence, and have been found to provide many benefits to teens, including: social development (Hartup, 1996), sense of value and belonging (Baumeister & Leary, 1995), social connections outside the family (Larson, 1983; Larson & Verma, 1999), support through transitions and stresses (Hartup, 1996), self confidence, social competencies (Buhrmester, 1990), and social capital (i.e. resources, information, support) (Bourdieu, 1999; Burt, 2000; Coleman, 1988; Lin, 1999). Teens' access to friends and the value they derive from them likely varies depending on their environment (Small, 2009). For adolescents, schools are often their primary social organization, where they meet and interact with similarly aged peers. Schools help shape teens' social worlds by orchestrating interactions through classroom placements, course scheduling and extracurricular activities. Indeed, sharing a classroom has been associated with friendship formation and stability (Frank, Muller, & Mueller, 2013; Neckerman, 1996). Friends within one's school can provide a teen with additional benefits that may help them navigate both the academic demands and social ecosystem of their school. These include: sharing of academic resources, fun and enjoyment, motivation to attend or persist in school, models of school behaviors and expectations, and information on future educational decisions. A student in a class with many advantaged classmates may find she gains greater benefits or resources from her school friends. The extent to which a student relies on friends' support may also depend on the characteristics of her school. Friends may be more valuable in under-resourced schools with less student supports.

Simply having social connections does not tell the complete story of the social world of teens. One's positioning within her greater school social network is also likely to impact outcomes, as

social positions are thought to facilitate or constrain individuals. Individuals that are more central in their networks – that is they are well connected to friends who are also well connected – are thought to have more access to resources and other people in their network than individuals who are more peripheral (Brass, 1984). Within a school, a student who is in her school's social periphery is often more dependent on her limited friendships for connection to her greater school network, and are generally regarded as less influential or independent (Brass, 1984). Students in peripheral network positions are also more likely to get cut off from the greater school social network if they lose their limited connections and are thus at greater risk for becoming social isolated within their schools.

Adolescents' friendships and positions within greater social networks are not static; approximately a third to a half of friendships change over the course of an academic year (Bowker, 2004; Chan & Poulin, 2007; Degirmencioglu, Urberg, Tolson, & Richard, 1998). Friendships are more likely to form when individuals share preferences (e.g. partaking in the same hobbies), environments (e.g. going to the same school) or context (e.g. being of the same culture) (Branje, Frijns, Finkenauer, Engels, & Meeus, 2007; Poulin & Chan, 2010). Instability often results when one or both members of the friendship: undergoes a significant personal change, is physically separated from her friend, decreases time in shared activities, develops new relationships or loses feelings of affection (Johnson et al., 2004). Even when friendships do not dissolve, the strength of the connection may ebb and flow (Cairns, Leung, Buchanan, & Cairns, 1995). Because of this, teens' social position and access to social support may fluctuate over the course of their adolescence. Given the tendency for friendships to change, stability in a friendship is often considered an indicator of deeper or higher quality friendships. Teens with stable friendships are thought to have: more dependable and greater sources of social support (Poulin & Chan, 2010), higher self esteem (Hartup, 1993), more positive relationships with school, higher academic performance and more positive views of their own academic behaviors (Berndt, 1999). Having any best friendship consistently across time has also been thought to relate to adolescents' development and behavioral adjustment (Bowker, 2004).

There are many reasons to suspect that pregnancy heightens friendship volatility and loss during adolescence. Many of the factors associated with increased friendship instability occur following conception. Friends may not appreciate the new changes a pregnant teen faces (Sherman & Greenfield, 2013), or her difficulty in continuing normal socialization and leisure activities (Clark, 2011). Pregnant teens also report facing stigma (Bermea, Toews, & Wood, 2016; Cherry, Chumbler, Bute, & Huff, 2015; Herrman, 2008; Wiemann, Rickert, Berenson, & Volk, 2005), which can be defined as loss of social standing or discrimination as a result of a distinguishing characteristic (Link & Phelan, 2001). Peers may avoid forming or continuing relationships with stigmatized individuals and, in turn, stigmatized teens may avoid settings where they face stigmatization. Pregnant teens may also change classrooms or schools – leaving behind old peers and encountering new ones – in order to better juggle school and pregnancy demands (Kleiner, Porch, & Farris, 2002; SmithBattle, 2007). These factors are also likely to vary depending on a pregnant teen's school environment. For example, pregnant teens may face less social disruption if they attend schools without alternate educational placement options. In a school with a high prevalence of teen pregnancies, pregnancy may be less stigmatizing or better supported through school resources than in schools where pregnancy is an anomaly.

Pregnant teens themselves may elect to alter their friend groups following a pregnancy. Girls qualitatively report pregnancy to be a wake-up call, which prompts them to reprioritize their friendships and behaviors (Herrman, 2008; SmithBattle, 1995). A voluntary reduction in friendships may be beneficial for a pregnant teen if it allows her to focus on her higher quality friendships in the face of increased stress and limited time. On the other hand, as socially supported pregnant teens report higher levels of well-being (Letourneau et al., 2004), a non-voluntary loss of friends following pregnancy could be detrimental. Staying socially connected at school may also encourage educational persistence for this at-risk population (Marcus & Sanders-Reio, 2001; Parker & Asher, 1987; Rumberger, 2011), as having more friends prior to pregnancy has been associated with lessening the relationship between pregnancy and high school attrition (Humberstone, 2018b).

Longitudinal Network Analysis

While past cross-sectional work found girls to have reduced social networks after experiencing a pregnancy (Humberstone, 2018a), longitudinal work is needed to understand how a girl's nulligravid social network evolves with pregnancy. Cross-sectional network analysis is limited for a number of reasons. Firstly, it is unable to account for social network tendencies (i.e. tendency towards reciprocation or friending a friend of a friend) that may partially explain observed network differences. Social networks are intrinsically interdependent so modeling strategies that assume independence of actors may misattribute the influences of network tendencies to non-network factors. Longitudinal networks are also needed to understand if and how individuals' positions within their social networks change over time. Conceivably, occupying a peripheral social position would be more jolting for a girl who had previously been very central in her network than for a girl who was less centrally connected.

Additionally, both friendship and pregnancy challenges are likely not immediate or constant over time. As explained above, friendships regularly ebb and flow with changing life circumstances. A cross-sectional snapshot fails to capture this inherent friendship dynamic or provide any information on friendship stability. The impact of pregnancy on the lives of teenagers also evolves with time. Initially, pregnancies may go undetected and have little impact on a girl's daily life. As a pregnancy continues, physical challenges may increase and eventually, the pregnancy often becomes visible. Stigmatization also likely builds with time, as word of a pregnancy spreads and others begin to gauge peers' reception to the news. For the pregnant teen, it may also take time to recognize if friends are distancing themselves and to adjust her social expectations accordingly. Thus, cross-sectional work is likely to underestimate pregnancy's impact on social networks depending on the timing of data collection.

There are a number of methodological strategies for evaluating networks across time. Descriptive analysis can be done by graphing overall networks at each available time point. Mapping networks allows for visual identification of network trends, and gives a quick understanding for how networks generally differ between schools. Visual representations of networks are often more impactful and easier to understand for audiences than more complicated statistical models. Network graphs, however, do not provide any information about how network differences develop or control for factors known to relate to network trends (i.e. gender homophily). Dynamic network models, such as SAOM, were developed to better account for both network tendencies and the co-

evolution of behavior and social changes over time. These models are also able to adjust for the association of covariates with network change, and further break down that association into estimates for: the likelihood an individual extends a friendship tie based on her own covariates, the likelihood a peer extends a friendship tie based on an individual's covariates, and the likelihood that an individual extends a friendship tie when they share the same covariate with a peer. Finally, these models account for overall network structures. This is important because friendships do not happen in isolation – social connections are enmeshed with and influenced by the social connections of others around them. For example, friends of friends are more likely to interact than those without any shared social connections.

While theoretically justified, the use of dynamic network models in this study is limited by the available data for the analysis. The Add Health data set has seven schools with whole network data and girls who become pregnant between time points. Each school only has a small pool of pregnant teens, which leaves the models likely underpowered for detecting possible pregnancy associations. Of the seven schools, five were small schools with very few pregnant girls for dynamic network modeling. Therefore, multilevel models will also be used in this study. Multilevel models account for variation across schools but do not control for network features. This allows more freedom in the models with limited data, provides the opportunity to account for background characteristics through matching, and uses all available pregnant teen data. Through these techniques, this study seeks to understand the relationship between social network change and pregnancy, and how this relationship may be associated with school environments.

Data and Methods

Data for this study comes from the National Longitudinal Study of Adolescent to Adult Health. Add Health is a nationally representative survey that follows a group of adolescents who were in grades 7 to 12 when the survey began. Schools were the primary sampling unit; 132 middle schools and high schools were selected based on region, urbanicity, and school size and characteristics. Data collection took place during multiple time points. At the first time point (1994-1995), called the In-School survey in the Add Health survey and referred to here as Time 1, every student attending a sampled school was invited to participate ($n = 90,118$). From those students, a subsample was selected for further study based on sex and grade. This subsample of 20,745 participants was surveyed again approximately six months to a year after Time 1 (1995) in what was called the Wave 1 survey and here will be called Time 2. They were again surveyed approximately a year later (1996) for the Wave 2 survey ($n = 14,738$), which I call Time 3.

Of the 132 sampled schools, sixteen had all their students followed during each time point of the study. This saturated sample was done to capture complete social network data of schools across time. The saturated sample is not nationally representative; schools within the saturated sample also differ from the sample of schools generally. Table 1 provides details on the distribution of saturated and non-saturated schools across school characteristics. The saturated sample has a higher representation of small, rural, and private schools, and schools that include primary school grades than the rest of the sample. Saturated schools also have a higher percentage of their student population experiencing a pregnancy, as reported by school administrators (saturated schools = 1.39%, non-saturated = 0.69%, $p < .05$). While these sixteen schools are not nationally

Table 1
Comparison of School Characteristics in Saturated Sample, Saturated Sample with Girls Experiencing a Pregnancy and Non-Saturated Sample Schools

	Saturated (w/ girls)	Saturated (w/ preg.)	Non-Saturated
<i>Urbanicity</i>			
Urban	4 (26.7%)	2 (28.6%)	33 (30.0%)
Suburban	6 (40.0%)	2 (28.6%)	63 (57.3%)
Rural	5 (33.3%)	3 (42.9%)	14 (12.7%)
<i>Region</i>			
West	3 (20.0%)	1 (14.3%)	22 (20.0%)
Midwest	5 (33.3%)	2 (28.6%)	22 (20.0%)
South	4 (26.7%)	3 (42.9%)	49 (44.5%)
Northeast	3 (20.0%)	1 (14.3%)	17 (15.5%)
<i>School Size*</i>			
Small (1-400)	13 (86.7%)	5 (71.4%)	16 (14.5%)
Medium (401-1000)	0 (0.0%)	0 (0.0%)	59 (53.6%)
Large (1001-4000)	2 (13.3%)	2 (28.6%)	35 (31.8%)
<i>School Type*</i>			
Public	10 (66.7%)	5 (71.4%)	104 (94.5%)
Private	4 (26.7%)	1 (14.3%)	2 (1.8%)
Catholic	1 (6.7%)	1 (14.3%)	4 (3.6%)
<i>Grades*</i>			
Includes primary grades	11 (73.3%)	4 (57.1%)	4 (3.6%)
No primary grades	4 (26.7%)	3 (42.9%)	106 (96.4%)
n	15	7	110

*Significant chi-square difference test between saturated and non-saturated samples, $p < .01$

representative, this data is the focus of this study because it provides both longitudinal data of whole school social networks and participant-level background information.

