

When Peers Help and Harm: Adolescent Social Structure and Mental Health

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Dissertation submitted in partial fulfillment of  
the requirements for the degree of Doctor  
of Philosophy in the Department of  
Sociology in the Graduate School  
of Duke University

2020

ABSTRACT

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## **Abstract**

Human social life requires navigating complex patterns of relationships that create underlying structures of social integration. In adolescence, teens manage close friendships while simultaneously evaluating their social position in broader peer groups and the larger school peer context. Social structures in each dimension of the peer network can relate to symptoms of mental distress, including depressive symptoms and self-harm, both critical health risks in this life course stage. Moreover, any association between network structure and mental health likely depends on contextual features that shape social relations and health, such as gender and friends' mental health. In this dissertation, I examine distinct dimensions of social integration and contextual features of networks to clarify when social integration among peers relates to better and worse mental health for teens. Using survey data from PROSPER, I test the association of network position with depressive symptoms and self-harm by gender and friends' mental distress.

In Chapter 2, I disentangle local and global social integration among peers by gender and friends' depression to clarify how adolescent network integration relates to depressive symptoms. Analyses indicate global integration is protective for both boys and girls. Friends' depression is largely irrelevant for boys. For girls with depressive friends, increased global integration predicts increased depressive symptoms, while

greater local integration buffers associations between friends' depression and girls' own depressive symptoms. Results indicate the importance of considering distinct types of social integration by gender for depressive symptoms in adolescence.

Chapter 3 examines peer networks and self-harm, or intentional injury to one's own body. I find that self-harm is largely unrelated to social position for boys, with only a small association between self-harm and being in the core of a peer group. For girls, however, greater integration among close friends and the overall peer network is associated with lower self-harm, unless friends are harming, then greater integration predicts higher self-harm. These results indicate that structures of cohesive close friendships and status among peers reduce self-harm risks for girls only in contexts where integration does not reinforce behaviors of harming peers.

Overall, this work demonstrates that distinct dimensions of social integration in peer social networks relate to depressive symptoms and self-harm in adolescence. However, these levels of structural integration should be considered in connection with features that shape the meaning of network structure. Further research is needed to define mechanisms linking integration to mental health, particularly self-harm, and to examine the consequences of this interplay between adolescent social integration and mental distress for health in subsequent life course stages.

## Dedication

*To my family, especially Ann Copeland, whose support made anything possible.*

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# 1. Introduction

While social integration relates to mental health at any stage of the life course, it takes on heightened salience in adolescence (Berkman et al. 2000; Cotterell 2007). Social integration can be conceptualized as structural characteristics of individuals' positions created by complex patterns of social ties in social networks (Pescosolido 2006; Umberson, Crosnoe, and Reczek 2010). In the developmental period of adolescence, youth focus on social positions in peer networks (McFarland et al. 2014). In this same period, mental health concerns increase, particularly for depressive symptoms and self-harm, or deliberately damaging one's own body (Hankin 2006; Nock 2010). Understanding how positions among peers relate to mental well-being in adolescence can clarify the role of social integration for health in this key life course stage for social development. Here, I examine how integration in distinct levels of peer network structure relate to mental health for teens, and how these associations vary with contextual features of who is connected in a network, specifically gender and friends' mental health.

I clarify research on how social network integration relates to mental health in several ways. First, I disentangle conceptually and empirically distinct levels of network integration. Within a given network, youth can be simultaneously more or less integrated among close friends, broader peer groups, and the overall network, as local, peer group, and global levels of integration. Second, I jointly examine network structure

and context, as any association between network structure and mental health likely depends on both how youth are connected to peers and the health and behaviors of those to whom they are connected (Pescosolido 2006; Umberson et al. 2010). I consider specifically how network structure relates differently to adolescents' mental health depending on friends' depressive symptoms and self-harm. Because gender shapes both social relationships and how social relationships relate to mental health (Rose and Rudolph 2006; Turner and Turner 1999), I also examine how gender moderates any association between network structure and mental well-being. Third, I extend research on adolescent social networks to consider self-harm, a serious indicator of mental distress presenting a growing public health crisis in adolescence that has rarely been studied in a social networks framework (Nock 2010). By clarifying levels of network integration, joining network structure and context, and expanding research into self-harm, this work contributes to our understanding of both the impact of peer networks in adolescence and how social connections with others can shape mental well-being more broadly.