The population of interest for this study is females who experienced their first pregnancies after Time 1 but prior to the last data collection (Time 3), while they were in school grades 7 through 12. Though pregnancy status was not asked at Time 1, I am able to calculate the timing of participants' pregnancies by comparing the dates that pregnancies began (reported at Time 2 and/or Time 3) to the date that the Time 1 In-School survey was administered. I retained any female that was not pregnant at Time 1 but reported a pregnancy by Time 3. Of these girls, I restricted my final analytic sample to only those girls who attended one of the 16 saturated sample schools. Limiting to these schools is necessary because students from these schools are the only respondents with full network data at multiple time points. The final pregnancy sample includes 60 girls in seven saturated sample schools. An additional 180 non-pregnant girls were retained as comparisons and were identified using propensity score matching (detailed in the Analytic Strategy section).

In addition, I use sociometric school network data to model the evolution of school social networks across time. I selected the two schools with the largest number of pregnant girls. From these schools, I retained only participants that completed a survey at all three time points. These two schools were large public high schools, and deliberately had all students included in the sample to add more representative schools to the saturated sample (the other schools were whole network sampled because of their small size). School 2 was in a rural area and had 479 participants (18 experiencing pregnancy after Time 1) with three waves of data and 136 participants with missing Time 2 or Time 3 surveys. Of those, 77 were seniors who were not followed to Time 3. School 3, located in a suburban area, had 850 complete cases (32 pregnant after Time 1) and 398 incomplete cases, with 263 being seniors who were not present at Time 3. The complete cases' ages differed significantly from the incomplete cases, with the incomplete case participants being roughly a year older. These groups were similar in terms of race, prior GPA, and participation in extracurricular activities.

While the initial Add Health surveys used here are dated, they were selected because they uniquely provide longitudinal whole school social networks. The age of the data limits generalizability of results if friendships or perceptions of pregnant teens have changed since the 1990's. The advent of the internet and social media has created a different social landscape than faced by teens in previous decades. Socially isolated students may find connections online; nevertheless, they still primarily attend in-person schools and are subjected to school social dynamics. While it may be argued that teen pregnancy is more socially accepted than in the 1990's, recent studies (Bermea et al., 2016; Cherry et al., 2015) find pregnant teens continue to report experiences of stigmatization, suggesting that negative social reception is an ongoing issue for pregnant girls today.

Measures

Pregnancy. Participants were asked if they had ever experienced a pregnancy (regardless of pregnancy outcome) during the Time 2 and Time 3 surveys. If a girl reported any pregnancies, she was asked the date her pregnancy began. These dates were compared to the survey administration date for the Time 1 survey to calculate who was pregnant before Time 1. Girls were selected if they had not experienced a pregnancy prior to the Time 1 survey but became pregnant before the Time 3 survey.

The measure of pregnancy in this study is not without limitations. First, it relies on self-reports of pregnancy, which many would consider highly sensitive personal information. To mitigate under reporting of such information, Add Health employed audio computer-assisted self-interviewing (CASI) for sensitive topics, including: pregnancy, sexual behaviors, contraceptive use, substance use, and delinquency behaviors (Harris, 2013). Audio CASI data collection has been shown to increase reporting of sensitive behaviors in adolescents (Turner et al., 1998). Still, it is feasible that some girls did not report their pregnancy experiences, and that those girls who felt most vulnerable, fearful or stigmatized by their pregnancies would be more likely to underreport. If the more potentially stigmatized girls were less represented in the sample, the results of this analysis may underestimate the relationship between pregnancy and social change.

Table 2
Average Network Degrees and Network Densities at Time 1 and Time 3 by School

School	n	Avg. Degree		Network Density	
		Time 1	Time 3	Time 1	Time 3
1	121	3.78	2.31	0.031	0.019
2	479	3.88	2.73	0.008	0.006
3	850	2.08	1.26	0.002	0.001
4	70	2.61	2.73	0.038	0.04
5	76	2.26	1.84	0.03	0.25
6	92	2.88	1.55	0.051	0.027
7	46	4.02	1.57	0.098	0.038

Second, different pregnancy trajectories (i.e. live birth, abortion, miscarriage) may have different associations with friendships change. This study focuses on any pregnancy, regardless of whether it ended in a live birth for the following reasons: (1) pregnancy-related stigma likely begins prior to birth; (2) teens report pregnancy as an impetus to reevaluate relationships and behaviors (Cherry et al., 2015; Herrman, 2008); (3) limiting to live births may skew the sample as those who abort are often from more advantaged backgrounds (Ashcraft, Fernández-Val, & Lang, 2013); and (4) an Add Health data administration error does not allow for the identification of pregnancy outcomes for all girls in the sample.

Networks. Participants in saturated schools reported up to five closest female and five closest male friends during the Time 1, 2 and 3 surveys.^{1,2} Nominations were then matched to school rosters and ultimately paired with their own survey data through their participant identification number. This study limits the analysis to only identifiable friends that attend the same school. I further only consider participants who were present in both the Time 1 and Time 3 surveys. Friendship nominations were used to construct sociometric school social networks. New students entering the school after the In-School survey did not join the sample. Generally, school networks became less dense between Time 1 and Time 3, primarily due to school attrition. Table 2 presents network densities and average degree for each school at Times 1 and 3.

¹ Though friend nominations were limited to 10 friends total, this constraint was not adjusted when modeling the data. In both the sample used for SAOM models and in the sample of girls eligible for propensity score matching, there were only a small number of participants with 10 friend nominations (time 1 ~12%; time 3 ~1%), suggesting few were limited by this constraint. For the stochastic actor oriented models, not including degree constraint is in line with other studies that use the Add Health data for this type of modeling (e.g. Flashman, 2012). SAOM fits according to observed data, which includes number of friend nominations. The regression models assess change between time points, both of which were bounded by the 10-nomination limit. Also, the models were not run as Poisson (given negative values in the outcome) so an offset was not used.

² A small number of participants in the saturated schools were erroneously limited to one male and one female nomination at Time 2. This may impact the SAOM models which take into account Time 2 data (network graphs and regression models only use Time 1 and Time 3 data). As a sensitivity test, SAOM models were run with and without an indicator for limited friend nominations (~8% of participants in Schools 2 & 3). Similar results were found and models without the indicator are reported here.

Given the overall trend for decreased network connections in the data, I compare whether pregnant and non-pregnant teens differ by extent of network change between time points. On average, did pregnant teens' friendship networks shrink more extremely than their non-pregnant peers? I assess change in number of friends reported (*out-nominations*), number of peers who report a participant as a friend (*in-nominations*), and reciprocated ties (between Time 3 and Time 1). I also look at change in network centrality, which is a measure of how connected one is to other well-connected participants, and general positioning of pregnant teens within their greater school networks. I lastly look at the how many friendships (both out- and in- nominations) pregnant teens maintain between Time 1 and 3. The average GPA of friends in one's network was probed to assess if networks change qualitatively following a pregnancy. Friends' GPAs were found to not significantly differ between Times 1 and 3 for pregnant teens so this variable was not included in further analysis.

Analytic Strategy

Because network densities generally trend downwards across Times 1 and 3, comparing girls' pre-pregnancy networks to their post-pregnancy networks does not allow for the disentangling of pregnancy effects from overall network trends. Propensity score matching was used to identify a similar non-pregnant comparison group in order to gauge whether the extent of network change differs for pregnant and non-pregnant girls. Each school's social network was then mapped to visualize the pregnant teens within the overall network and how their network position compares to their matched non-pregnant peers across time. However, a visual inspection of network maps does not account for the influence of actors' characteristics and overall network tendencies on an individual's social network changes. As such, stochastic actor oriented modeling was used on two schools to better control for possible relationships between covariates and network change. These models look at the evolution of the overall networks across time to see if pregnancy is a factor in friendship tie formation, accounting for other individual and network covariates. However, using models in this study has limitations; the population of girls experiencing pregnancy is small and is likely underpowered. Further, smaller schools in the saturated sample could not be included since they only have a few pregnant girls. In order to include all schools and mitigate concerns of over controlling present, regression models were run to assess whether pregnancy is a significant predictor of rate of network change (i.e. number of reported friends at Time 3 minus the number of reported friends at Time 1) compared to non-pregnant matched girls.

Propensity Score Matching. Propensity score matching was used to identify girls of similar background characteristics to teens experiencing a pregnancy. Matching was done based on characteristics at Time 1 and included the following variables: age, grade, Hispanic origin, race, parents' education, household size, extracurricular involvement (1 = not involved in any clubs, organizations or teams), trouble getting along with teachers or students (0 = never, 2 = once a week, 4 = everyday), effort in school (1 = try very hard, 4 = never try), prior GPA, overall health (1 = excellent, 5 = poor), tried alcohol (1 = yes, 0 = no), frequency of cigarette consumption, school skipping and lying to parents in last year (0 = never, 6 = almost every day), number of reported friends and number of friend nominations received from others at Time 1, and expectations of likelihood of contracting HIV or AIDS. Time 1 network variables were included to better identify non-pregnant peers in similar starting network positions as pregnant girls prior to their pregnancies. HIV/AIDS expectations serve as a proxy for sexual behaviors as there are no sexual history questions in the Time 1 survey. Each pregnant teen was matched to three non-pregnant

girls within her same school. The large size of the non-pregnant sample compared to pregnant girls allowed for additional matches (three-to-one instead of one-to-one matching).

As missing data was present among the matching variables, multiple imputation by chained equations was done using the ‘mice’ package in R (10 imputations, 10 iterations per imputation) (van Buuren & Groothuis-Oudshoorn, 2011). Variables in the imputation include: network variables (i.e. number of nominations, centrality, number of maintained friendships), individual characteristics (i.e. age, grade, race, ethnicity, health), family characteristics (i.e. family size, parent education), behavioral variables (i.e. delinquency, effort in school, extracurriculars, GPA), future expectations (i.e. college completion, marriage, sexual risk, income) and school. Of the 812 participants eligible for propensity score matching, 450 were cases were complete, with expectation of college graduation as the most commonly missing variable (17% missing) and expectation of contracting HIV as the second most missing (14%). Propensity scores were calculated for each imputation and then averaged to create a final matched sample (Mitra & Reiter, 2016). This propensity score was used for k-3 nearest neighbor matching without replacement (exact match on school), which identifies three unique non-pregnant girls in the same school for every pregnant teen. Matching resulted in a pregnant sample of 60 and a non-pregnant matched sample of 180.