Chapter 2 examines how local and global integration in peer networks relate to adolescent depressive symptoms. I expand theories of integration as structural cohesion (Moody and White 2003) to examine nestedness in the overall network and in cohesive friend groups in association with depressive symptoms. Using data from the PROSPER Peers survey, I use fixed effects models to test how changes in local and global

integration relate to changes in depressive symptoms and how gender and friends' depressive symptoms moderate these associations. I find that local and global integration have beneficial and detrimental associations with depressive levels in ways that vary with gender. Global integration predicts lower depressive symptoms, but for girls, this association reverses if friends are experiencing depressive symptoms. While friends' depression and local integration are largely orthogonal to depressive outcomes for boys, for girls, greater local integration can buffer the negative impact of depressive friends on girls' depressive levels.

Chapter 3 provides one of the first comprehensive sociological social network examinations of peer networks in relation to self-harm. Self-harm is a potentially visible, highly stigmatized, and increasingly prevalent behavior among adolescents that has been shown to have distinctly social functions and serious consequences for subsequent health, warranting investigation of how social network contexts relate to this behavior (Bentley, Nock, and Barlow 2014). I consider how positions among peers at the close friend, peer group, and whole network level have risky and protective associations with self-harm. Using data from PROSPER Peers, one of the only datasets providing information on self-harm in hundreds of sociocentric peer networks, I further examine the social conditions of self-harm by testing how positions in these three levels of network structure relate to self-harm differently depending on gender and friends' engagement in self-harm. I find that integration at all three levels of the network relate

to self-harm, with peer group integration predicting self-harm for boys, while integration among close friends and the overall network predicts self-harm for girls. For girls, friends' self-harm moderates these associations, so that greater integration is beneficial, but becomes detrimental if friends are self-harming.

Overall, this research shows that structural features of adolescents' social integration in peer networks relate to depressive symptoms and self-harm. However, integration is not uniformly beneficial. Instead, examining the network level and context of integration can separate when greater integration among peers helps and harms mental health for youth. Specifically, integration is best separated into three distinct but concurrently experienced levels of network structure, at the local, peer group, and global levels, and understood in relation to the network context, including gender and friends' mental health. By exploring the structural and contextual facets of integration associated with depressive symptoms and self-harm in adolescence, this research clarifies how adolescent networks relate to mental health and how connections with others relate to well-being more broadly.

## **2. Adolescent Social Network Integration and Depressive Symptoms**

Social integration is a critical component of mental health (Berkman et al. 2000; Durkheim [1897] 2006). Social integration relies in part upon the underlying pattern of social ties in relevant social contexts, with this structure providing a meso-level link between macro-level contextual forces and micro-level social psychological factors (Berkman et al. 2000; Pescosolido 2006). Structurally, one's level of social integration is represented by embeddedness within more or less cohesive structures of ties, creating social contexts that can shape behaviors, opportunities, or constraints to affect mental health (Moody and White 2003; Pescosolido 1992).

Understanding how social integration relates to mental health is particularly important in adolescence, a developmental period when integration among peers takes on heightened salience (Ragan, Osgood, and Feinberg 2014) and risks for depressive symptoms rise (Hankin 2006). 20-50% of adolescents report significant depressive symptoms, with even minor depressive levels linked to subsequent suicidal behavior, depressive disorders, and impaired functioning (Allen et al. 2014; Hankin 2006). However, how social contexts shape depression early in the life course remains unclear (Adkins et al. 2009), with social integration related to both lower (Ueno 2005) and higher depressive levels (Falci and McNeely 2009).