Network Graphs. Maps of sociometric school networks were created using the software Gephi (Bastian, Heymann, & Jacomy, 2009). Friendship pairs that included participants with complete longitudinal data (male and female) were loaded into the program to build the network maps, with each participant being a node on the map and each friendship represented by a directed tie between nodes. Directed ties are indicated by arrows where the arrow originates from the person making the friendship nomination and points to the person he/she nominates. The layout of the network was created using the Yifun Hu Proportional layout algorithm (Hu, 2006). This layout is a force-directed algorithm where related nodes are attracted to each other and unrelated nodes are pushed apart. Node relatedness is based on connections between nodes, where friend pairs or friend of friends are placed closer together and nodes with no common connections further apart. Yifan Hu Proportional also places more central nodes central in the network map and outer nodes towards the edges of the graph. It should be noted that nodes that were unconnected to the main component of the network map were manually moved closer in order to create images that more closely focus on the main component. Pregnant nodes were colored blue and matched non-pregnant nodes were colored orange.

Stochastic Actor Oriented Models. I employed stochastic actor oriented models (SAOM) to model the evolution of networks across time points, which takes into account the dependencies present from network structures and tendencies (Snijders et al., 2010). SAOM relies on the Markov assumption that knowing the network state at a previous time point is all the history needed to evaluate network changes at future time points. It specifically uses continuous Markov chains based on the assumption that networks changes (and changes to individual attributes) are happening at random continuously over time. The measures of networks at Times 1, 2 and 3 represent time points within that continuous time range. The evolution of a network is simulated through micro-step changes in network features between time points. It assumes that at any one moment, an individual decides to form a tie (e.g. friendship), dissolve a tie, change an individual attribute or behavior (e.g. become pregnant), or remain constant. All changes have a temporal

ordering (e.g. one friend decides to dissolve a friendship slightly before the other or an individual decides to stop drinking before ending friendships with alcoholics), even if the time between changes is very small. Each individual in the network gets an opportunity to make a change randomly, with the chance of getting an opportunity to change being dictated by a set rate function.

In addition to this set rate function, SAOM uses evaluation functions to estimate a participant’s likelihood to change a network tie or behavior. Given this study’s focus on friendship tie change, I focus on the network change evaluation function:

$$f_i(x) = \sum_k \beta_k s_{ki}(x) \tag{1}$$

Eq. 1 is a weighted sum that takes into account the state of the network x , an actor i ’s covariates, the covariates of other network members and the network structure and tendencies. The function $s_{ki}(x)$ represents the k th covariate’s value for individual i , and are associated with changes in network ties. The term β_k is the estimated coefficient for function $s_{ki}(x)$ and the summation is taken over all covariates. Variables in SAOM can include network structure factors (e.g. tendency for reciprocation) and covariates (e.g. female). Covariates are considered for both the association the covariate has on the actor’s likelihood to extend a tie and the association it has on another person’s likelihood to extend a tie to the actor. β is derived from the data and represents the weight of each effect on potential tie change.

In this study, I include the following network structure variables: number of reported friends, tendency for reciprocation in friendships, and tendency for transitive triplets (i.e. if participant A is friends with participant B, and participant B is friends with participant C, participants A and C are more likely to form ties). Covariate variables include being of the same sex (“female similarity”) and being the same school grade (“grade similarity”). I also include similarity on pregnancy status (“pregnant similarity”) and an indicator for the relationship between one’s own pregnancy and one’s likelihood to form a friendship (“pregnant ego”). Lastly, a “pregnant alter” variable represents the one’s likelihood to extend a friendship tie to a pregnant peer.

SAOM is not without its limitations. Some argue that restricting networks so that simultaneous changes to ties and/or attributes/behaviors are not possible is a strong assumption (VanderWeele & An, 2013), as changes theoretically could occur at the same time. Further, assuming that only knowledge of the past network state is needed to evaluate future states may be problematic as, theoretically, older relationship histories may have lasting influences on network dynamics (such as if two people broke up years ago but their history still serves as a repelling force between their friends). Moreover, it is often infeasible for individuals to have full knowledge of the network in which they are embedded, which they are assumed to have when making a decision about their micro-step changes. Changes in ties are also given equally weight even though ending a relationship is often more difficult than forming a new one.

It should be noted that SAOM is not the only estimation strategy for longitudinal network modeling. Temporal random exponential graph models are also used for analyzing networks at multiple time points (Krivitsky & Handcock, 2014). SAOM models are actor-focused and treat time as continuous, whereas TERGMs are tie-focused models that analyze longitudinal networks as discrete time points. Because TERGMs focus on ties between actors instead of the actors

themselves, hypotheses about actors' agency in tie changes are not testable (Broekel, Balland, Burger, & van Oort, 2014). Further, these models provide information on overall network structure and do not allow for the evaluation of factors or processes underlying network change across time (Block, Boda, Hollway, & Voros, 2017). It is for these reasons that SAOM was selected for this study. However, few studies include a comparison of the two strategies, and past work has found estimated parameters may differ (Leifeld & Cranmer, 2018). As such, I ran separable temporal exponential random graph models (STERGMs) as an additional check and include the results in Table 8. STERGM models fit separate models predicting the overall pattern of tie formation and tie dissolution, based on the prevalence of ties at the previous time point. Specifically modeling tie dissolution aligns with this study as it is theorized that factors related to pregnancy may lead to friendship reductions.

Regression Analysis. Finally, I ran multilevel models on the difference between network variables between the pregnant and non-pregnant matched sample. Multilevel models account for the nesting of students within schools, which is an important factor as social networks are unique to each school. Covariates (age, race and prior GPA) were probed in an effort to be doubly robust following propensity score matching but were insignificant and did not substantively change the pregnancy estimates, and are thus not reported here³. I ran the following model:

$$Y_{ij} = \beta_{0j} + \beta_1 X_{ij} + e_{ij} + u_{0j} \quad (2)$$

X_{ij} is pregnancy status for student i , in school j . Y_{ij} is the various network outcomes, which include: the change in the number of out-, in- and reciprocated nominations (calculated as the number of friends at Time 3 minus the number of friends at Time 1), change in centrality (centrality at Time 3 minus centrality at Time 1), and number of maintained out- and in-nominations (a count of the number of friend nominations that were the same at Time 1 and Time 3). β_{0j} represents the intercept, u_{0j} the random school-level component and e_{ij} the individual error term.

Results

Table 3 provides descriptive statistics comparing girls who become pregnant during the Add Health survey ($n = 60$) to non-pregnant girls who were matched using propensity score matching ($n = 180$) and non-matched non-pregnant girls ($n = 572$). The non-matched non-pregnant group was younger, with higher GPAs and less delinquency behaviors (i.e. consuming alcohol and cigarettes, lying and skipping school) than pregnant teens. They also reported higher levels of health, trying in school, and extracurricular participation. The matched non-pregnant teens did not differ on any covariates compared to pregnant teens. The pregnant and non-pregnant matched groups also had standardized biases of less than .25 on all covariates, which is an indicator of sufficient similarity following propensity matching (Stuart, 2010).

Prior to pregnancy, girls who become pregnant reported an average of 5.12 ($SD = 3.44$) friends at Time 1. By Time 3 (after experiencing a pregnancy), they reported 3.15 fewer friends on average

³ The number of covariates probed was limited given the small sample size.

Table 3
Comparison of Pregnant Girls to Non-Pregnant Matched Girls and Not Matched Non-Pregnant Girls Using Mean Difference Testing and Standardized Biases.

	Pregnant		Matched Non-Preg			Not Matched Non-Preg		
	M	SD	M	SD	Std bias	M	SD	Std bias
<i>Out-Nominations</i>								
Num. at first survey	5.12	3.44	5.18	3.21	-0.02	5.49	3.22	-0.11
Avg. diff. bt surveys	-3.15	3.29	-2.38	3.16	-0.23	-2.01*	3.47	-0.35
Num. maintained bt surveys	0.65	0.90	1.03*	1.32	-0.42	1.41*	1.47	-0.85
<i>In-Nominations</i>								
Num. at first survey	4.48	3.39	4.29	3.62	0.06	4.78	3.66	-0.09
Avg. diff. bt surveys	-3.12	3.02	-2.11*	2.86	-0.33	-2.28*	3.18	-0.28
Num. maintained bt surveys	0.30	0.59	0.58*	0.92	-0.47	0.87*	1.12	-0.97
<i>Reciprocated Friends</i>								
Num. at first survey	1.60	1.53	1.74	1.70	-0.09	1.98	1.74	-0.25
Avg. diff. bt surveys	-1.12	1.56	-0.83	1.64	-0.18	-0.88	1.72	-0.15
<i>Centrality</i>								
Num. at first survey	0.57	0.47	0.58	0.47	-0.01	0.55	0.46	0.05
Avg. diff. bt surveys	-0.27	0.87	-0.24	0.86	-0.04	-0.23	0.83	-0.05
<i>Covariates</i>								
Age	15.57	1.09	15.49	1.11	0.07	15.02*	1.36	0.50
White	0.47	0.50	0.44	0.50	0.06	0.44	0.50	0.05
Black	0.22	0.42	0.23	0.42	-0.03	0.16	0.37	0.13
Hispanic	0.52	1.47	0.66	1.65	-0.09	0.91	2.19	-0.27
U.S. Born	0.95	0.22	0.92	0.28	0.15	0.84*	0.37	0.50
Prior GPA	2.31	0.73	2.39	0.68	-0.10	3.07*	0.69	-1.04
HIV/AIDS Expectations	1.00	1.35	1.21	2.03	-0.15	0.85	1.57	0.11
Number in Household	4.55	1.33	4.56	1.13	0.00	4.74	1.12	-0.14
Extracurricular	0.33	0.48	0.32	0.47	0.04	0.14*	0.34	0.41
Get Along w. Teacher	1.22	1.30	1.11	1.30	0.09	1.06	1.34	0.12
Get Along w. Peers	1.58	1.45	1.56	1.49	0.02	1.43	1.54	0.10
Try in School	1.78	0.61	1.76	0.66	0.05	1.58*	0.59	0.34
Tried Alcohol	0.78	0.42	0.79	0.41	-0.03	0.44*	0.50	0.82
Overall Health	2.73	0.88	2.81	0.90	-0.08	2.14*	0.94	0.67
Cigarette Consumption	2.53	2.80	2.27	2.53	0.09	0.65*	1.43	0.67
Lie to Parents	2.83	1.86	2.86	1.84	-0.01	2.00*	1.68	0.45
Skip School	1.57	1.69	1.44	1.68	0.08	0.35*	0.77	0.72
n	60		180			572		

*p ≤ .05 - Significance of mean difference test compared to pregnant group.