This ambiguity may be due in part to conflation of two conceptually distinct ways individuals can be structurally embedded within a network: locally and globally. Individuals occupy complex, multidimensional positions in their social networks that simultaneously include both patterns of immediate ties with close friends and broader positions in the overall network among friends-of-friends or classmates. These structures may relate to mental health differently, so that disentangling the local and global dimensions of social network structure can clarify how integration relates to mental health. Moreover, any effect of network structure also depends on the content and context of that structure (Pescosolido 2006). Specifically, any association between mental health and integration likely depends on socially salient characteristics that shape social relations and mental health, such as gender, and the mental health of those to whom an individual is connected.

Here, I clarify research on the relationship between social integration and mental health by examining gendered contexts of local and global integration. Using PROSPER Peers survey data containing measures of depressive symptoms and rich, sociocentric social network data from hundreds of networks across four years of adolescence, I examine whether local and global dimensions of social integration predict depressive symptoms. I then test whether gender and friends' depressive levels moderate the association of local and global network structure on depressive symptoms to provide a more holistic view of the contextual forces shaping adolescent mental health.

## **2.1 Background**

### **2.1.1 Social Integration as Structural Embeddedness**

The social networks perspective recognizes that connections with others create key social contexts for health (Pescosolido 2006). In social network theory, social integration refers to how individuals are embedded in a web of social relations created by patterns of direct and indirect ties (Berkman et al. 2000; Granovetter 1973)<sup>1</sup>. Being embedded in such a web of social connections creates social resources, demands, and norms that can bind, regulate, or protect individuals, with consequences for mental health (Abrutyn and Mueller 2016; Bearman 1991; Durkheim [1897] 2006). Despite calls for medical sociologists to recognize the central role of embeddedness in social network structure (Pescosolido 1992), many studies of mental health and social integration have neglected the role of network structure, instead measuring social integration as simply the quantity of one's social ties or frequency of contact (Hartwell and Benson 2007; House, Umberson, and Landis 1988).

However, counting up an individual's ties does not fully address the conceptual purpose of integration. An individual with many ties could be in a non-cohesive group that is easily disconnected or dispersed, which would not hold the same implications for

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<sup>1</sup> While questions of mental health related to perceived relationships or social support warrant investigation in their own right, here I focus on the structural patterns of network ties between individuals, following the social network perspective that conceptualizes networks as the structural bedrock of social integration (Hartwell and Benson 2007). Furthermore, examining social integration as network structure may be particularly useful when considering associations with mental health, as perceptions of self-integration may be most skewed for individuals experiencing depressive symptoms (Cillessen and Bellmore 1999; Stice, Ragan, and Randall 2004).

benefits or constraints as being deeply embedded within a cohesive network that is hard to disconnect (Granovetter 1985; Moody and White 2003).

Instead, network theories of structural embeddedness consider integration as being more or less embedded in structurally cohesive sets of social relations. In this theoretical perspective, individuals occupy a position nested in the web of social ties “like Russian dolls – with increasingly cohesive groups nested inside each other” (Moody and White 2003:109). Conceptualizing social integration as structural embeddedness thus provides a theoretical starting point for considering how being more or less deeply nested in the network structure can relate to mental health. This embeddedness is then distinct from tie volume, contact frequency, or feelings of cohesion or belonging, which fail to adequately capture the social cohesion involved in social integration (Bearman 1991).

### **2.1.2 Social Integration in Adolescence**

Examining the structure of integration as embeddedness is particularly important in adolescence, when teens’ peripheral social ties and their position in the wider structures of indirectly connected peers are developmentally salient (Wrzus et al. 2013). Adolescence is a key developmental stage of the life course that is shaped by social network contexts, with long-term consequences into adulthood (Crosnoe 2000; Johnson, Crosnoe, and Elder, Jr. 2011). Even subclinical levels of adolescent depression can induce detrimental health outcomes, including increased risk of substance abuse,

suicidality, self-harm, and subsequent development of depressive disorders in adulthood (Allen et al. 2014).