Table 4
Characteristics of Saturated Schools with One or More Pregnancy Occurrence

School	Type	Urbanicity	Size	Grade	Region
1	Public	Rural	Small	K-12	South
2	Public	Rural	Large	9-12	Midwest
3	Public	Suburban	Large	10-12	West
4	Public	Rural	Small	K-12	Midwest
5	Private	Urban	Small	K-12	South
6	Public	Suburban	Small	6-8	South
7	Catholic	Urban	Small	K-8	Northeast

($m = 1.97$, $SD = 1.84$). In comparison, matched non-pregnant teens started with a similar number of friends ($m = 5.18$, $SD = 3.21$) and lost roughly 2.38 friends by Time 3 ($m = 2.81$, $SD = 2.39$). These non-pregnant matched girls ended with nearly one more reported friend on average than pregnant teens. The pregnant and non-pregnant matched girls also started with similar number of in-nominations friends (pregnant $m = 4.48$, $SD = 3.39$; non-pregnant matched $m = 4.29$, $SD = 3.62$). By Time 3, pregnant teens received roughly three fewer friend nominations from peers while their non-pregnant matches received two fewer friends. Pregnant teens started with 1.60 ($SD = 1.53$) and ended with 0.48 ($SD = 0.72$) reciprocated friendships. Non-pregnant matched girls started with only slightly more reciprocated friendships and ended with 0.91 ($SD = 1.12$) reciprocated friendships, which was not significantly different from pregnant teens. Pregnant teens also maintained fewer friendships between time points than their non-pregnant matches. Pregnant girls maintained .65 ($SD = 0.90$) reported friends between Time 1 and Time 3 compared to matched non-pregnant teens' 1.03 ($SD = 1.32$). On average, 0.30 friends reported pregnant teens as friends at both Time 1 and Time 3 compared to matched non-pregnant teens 0.58 ($SD = 0.92$) maintained in-nominations. Pregnant and non-pregnant matched did not differ in terms of centrality at any time point.

Network Graphs. Network maps of whole school social networks were drawn to visualize how pregnant teens' network positions changed between time points compared to their propensity score matched non-pregnant peers. These maps are presented in Figures 1-7, with pregnant girls colored in blue and non-pregnant matched girls in orange. Table 4 provides a breakdown of each school's characteristics. Overall, there are 5 graphed public schools, one Catholic school and one private school. Three schools were in rural areas, two in suburban and two in urban. All but two of the schools were small (less than 200 students) and four included primary grades. The two schools with the largest pregnant populations were Schools 2 and 3, and these schools were further modeled with stochastic actor oriented models. The seven schools mapped here are not nationally representative, nor do they reflect the distribution of types of schools within the larger Add Health data set (see Table 1). Descriptive analysis of these schools' networks cannot be generalized to other schools in similar contexts (i.e. associations noted here in rural schools could not be applied to all rural schools).

While all the school networks became less densely connected with time (Table 2), network changes of pregnant girls compared to their non-pregnant matches appear to vary across schools. Looking first at the extent of friendship loss, roughly half the schools saw greater losses for pregnant girls

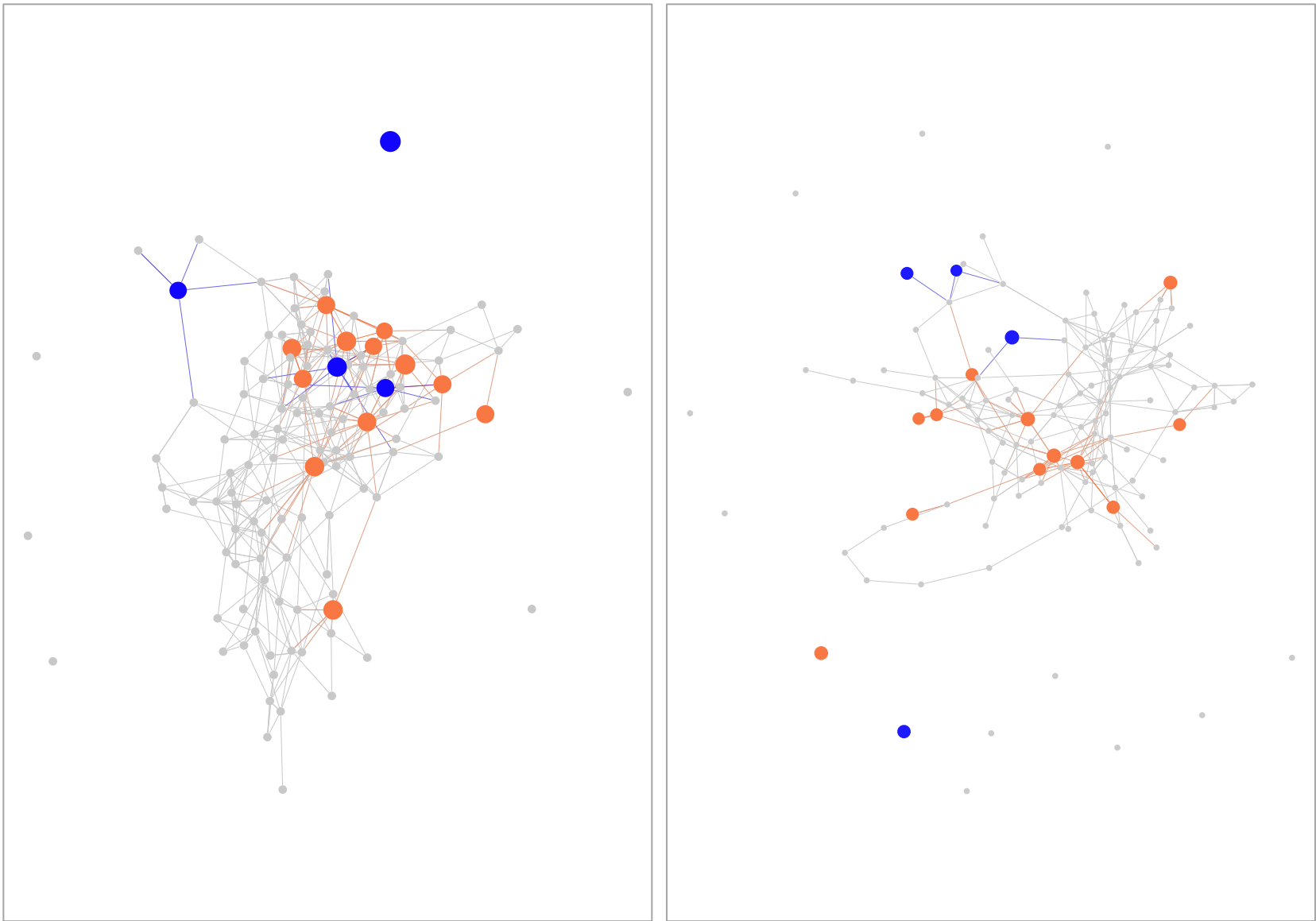


Figure 1. School 1 (public, rural) network maps at Time 1 (left) & Time 3 (right). Blue = pregnant, orange = non-pregnant match.

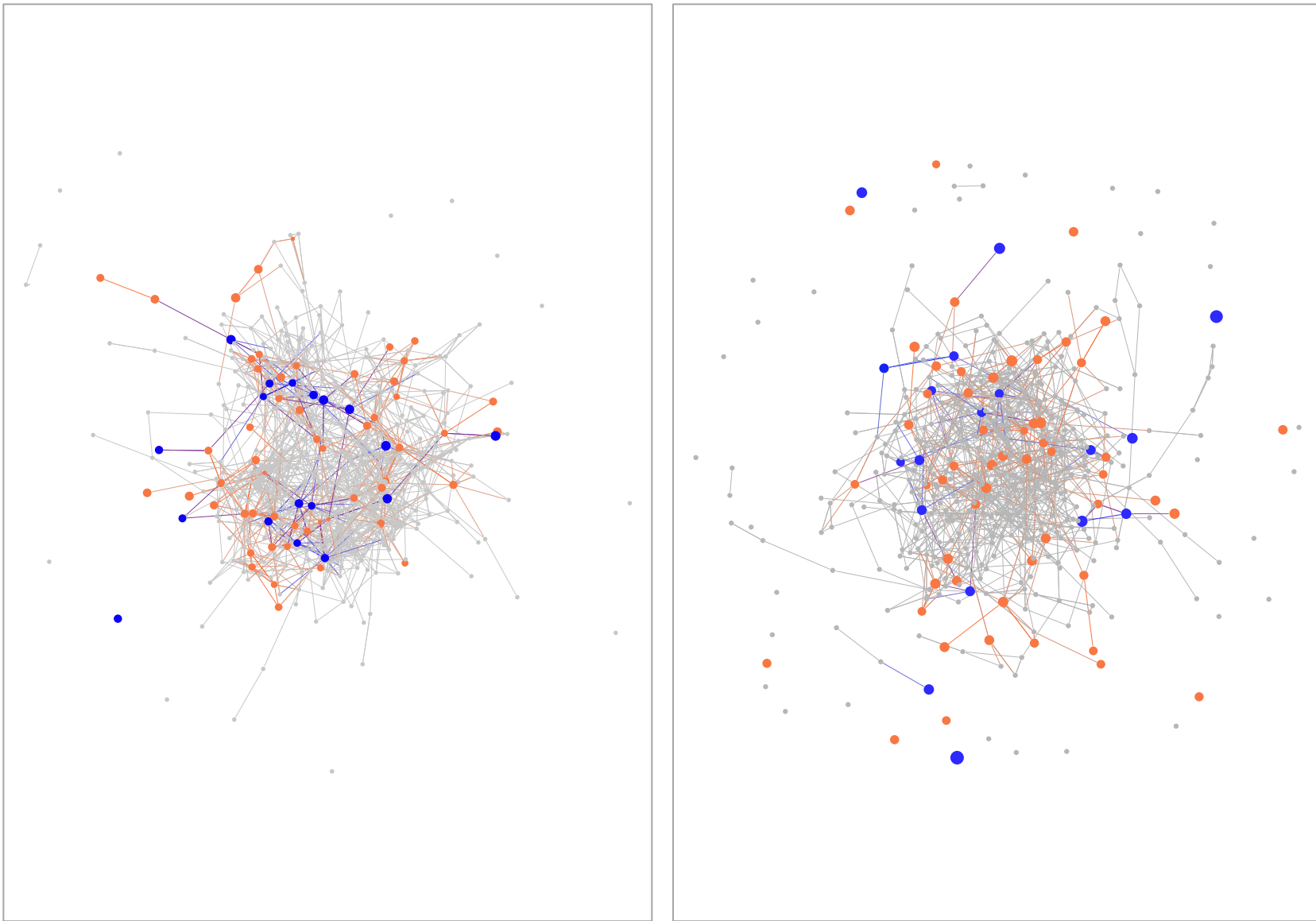


Figure 2. School 2 (public, rural) network maps at Time 1 (left) and Time 3 (right). Blue = pregnant, orange = non-pregnant match.