At the same time, peers play a substantial role in healthy adolescent development (McFarland et al. 2014). Peer relationships provide a way for adolescents to accomplish the developmental tasks of this life course stage, including increased autonomy and independent, non-familial attachments (Wrzus et al. 2013). Same-age peers are the main reference group for normative behavior, a major source of psychological well-being, and a central factor guiding teens' behavior and identity formation (Crosnoe 2011; Umberson et al. 2010). This focus on peer relationships makes adolescents attentive to status and positions in the peer social hierarchy (Coleman 1961; McFarland et al. 2014). School peers become a focal group for most teens, with school networks providing meaningful social boundaries where social position and status are highly salient (Faris 2012). As such, peer networks in school provide multi-faceted social contexts that can affect health and well-being, beyond the effects of direct ties or friends (McFarland et al. 2014; Suh, Shi, and Brashears 2017).

Despite recognizing the importance of peers in adolescent life, the adolescent social networks literature lacks consensus about how social integration relates to mental health. Several studies find that social integration benefits mental health in adolescence, predicting lower levels of depressive symptoms (Ueno 2005). Integration in a peer network can support mental health by providing structural conditions for receiving

social support (Santini et al. 2015; Thoits 2011), engendering high social status that boosts self-esteem (La Greca and Harrison 2005), or promoting other psychosocial traits such as a sense of identity or belonging (Ueno 2005). Similarly, being un-integrated or isolated from peers predicts higher depressive symptoms (Hall-Lande et al. 2007).

However, other research shows that integration is associated with worse mental health for teens. Studies find that higher integration predicts greater levels of depression (Falci and McNeely 2009; Reynolds and Crea 2015). Such an association could result from depressed teens seeking greater peer support (Barrera and Garrison-Jones 1992). Alternatively, high integration could increase feelings of visibility and scrutiny, confining over-regulation of behavior, or stressful demands that lead to greater depressive symptoms (Falci and McNeely 2009; Pescosolido 2011). Integration can also relate to greater negative affect if depressed adolescents befriend similarly depressed peers, creating feedback cycles or opportunities for co-rumination that perpetuate depressive symptomatology (Cheadle and Goosby 2012; Schwartz-Mette and Rose 2012).

Thus, while peer network integration plays a significant role in adolescent mental health, current research is unclear about the conditions under which integration relates to higher or lower levels of depressive symptoms. This discrepancy suggests that understanding this relationship requires further distinctions of how youth are socially integrated and among whom.

### 2.1.3 Local and Global Integration

Social network theories of structural embeddedness not only enable conceptualizing integration as nestedness beyond tie volume, they also provide another important distinction that can clarify how depressive symptoms relate to adolescent mental health. This clarification lies in explicitly disentangling two simultaneous levels of social integration, here termed local and global (Granovetter 1992)<sup>2</sup>. Most prior work on peer networks conflates local and global network dimensions, artificially and atomistically examining dyadic relationships or larger peer groups in isolation from other network features (Cillessen 2007). Yet at any given time, an individual is more or less embedded in structures of direct ties (or ego-networks, Perry, Pescosolido, and Borgatti 2018) that are simultaneously embedded within the larger web of connections in the overall network. Put differently, individuals' positions can be more or less embedded in both local structures and global structures within the network.

Groups of direct ties in ego-networks can be more or less tight-knit or cohesive, providing a level of local integration that may relate to mental health. For example, two individuals can have the same number of friends, but the level of cohesion (and resultant regulation or support) provided by friends would be very different if friends are or are not friends with each other. Global integration, as structural embeddedness,

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<sup>2</sup> Granovetter (1992) calls these levels "relational" and "structural", but as these terms are now more often used to refer to network structure, I use local and global to refer to the levels of embeddedness.

addresses position in the broader network structure by indicating how deeply nested an individual is within the entire network. In addition to being theoretically and empirically distinct from other aspects of individuals' positions in their networks, such as the number of ties (degree centrality) or bridging different social groups (betweenness centrality), this nestedness in the overall network is distinct from an individual's embeddedness among close friends (Moody and White 2003).

While local and global integration can be correlated, they are distinct (Moody and White 2003). For example, an adolescent may have a cohesive, tight-knit group of close friends situated on the fringe of the overall network, representing high local and low global integration. Alternatively, an adolescent may be deeply nested within the network but span different friend groups, representing high global and low local integration.

As these dimensions capture different levels of integration, they likely relate to depressive symptoms in different ways. For example, processes that typically occur in close relationships likely relate to local rather than global integration, including beneficial social support or detrimental co-rumination (La Greca and Harrison 2005; Schwartz-Mette and Rose 2012). By contrast, global integration may relate to mental health through processes signaling social status among peers. Higher global embeddedness may relate to a sense of high social status that benefits mental health, or may carry greater burdens of behavioral expectations, scrutiny, or pressure to maintain

status related to worse mental health (Falci and McNeely 2009; Kornienko and Santos 2014). Thus, while prior research suggests distinct processes linking local and global integration to mental well-being, the conditions under which these features predict higher or lower levels of depressive symptoms is unclear because they have not yet been separately examined in relation to mental health.

#### **2.1.4 Friends' Health and Integration**

An additional way to disentangle the relationship between adolescent peer networks and mental health is by recognizing that networks matter not just because of how they are structured, but also because of who they connect (Pescosolido 2006). Network ties connect individuals through a fundamental relational process, where individuals are exposed to the norms, characteristics, and health behaviors of those to whom they are tied (Cotterell 2007; Umberson et al. 2010).

When considering mental health, research suggests any association between depression and social integration likely varies with friends' mental health. Depressed friends may introduce greater conflict into relationships or maladaptive processes such as co-rumination that perpetuate negative affect (Coyne 1976; Schwartz-Mette and Rose 2012). Greater integration among depressive friends may mitigate any potential benefits of integration, or lead greater network integration to predict greater depressive symptoms (Reynolds and Crea 2015).

Note that while some network studies examine the effects of friends' mental distress via diffusion, such as contagion or socialization of depressive symptoms (e.g., Cheadle and Goosby 2012; Schaefer, Kornienko, and Fox 2011), the effect of friends' depressive symptoms can also be viewed as moderating the effect of social network positions, independent of any direct contagion process. Put simply, being more or less integrated may have a different association with one's mental health depending on the mental health of friends, regardless of any direct diffusion. In this way, considering whether youth are integrated among depressive or non-depressive peers can clarify when integration relates to better and worse mental health.

However, mental distress and depressive symptoms remain highly sensitive and stigmatized topics, even among adolescent peers (Schaefer et al. 2011; Siennick and Picon 2019). Processes such as seeking social support or co-rumination generally occur among close friends, rather than more distant social acquaintances or random individuals within one's wider social web (Cornwell 2003; Schwartz-Mette and Rose 2012). Thus, if friends' mental distress moderates the association between integration and depressive symptoms, such a process likely applies more closely to local integration, rather than global integration.

### **2.1.5 Gender and Integration**

Another characteristic that may shape any association between integration and depressive symptoms is gender. Gender is a major social status characteristic organizing

social life and interpersonal interactions that affects mental health, social networks, and the effect of social relationships on mental health across the life course (Ridgeway and Correll 2004; Turner and Turner 1999). Gender differences in depression in adolescence mirror those found in adulthood, with teen girls typically reporting higher rates of depressive symptoms than boys (Hankin 2006; Rosenfield and Mouzon 2013).

Gender socialization theories suggest this gap is due in large part to differences in how boys and girls are systematically socialized to engage in social relationships, starting from very young ages and intensifying in adolescence (Rosenfield, Lennon, and White 2005; Turner and Turner 1999). Girls are socialized to be more attentive to others' emotions and preferences, to reduce emotional tension, and to prioritize others over the self in relationships, even when doing so increases risks for mental distress (Rosenfield 2012; Zahn-Waxler, Klimes-Dougan, and Slattery 2000). Girls are also socialized to emphasize emotional disclosure and support in relationships, and depend upon others and interpersonal ties in general, which makes social ties a stronger source of support, but also stress and conflict, for women relative to men (Turner and Turner 1999).