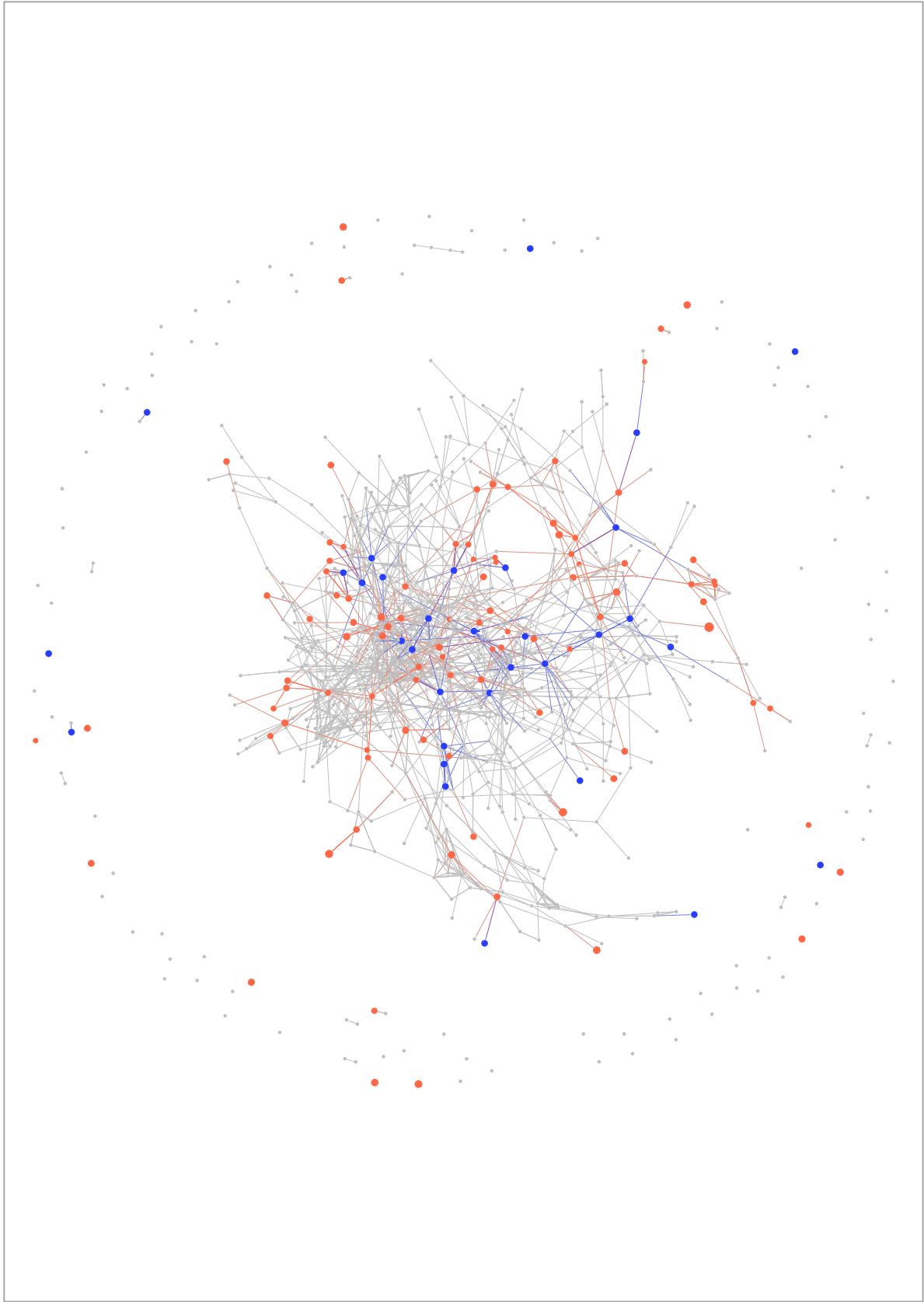


Figure 3a. School 3 (public, suburban) Time 1 map. Blue = pregnant, orange = non-pregnant.

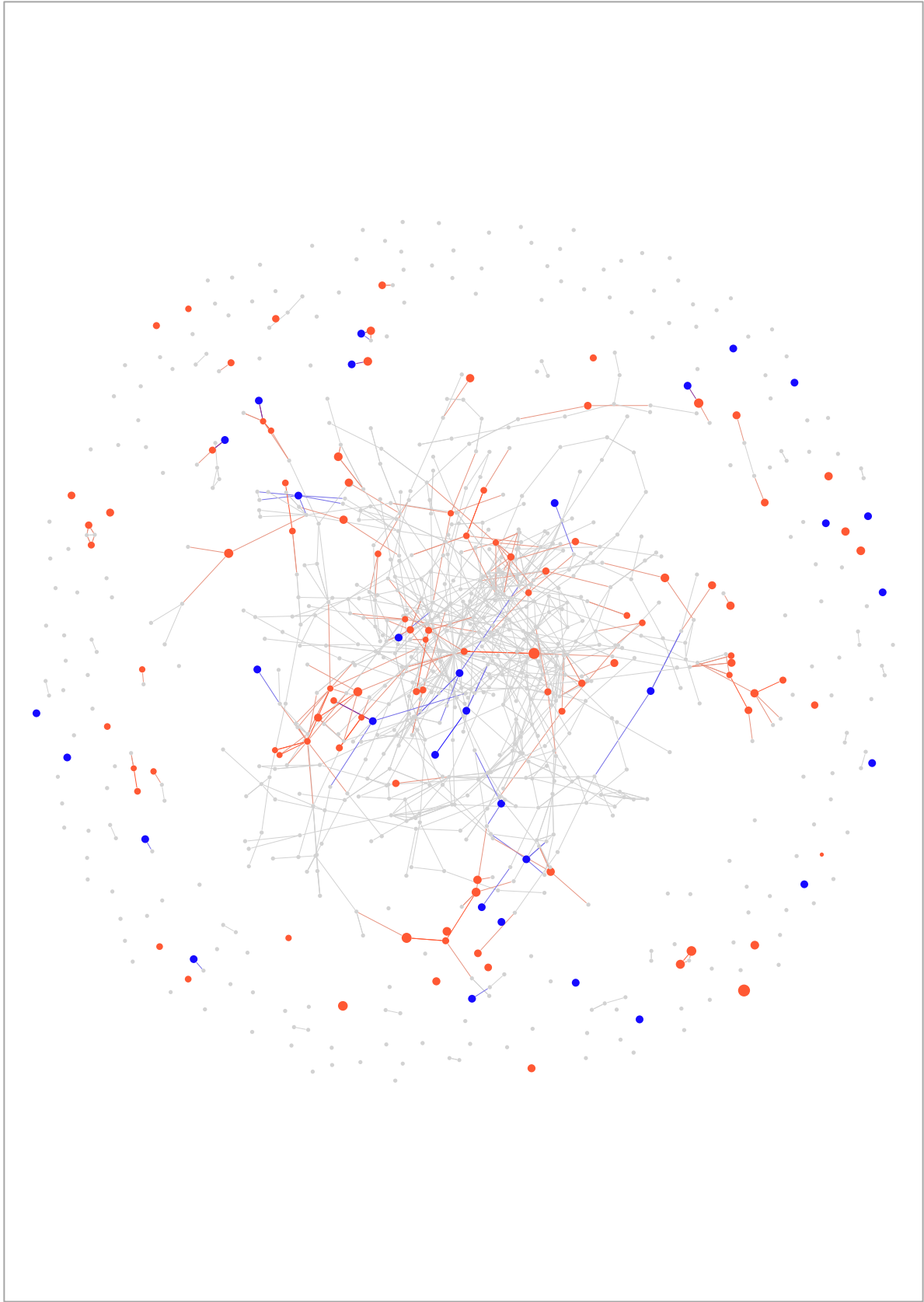


Figure 3b. School 3 (public, suburban) Time 3 map. Blue = pregnant, orange = non-pregnant.

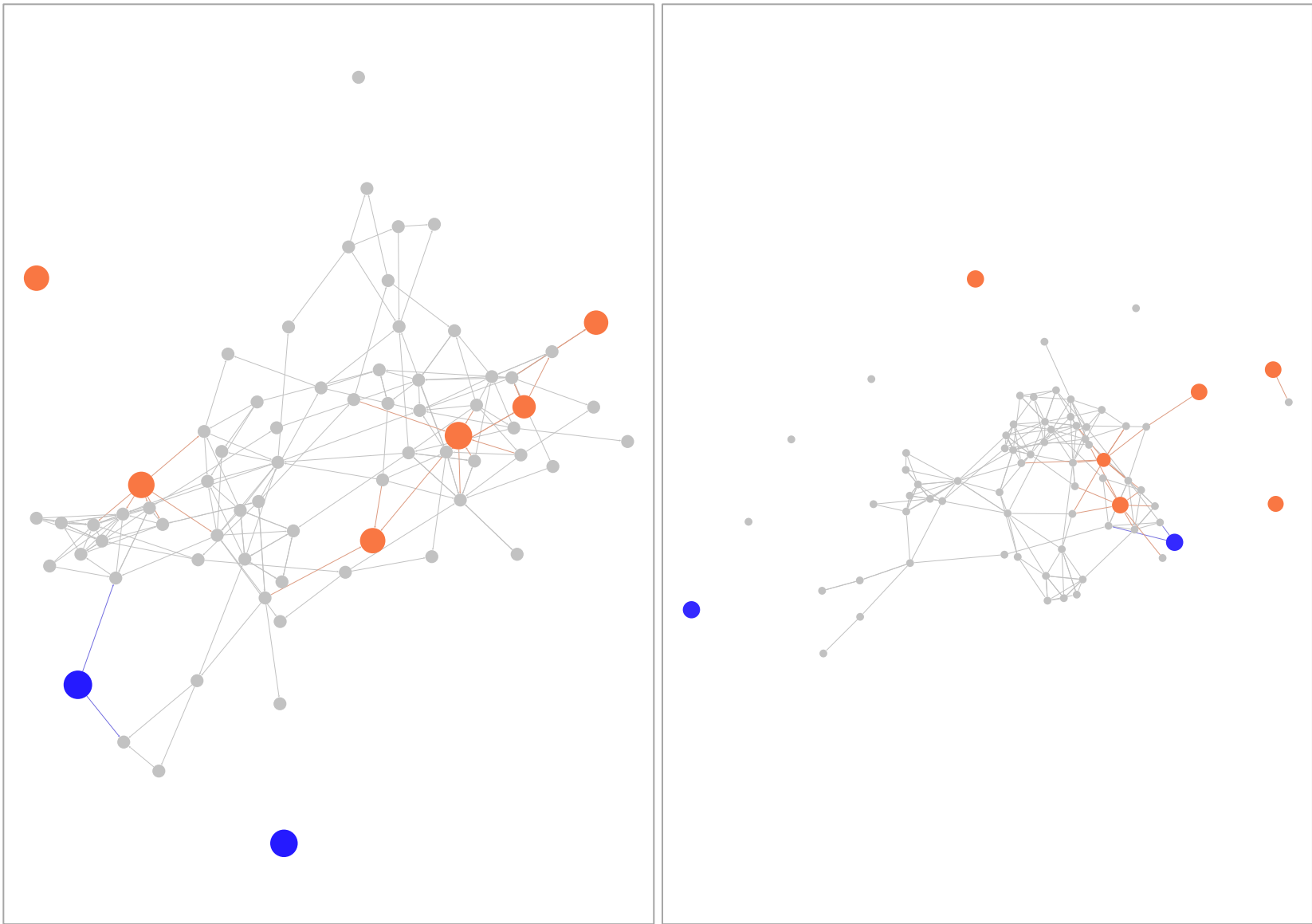


Figure 4. School 4 (public, rural) network maps at Time 1 (left) and Time 3 (right). Blue = pregnant, orange = non-pregnant match.

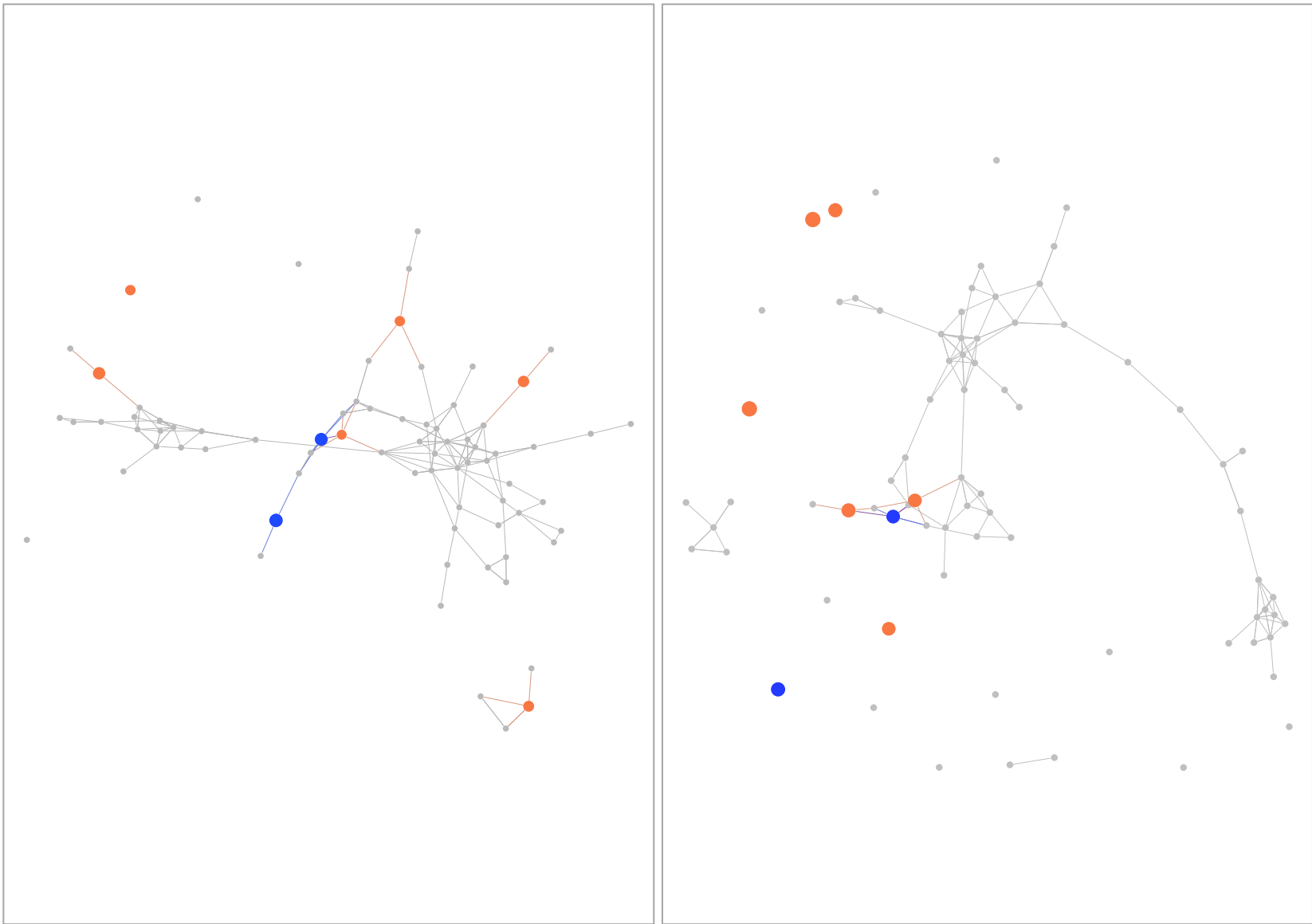


Figure 5. School 5 (private, urban) network maps at Time 1 (left) and Time 3 (right). Blue = pregnant, orange = non-pregnant match.

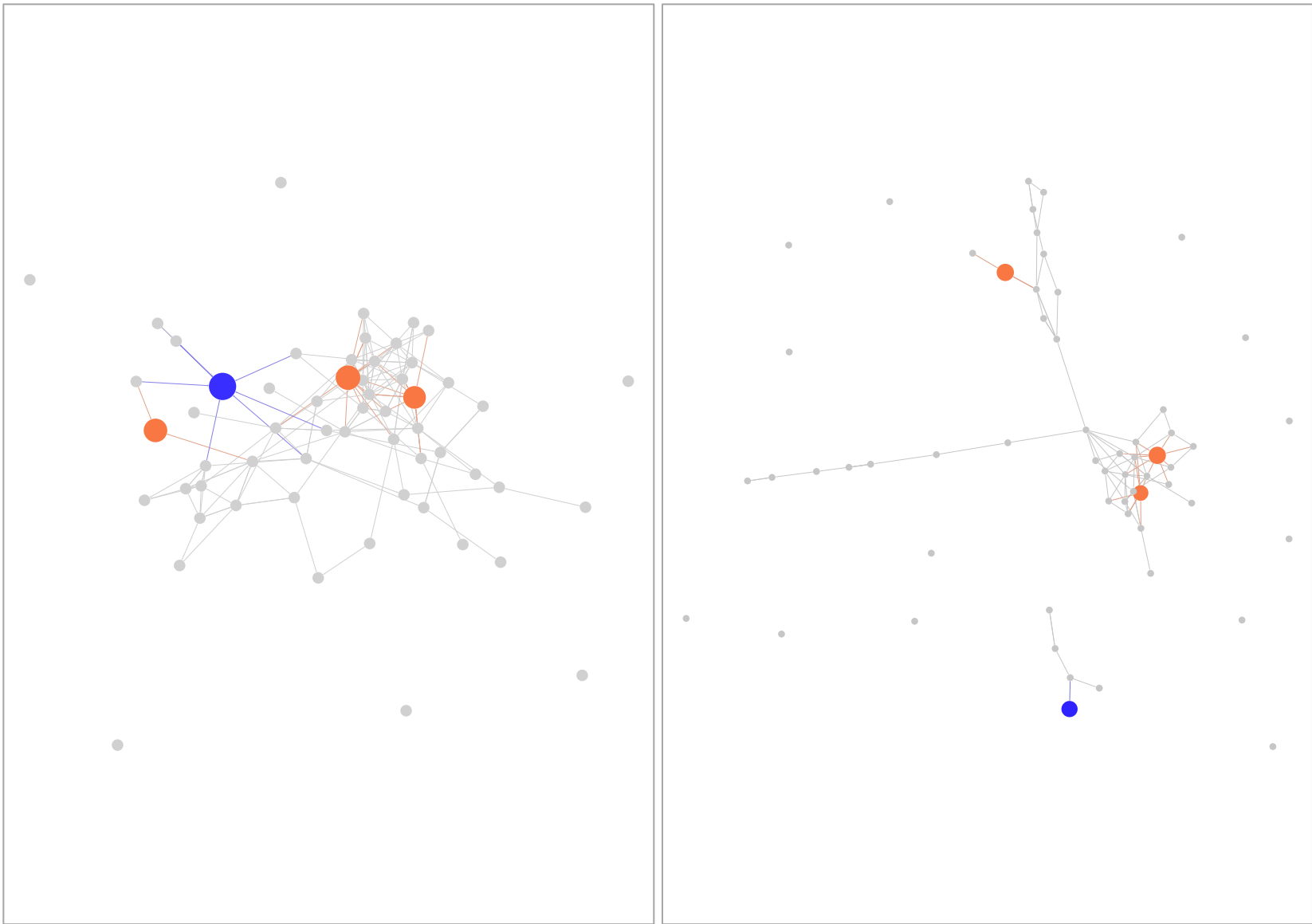


Figure 6. School 6 (public, suburban) network maps at Time 1 (left) & Time 3 (right). Blue = pregnant, orange = non-pregnant match.