In line with these theories, teen girls report much higher sensitivity to how others view them, creating a tighter link between interpersonal relationships and identity compared to adolescent boys (Soller 2014; Turner and Turner 1999). These patterns can make the social turbulence of adolescence more stressful for girls than boys in ways that manifest as higher depressive symptoms (Keenan and Hipwell 2005). In the

same vein, boys are socialized to strictly adhere to masculine norms (Reigeluth and Addis 2015). Boys' peers typically enforce masculinity in ways that can increase stress and distress, while simultaneously limiting peer support seeking behaviors that might alleviate depressive symptoms (Kornienko and Santos 2014; Reigeluth and Addis 2015).

The developmental trade-off model suggests these socialized gender differences extend to social network structure, shaping both how teen boys and girls actively construct their peer networks and how the resultant structures affect mental health (Rose and Rudolph 2006). Gender differences in networks are common in adolescence, with girls typically focusing on a few close, emotionally-invested friendships, while boys engage more in larger, activity-focused friend groups (Giordano 2003). Girls are also typically more aware of patterns of network structure among friends, with imbalanced or non-cohesive patterns of close friendships predicting mental distress for girls only (Bearman and Moody 2004). Additionally, in line with socialized gender processes of what relationships mean for mental health, even when boys and girls occupy similar positions in the peer network structure, that integration predicts different mental health outcomes (Copeland et al. 2019; Falci and McNeely 2009).

These gender theories suggest that network levels may relate differently to depressive symptoms by gender. Specifically, given that girls are more likely than boys to maintain close, emotionally expressive friendships and are more attentive to patterns

of ties among friends, local integration may be more highly salient to girls' mental health. No such clear gender difference is expected for global integration.

## **2.2 The Current Study**

The current study contributes to research on the association between social networks and mental health by distinguishing how distinct facets of social integration predict depressive symptoms. I conceptualize adolescent peer network integration as the structural embeddedness of individuals' social position in the key developmental period of adolescence. The research reviewed thus far suggests several hypotheses.

First, social network theories of social integration as structural cohesion and embeddedness indicate that integration consists of two separate, simultaneously experienced dimensions of local and global integration. Though these dimensions are rarely both examined or explicitly distinguished in adolescent network research, integration overall is generally considered to support mental health, leading to the hypothesis:

**H1: Local and global integration are associated with lower depressive symptoms.**

However, any association between integration and depressive symptoms likely depends on whether or not a teen's friends are themselves experiencing depressive symptoms. Because depressive symptoms likely affect an adolescent's direct relationship ties (e.g., by experiencing conflict or co-rumination among close friends) rather than

their position among friends-of-friends or classmates, any such moderating affect likely shapes the association between depressive symptoms and local, but not global, integration. Furthermore, being more tightly integrated among close friends experiencing depressive symptoms may exacerbate any detrimental associations between friends' mental distress and individual's own depressive levels:

**H2: Friends' depressive symptoms moderate the association between local integration and depressive symptoms.**

**H2B: Greater local integration among depressive friends is associated with increased depressive symptoms.**

Finally, gender socialization affects how adolescent boys and girls construct social relationships and how those relationships affect health. In particular, girls are deeply invested in close friendships and highly sensitive to the cohesion or balance among close friends. This attunement suggests that any association between depressive symptoms and local integration is likely intensified for girls compared to boys:

**H3: Local integration is more strongly associated with depressive symptoms for girls than boys.**

Overall, by considering two distinct forms of network integration and potential moderation by gender and friends' mental health, this study helps to clarify our understanding of the benefits and drawbacks of social integration for adolescents.

### **2.3 Data and Methods**

The data used here were collected as part of the PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project, a randomized controlled trial evaluating a partnership-based delivery system for evidence-based preventive interventions (Spath et al. 2004, 2013). This study uses data from the in-school survey within the larger PROSPER Project. Pencil-and-paper surveys were administered to students during school starting in the Fall of 6<sup>th</sup> grade in two cohorts of students. These cohorts were in successive calendar years starting in 2002 and 2003. Subsequent surveys were administered every spring from grades 6 to 12. Surveyed school districts (n=28) are located in semi-rural and rural areas in Pennsylvania and Iowa. Sampled districts have enrollments ranging from 1,500 to 5,200 with predominantly white student populations. At least 15% of students in each school district come from low-income families.