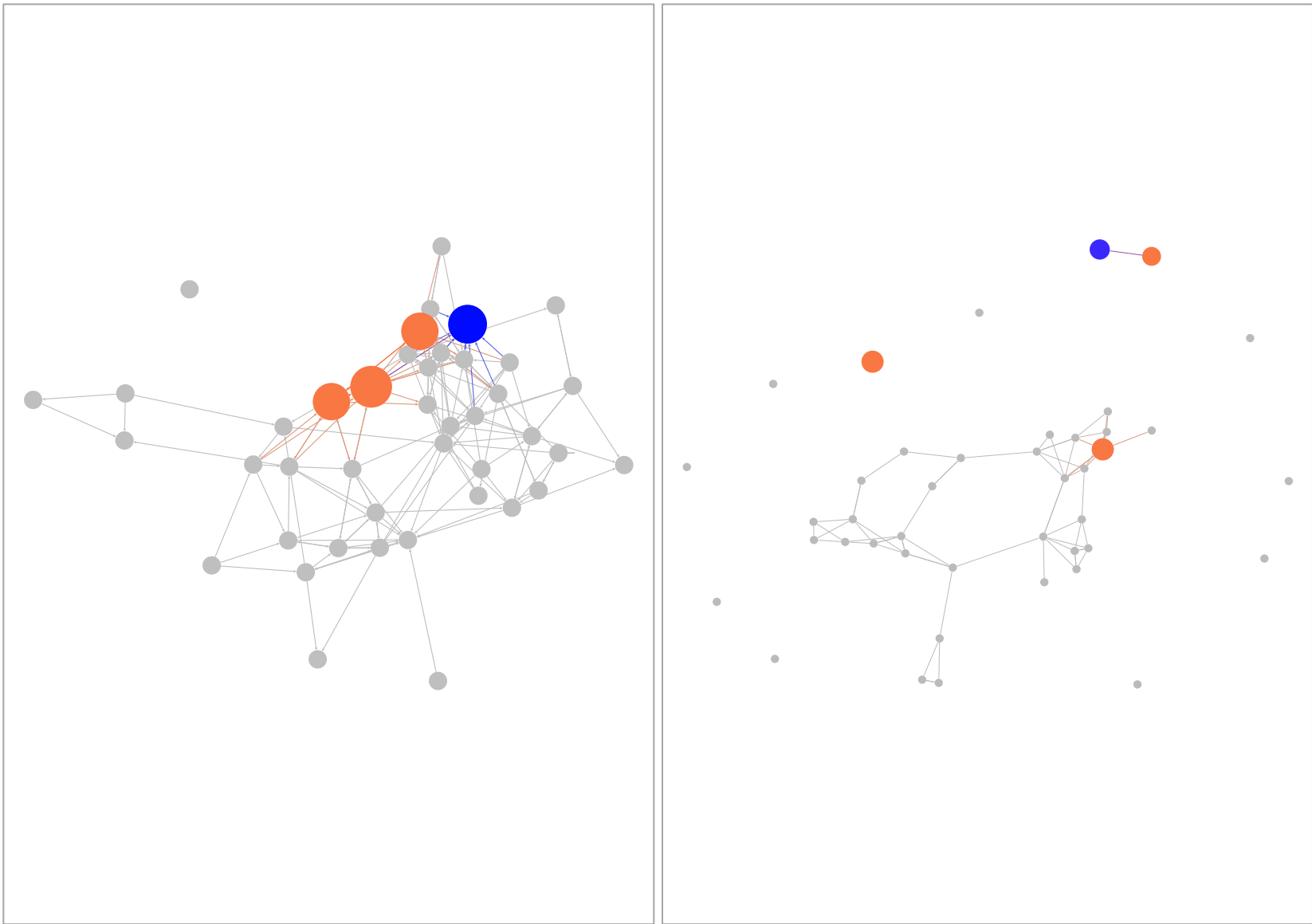


Figure 7. School 7 (Catholic, urban) network maps at Time 1 (left) and Time 3 (right). Blue = pregnant, orange = non-pregnant match.

than their matches. In School 1 (Figure 1), nearly half of the non-pregnant matched girls end with six ties or more (a mix of out- and in-nominations), whereas the pregnant girls ended with 2 ties or less. Of those, only one of the pregnant girls receives an in-nomination friendship from a peer and none had any reciprocated friendships. Pregnant teens in School 2 (Figure 2) also lost more ties than their matches, but compared to School 1, they still had a mix of out- and in-nomination friendships at Time 3. In School 3 (Figures 3a-b), pregnant teens appear to have slightly fewer ties than the non-pregnant matches generally, but these differences are not as pronounced as those seen in Schools 1 and 2. Nevertheless, School 3 is the only school where more pregnant teens become complete social isolates than non-pregnant matches. The two schools with only one pregnant teen each (Schools 6 and 7, Figures 6-7) both had their pregnant teens go from highly connected to only having one connection at Time 3. In School 6, this change is a deviation from the non-pregnant matches (who mostly remained highly connected), whereas some of School 7's non-pregnant matches also experienced extensive friend loss. In contrast, the pregnant teens in Schools 4 and 5 (Figures 4-5) had similar number of connections as their matches at both time points, suggesting that pregnant girls did not experience greater changes than comparable peers in these schools.

In terms of network position, pregnant teens experienced more extreme moves to network peripheries in some schools. School 1 saw its three central pregnant girls move to more exterior network positions at Time 3, while some of their non-pregnant matches remained more centrally positioned. Similarly, pregnant teens in School 2 experienced greater moves to the network perimeter than their non-pregnant matches, many of who remained as central actors. In Schools 6 and 7, with only one pregnant girl each, the pregnant girls went from being in the main component of the network at Time 1 to disconnected from the main network at Time 3. In School 6, the non-pregnant matches remained central and connected to the main component, whereas in School 7 only one match remained as well positioned at Time 3. In School 3, pregnant girls do not appear to move as drastically towards the exterior of the network compared to their matches as seen in the Schools 1, 2, and 6. Again, pregnant girls in Schools 4 and 5 do not appear to differ from their non-pregnant matches.

Stochastic Actor Oriented Models. The descriptive analysis of network maps above does not account for any underlying drivers of network change. Stochastic actor oriented models test network tendencies and covariates to assess whether they are related to changes seen in networks over time. Table 5 presents results from the stochastic actor oriented models run on Schools 2 and 3. It should be noted that the models slightly exceed the recommended benchmarks for levels of model convergence. There are two measures of convergence in SAOM, which are indicators of the extent to which the simulated statistics deviate from the observed network at each time point (Ripley, Snijders, Tom A.B., Boda, Voros, & Preciado, 2016). The first, a maximum convergence ratio, is the maximum value of the ratio of average deviation divided by the standard deviation. It is recommended that these overall convergence ratios are less than 0.30. School 2 slightly exceeds this recommendation, with convergences of 0.32. The t-ratio of convergence is calculated by dividing the estimate by its standard error, adjusted to a standard normal distribution. It is recommended that no estimate exceed 0.2. School 3's 'pregnancy ego' covariate slightly exceeds this cut off with a t-ratio of 0.204. These convergence issues may result from the inclusion of weak covariates that are not significant. It is usually recommended to remove these covariates and re-estimate the models (Ripley et al., 2016); however, this would remove the pregnancy covariates, which are the focus of this study. As such, the results of the models are still presented here.

Table 5
Stochastic Actor Oriented Model Estimates for Schools 2 and 3

	School 2	School 3
Rate (Period 1)	11.37 (0.55)	9.30 (0.87)
Rate (Period 2)	10.31 (0.47)	5.00 (0.31)
Out degree	-3.32 (0.03)	-4.16 (0.04)
Reciprocity	2.16 (0.05)	2.60 (0.08)
Transitive Triplets	0.44 (0.02)	0.61 (0.03)
Female Similarity	0.18 (0.03)	0.35 (0.04)
Grade Similarity	2.01 (0.11)	2.11 (0.13)
Pregnant alter	-0.34 (1.42)	0.09 (0.24)
Pregnant ego	-0.77 (1.37)	-0.35 (0.30)
Pregnant similarity	-0.36 (1.41)	0.33 (0.24)
n nodes (preg. nodes)	479 (21)	850 (60)

Each school has two rate function estimates, which represent the average number of opportunities that each person in the network has to make a change or remain constant. This means, for example, that between Time 2 and Time 3 in School 2, each person theoretically had the opportunity to change a friendship tie or a characteristic (i.e. non-pregnant to pregnant) 10.31 times. These rates do not represent average number of changes made because network actors can remain the same when they have an opportunity to change. The Period 1 rate represents the opportunities for change between Time 1 and Time 2, and Period 2 represents opportunities between Time 2 and Time 3.

In terms of network structure variables, across schools the more out-nominations a participant had previously, the less likely they were to extend new friendship ties. This result is generally expected when modeling networks as those with the most friends have less time for new, additional friends. Participants in both schools were also predicted to be more likely to extend friendship ties if it reciprocates a friendship or completes a transitive triplet. Being of similar sex and in the same grade were also associated with increasing the likelihood that a friendship forms. The preference for friends in the same grade was much higher than the sex preference across schools.

Overall, no significant relationships were found between any pregnancy variables and friendship change within a network. Likely, the analysis of pregnancy covariates is underpowered given the limited number of pregnant occurrences, and connections to pregnant teens, at each time point.

Table 6
Separable Temporal Exponential Random Graph Models of Schools 2 and 3

	School 2				School 3			
	Formation		Dissolution		Formation		Dissolution	
	Base	Covars.	Base	Covars.	Base	Covars.	Base	Covars.
Edges	-6.40*	-6.52*	-6.56	-1.47*	-6.92*	-7.52*	-0.76*	-1.65*
	(0.03)	(0.04)	(0.03)	(0.06)	(0.03)	(0.05)	(0.04)	(0.08)
Preg - Out	-0.70*	-0.37	-0.85	-0.77	-0.61*	-0.51*	-0.51	-0.31
	(0.03)	(0.31)	(0.45)	(0.52)	(0.18)	(0.19)	(0.28)	(0.30)
Preg - In	-0.26	0.15	-0.66	-0.30	-0.27	-0.12	-0.79*	0.47
	(0.24)	(0.21)	(0.38)	-(0.45)	(0.16)	(0.16)	(0.30)	(0.05)
Triad (gwesp)		1.16*		0.37*		1.38*		0.47*
		(0.03)		(0.04)		(0.05)		(0.05)
Reciprocity		3.18*		1.75*		3.68*		1.38*
		(0.90)		(0.11)		(0.11)		(0.14)
Gender Homophily		0.11*		0.64*		0.34*		0.68*
		(0.05)		(0.07)		(0.06)		(0.09)

* $p < .05$

Moreover, there is likely little variation left to be explained after the inclusion of the significant network tendency predictors. The STERGM models (Table 6) further suggest this in at least one of the schools, as pregnancy parameters switched from significant to non-significant after the addition of network tendency variables (reciprocity, triad effect and gender homophily) in some models. For School 2, pregnancy was a significant predictor of tie formation when it was the only covariate in the model (outside of total edge count) but it did not maintain significance after the addition of network factors. In School 3, pregnancy was a significant predictor of tie dissolution (modeled as tie duration so a negative coefficient indicates an increase in dissolution) until other network tendency variables were added to the model. School 3 differed from School 2 in that pregnancy remained a significant negative predictor of tie formation (frequency of tie patterns including pregnancy) even after the addition of network covariates.

While conclusions cannot be drawn from these results, it is interesting to note differences between the two schools. In the STERGM models, the association between pregnancy and tie formation was detectable in School 3 even after network tendencies were added whereas it was not in the School 2. This difference could reflect pregnancy having a different relationship with social networks in each school, or could be an artifact of School 2 being underpowered (as it had fewer pregnant girls than School 3). In the SAOM models, an opposite relationship was seen for the ‘pregnancy similarity’ parameter between the two schools, where pregnancy homophily had slightly negative relationship in School 2 and a slight positive relationship in School 3. Again, these are not significant relationships but may suggest that the role of pregnancy in one’s social networks may vary across schools.

Table 7
Random Intercept Models of Change in Network Variables between Time 1 and Time 3 Surveys

	Out-nom.	In-nom	Recip. Friends	Centrality
Intercept	-2.54*	-2.55*	-0.93*	-0.14
	(0.34)	(0.63)	(0.26)	(0.23)
Pregnant	-0.77	-1.01*	-0.28	-0.01
	(0.47)	(0.42)	(0.24)	(0.02)
Random Intercept	0.20	1.93	0.24	0.35
Student-level residual	10.06	7.8	2.50	0.01
n	240	240	240	240
School n	7	7	7	7

* $p \leq .05$

Table 8
Random Intercept Models of Number of Friendships Maintained between Time 1 and Time 3 Surveys

	Out-nom.	In-nom
Intercept	1.08*	0.7*
	(0.19)	(0.13)
Pregnant	-0.37*	-0.28*
	(0.18)	(0.13)
Random Intercept	0.12	0.06
Student-level residual	1.41	0.68
n	240	240
School n	7	7

* $p < .05$

Regression Analysis. Multilevel models were run in addition to SAOM as it allowed for inclusion of all pregnant girl (not just those in the largest schools). Additionally, multilevel models do not adjust for network tendencies but still account for the clustering of students within school networks in a way that descriptive analysis of network maps does not (Table 7). While mean difference testing found a difference between number of reported friends for pregnant and non-pregnant matched teens, this difference was not found in the multilevel model. Pregnant and non-pregnant matched teens were not found to differ significantly in the extent to which their reported friendship networks changed between Times 1 and 3. This suggests that pregnant teens were not less likely to report having friends after pregnancy than their comparable peers. Pregnant teens, however, were significantly less likely to have peers report being friends with them than their non-pregnant matches. Being pregnant was associated with losing an addition in-nomination friend compared to non-pregnant matched peers ($\beta = -1.01$, $SE = 0.42$). Pregnant teens were also predicted to have fewer maintained friendships between time points (Table 8). Being pregnant was associated with having 0.37 ($SE = 0.18$) fewer reported friendships that were the same at Time 1 and Time 3. To put this difference in context, a reduction of 0.37 is almost third of the average 1.27 friendships

maintained for all girls. Peers were also less likely to report pregnant teens as friends at both Time 1 and Time 3. Pregnancy was associated with maintaining 0.28 ($SE = 0.13$) fewer in-nomination friendships than non-pregnant matched teens. Again, this difference is roughly a third of the 0.76 average maintained in-nomination friendships for girls generally. Change in reciprocated friends and centrality did not differ for pregnant and non-pregnant matched girls.

Discussion

Past cross-sectional research has found pregnant teens to be less well connected to friends than their non-pregnant counterparts (Humberstone, 2018a). By harnessing longitudinal network data, this study expands this work by following a group of girls who become pregnant in the middle of data collection. This design allows for the comparison of social networks before and after a pregnancy occurrence within the same individual. Longitudinal analysis also provides many advantages over a cross-sectional study as it accounts for overall network tendencies and change in position in the greater network, and better captures the impact of friendship and pregnancy challenges that likely evolve over time. This study explores longitudinal data using three methodological strategies. It finds multilevel models the most informative given the limited and non-representative data available. Multilevel models adjust for variations across school networks – which are expected as each school’s social network is unique – while providing more model freedom than network-specific stochastic actor oriented models.

A common concern in longitudinal social network studies is how to account for individuals leaving the network between time points. This study harnessed propensity score matching as a strategy to evaluate whether pregnant teens experience larger changes to their networks than comparable peers. It finds that pregnant teens experience a greater reduction in the number of peers who consider them as friends (in-nominations) than their non-pregnant counterparts. The measure of friendship nominations received is calculated from the surveys of other participants and is not known by the pregnant participant. Thus, it can be considered a measure of how one is received socially by her peers. The differences observed in in-nomination friendships between pregnant and non-pregnant girls suggest that peers cease their relationships with pregnant teens at a faster rate than with non-pregnant classmates. This finding coupled with the finding that pregnant girls do not significantly differ in reporting friends (out-nominations) may suggest that peers potentially stigmatize pregnant teens. Pregnant teens reporting friends at a similar rate may also counter the idea that pregnant girls limit the number of friendships they have in the face of pregnancy challenges. These results mirror those found when the networks of those experiencing a pregnancy were cross-sectionally compared to never pregnant girls.

Longitudinally studying network change also allows for one to analyze friendship stability across time. As friendships are known to be dynamic through adolescence (Bowker, 2004; Poulin & Chan, 2010), differences in maintained friendships may imply that one has greater friendship volatility than peers. Enduring friendships may also point to stronger relationships that are better able to weather time or major life changes. Pregnancy was associated with having fewer maintained friendships across time points. Pregnant teens were less likely to report having the same friends before and after pregnancy. There are a number of possible explanations for this finding. First, friendships held prior to pregnancy may not have been deep enough to last through the stresses of a pregnancy. Changing relationships may also result from the pregnant teens’

reprioritization of friendships and activities that girls qualitatively report following a pregnancy (SmithBattle, 1995). Pregnant girls also have less stability in the peers who consider them friends. They were less likely to maintain the same in-nomination friends between Time 1 and 3 than non-pregnant girls. Again, this may result from more superficial friendships that were not deep enough to last through time and/or a pregnancy, or from stigma that discourages friends from maintaining a relationship. Past work has suggested a relationship between more in-nominations prior to pregnancy and improved odds of educational attainment (Humberstone, 2018b). It stands to reason that maintaining these friendships through a pregnancy would also benefit academic persistence. Work with a larger sample of pregnant girls may help elucidate how extent of network change and friendship stability relates to educational success for pregnant girls, and at-risk teens more generally.

This study also adds to the literature by analyzing pregnant teens embedded within their whole school social networks. The value of one's social network is not determined solely by the number of friends one has but also one's position in her greater social environment. While cross-sectional comparison can provide information on whether pregnant teens have different network positions than their non-pregnant peers, longitudinal work is able to tell a more nuanced story. Changes in network position likely impact an individual as much as the network position itself. A less central girl prior to pregnancy is presumably less jolted by finding herself in a peripheral network position after pregnancy than a girl who starts off in a highly central position. Mapping the sociometric networks of individual schools also suggests that the extent of change may range across schools. Some schools had greater network position change for pregnant teens than others, and in two schools these changes were not observed. Pregnant teens in many schools also had less friend connections generally, with the severity of the reduction in friends compared to matched non-pregnant peers varying between schools. In a majority of the schools analyzed here, pregnant teens moved from the center of the network map to the periphery, but the degree of this movement depended on the school. Being more exterior in the network suggests these girls are less similar to the well-connected actors within their schools. Being more peripheral in a social network is thought to be associated with having less access to resources and information from others, being less influential, and being less independent (Brass, 1984). People in the periphery are also more dependent on their limited relationships for information, support and connection to the greater network (Daly, 2012). Being in the network periphery with fewer connections also leaves individuals more at risk of becoming social isolates.

These between-school differences suggest that the social impact of pregnancy may at least partly depend on school environment. Small differences between schools were also observed in the stochastic actor oriented models, although these findings were insignificant. The direction of the estimated relationship between pregnancy homophily was opposite in the two modeled school. Because the ratio of pregnant to non-pregnant teens in these schools is small, it is likely that the models are underpowered and unable to detect if there is a true relationship between pregnancy and friendship tie formation. The schools also differed in the STERGM models; pregnancy remained a significant parameter after adding network tendency covariates in the tie formation model for School 3 but not for School 2. This could reflect pregnancy having a different relationship with the pattern of friendship ties in each school. Alternatively, with fewer pregnant teens, School 2 may also be underpowered. Nevertheless, it stands to reason that social milieus would depend on the school environment. In schools where teen pregnancy is more prevalent,

pregnancy may be less shocking and thus less stigmatizing. Schools with regular pregnancy occurrences are also more likely to have the procedures or resources to support pregnant girls and encourage more normal school going. The starker, negative changes seen in the smaller school with few pregnant girls may derive from an environment where pregnancy is more scandalous or less institutionally supported. This aligns with past work that suggests environmental context is a key factor in friendship formation and durability (Small, 2009). This study is limited by its non-representative school sample and small size. Seven schools are not enough to draw conclusions and many other school contexts, such as urban or private schools, are not represented here. However, these preliminary findings align with past work that has found attitudes towards and supports for pregnant teens vary across schools and classrooms (Vincent & Thomson, 2010). More work is needed to understand how different school factors impact the social networks of their at-risk students.

There are several limitations to this study. First, the sample excludes seniors from the analysis since they finished school prior to the Time 3 survey. As older girls are more likely to experience a pregnancy, the pregnant populations within each school are underrepresented. Friendship connections are also likely underestimated since friendships with seniors and other students who left due to attribution are not included. Further, this study only considers within school friendships of individuals who were identifiable in the Time 1 and Time 3 surveys. This fails to account for any friendships held outside of school. Most likely, this also underestimates friendships for all participants. If pregnant teens were more likely to be connected to school-leavers or senior students than their non-pregnant peers, this would bias the results. Pregnant girls were matched to peers who had a similar number of friends (with complete longitudinal data) at Time 1 in an attempt to mitigate this limitation. Nevertheless, this study's use of propensity score matching rests on the assumption of no unobserved confounding. Conceivably, the pregnant and matched non-pregnant girls may differ by an unmeasured or unaccounted for variable. If an omitted variable relates to both pregnancy and friendship, the results reported here may overestimate the association between pregnancy and social network change. .

Further, because I had a limited number of teens who become pregnant in the saturated schools, this study may be underpowered and unable to detect pregnancy effects, such as with the insignificant stochastic actor oriented models. While limiting to the saturated schools was necessary in order to have full school social networks, these schools are not representative. Most were small schools that were included in the saturated sample because of size. This does not allow for a more detailed examination as to how the relationship between pregnancy and social connections may vary in different school contexts, such as in large urban schools. I also consider any pregnancy occurrence, regardless of outcome (e.g. miscarriage, live birth). Girls report pregnancy to be a life turning point that changes their priorities (Clemmens, 2003), and most likely stigmatization of a teen pregnancy starts before a live birth. Still, future work exploring network changes by pregnancy outcome would add to this literature. Finally, with the arrival of the internet and social media, the social landscape of teenagers has changed substantially and thus, the generalizability of these results are limited by the age of the data. Nevertheless, pregnant teens are still likely to attend school in person and are subject to possible challenges stemming from in-school friendships or stigmatization. Indeed, recent studies continue to report stigmatization as a problem facing teens experiencing pregnancy today (Bermea et al., 2016).

Overall, this study suggests a possible relationship between experiencing a pregnancy and social network differences. Nevertheless, this analysis cannot assess whether network changes would be qualitatively negative or positive for pregnant girls, nor evaluate the quality of reported friendships. Were pregnant girls consciously pruning their friend networks to focus on their strongest friendships, a change to fewer friends may benefit both pregnant teens and their friendships. On the other hand, a non-voluntary loss of friends may be daunting for a pregnant teen, especially if it leaves her with few or no friends. This would be particularly concerning as social connections at school are thought to buffer against dropout (Rumberger, 2011) – a major concern for pregnant teens that limits their future prosperity. Opportunely, the extent to which pregnant girls’ social networks changed appeared to depend on her school environment. Though the results are limited to seven school cases, it points to school-level factors as possible loci for bolstering pregnant teens’ connections to classmates, and ultimately their schools. More work is needed with a larger sample of representative schools to better understand this possible relationship, and try to identify school factors that positively relate to social outcomes for pregnant teens.

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