Mental health data were collected in the last four waves of high school, when students were in grades 9-12, with an average response rate of 81%. Social network measures come from a friend nomination question administered in all four waves, where respondents listed the names of up to seven best or close friends in their grade and school. These nominations were then matched so that survey responses from students nominated as friends are linked. This design provides an opportunity to use sociocentric network measures that take the entire peer network in that grade and school

into account. This dataset also provides an opportunity to examine social networks across four years of high school, a larger range of adolescence than is typically available in sociocentric surveys. Additionally, this design provides self-report data from peers rather than focal adolescents' perceptions of peer behavior, eliminating concerns of false consensus bias, where teens erroneously over-estimate the similarity of peer behavior relative to their own (Prinstein and Wang 2005).

Respondents who repeat a grade during observed years ( $n=24$ ) are removed, as they appear twice in the same wave. The total remaining sample is 34,888 person-waves. Given the lack of validated imputation methods for sociocentric network measures and the robustness of network measures to missingness (Smith, Moody, and Morgan 2017), analyses use listwise deletion. Less than 1% of cases are missing on the dependent variable, meaning listwise deletion mostly removes cases missing on predictor variables, a method to which analytic models are generally robust (Allison 2002). Further, the average depressive symptoms of cases removed by listwise deletion due to missing covariate values and the average depressive symptoms of complete cases included in the analysis are comparable (both .27). Local and global integration are not correlated with missingness on the dependent variable, and removing control variables with the highest missing values (Low SES and Out-of-grade friends) does not substantively change results. The final analytic sample after listwise deletion is 27,091 person-waves representing 11,418 individuals. This sample includes 14,709 female and 12,382 male

observations, representing 5,969 unique female students and 5,449 unique male students across the four waves.

### **2.3.1 Dependent Variable**

*Depressive symptoms* are measured with five items from a popular and well-validated psychological scale assessing experiencing symptoms of depression in the last six months, such as depressive affect, feelings of worthlessness, and suicidality, consistent with American Psychiatric Association guidelines (American Psychiatric Association 2000)<sup>3</sup>. Individuals' scores were averaged at each wave to create one depressive symptom score ranging from 0 to 2 ( $\alpha = .83$ ) for each respondent at each wave, consistent with prior work using this dataset (Siennick and Picon 2019).

### **2.3.2 Independent Variables of Interest**

*Local integration* is measured by ego-network density at each wave. This measure indicates the proportion of existing ties divided by the total possible ties in an individual's ego-network, defined by sent and received ties (Wasserman and Faust 1994). This measure indicates the extent to which adolescents are nested in cohesive, tight-knit friend groups where an adolescent's friends are friends with each other. Prior work supports the use of ego-network density to measure integration or cohesion

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<sup>3</sup> The exact items of this scale are available only during review, as copyright prohibits itemized scale publication.

among close friends (Falci and McNeely 2009; Haynie 2001), and as a local corollary to the measure of global integration employed here (Moody and White 2003).

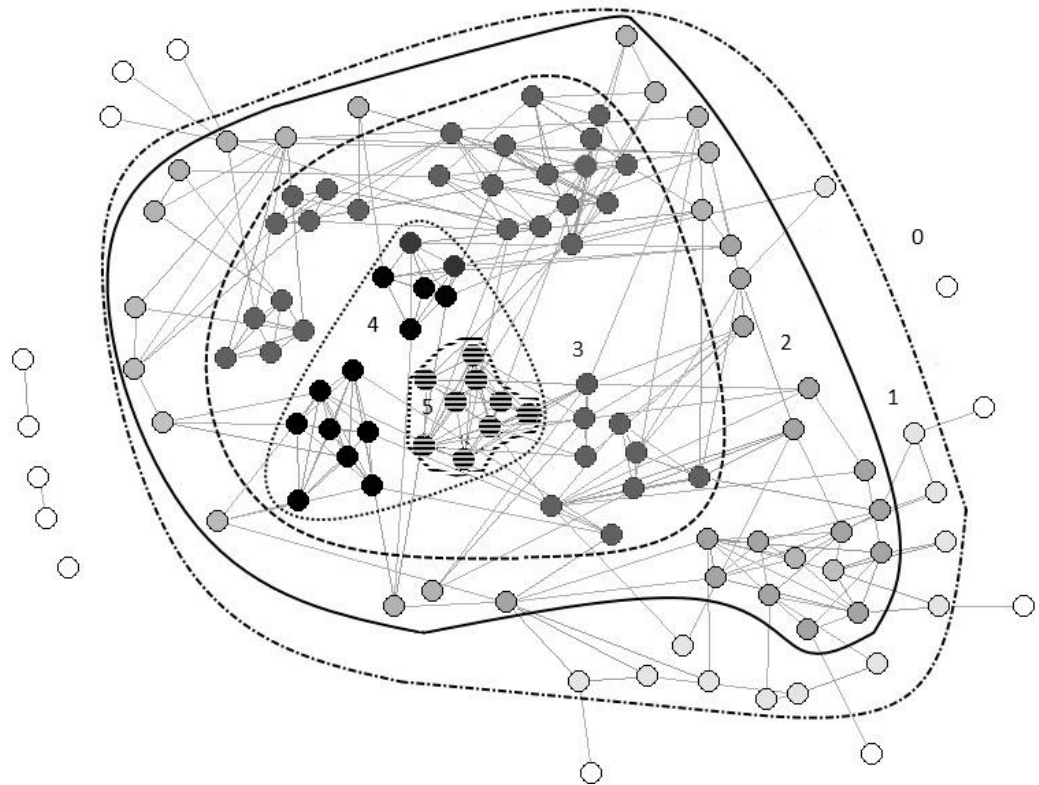
*Global integration* is measured as individual structural embeddedness. This measure captures how deeply nested an individual is within the entire network by assessing structural cohesion, or how difficult it would be to disconnect that individual from the network (Moody and White 2003)<sup>4</sup>. This measure is assessed at each wave and ranges from 0-5, indicating least to most embedded.

One example of global integration levels in this dataset is shown in Figure 1. This figure represents one grade-cohort network in grade 9 from the data where the circles, or nodes, represent adolescents, and lines, or edges, represent friendship nominations. Here, the shade of each node and boundary lines indicate successively nested sets that generate each level of global integration. Values range from the blank white nodes who are relatively disconnected from the network (global integration = 0) to the striped nodes that would be the hardest to disconnect from the network and thus are the most deeply embedded (global integration = 5).

Correlations between local integration, global integration, and depressive symptoms are shown in Table 1. Global and local integration are moderately positively

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<sup>4</sup> This measure is calculated as an individual's, or node's, deepest cutset level. A cutset includes any set of nodes whose removal disconnects the network, so that successively identifying minimum cuts disconnects some nodes from the network. Nodes that are least likely to be disconnected are the most deeply embedded in the network.



**Figure 1. Global Integration in an Example PROSPER Network.**

correlated, though tests for collinearity indicate that values are well within acceptable ranges, with all individual variance inflation factors (VIF scores) under 4 and a mean VIF of 1.5 in final models (Neter, Wasserman, and Kutner 1989). Each type of integration is only slightly negatively correlated with depressive symptoms.

**Table 1. Correlation of Depressive Symptoms and Integration in PROSPER Peers.**

	(1)	(2)	(3)
(1) Depressive Symptoms	1.00		
(2) Local Integration	-.029	1.00	
(3) Global Integration	-.071	.36	1.00

### 2.3.3 Demographic and Control Variables

Several variables adjust for known sources of variation in levels of depressive symptoms and network position. Gender is a time-invariant variable measured dichotomously as *male* (male=1, female=0). Eligibility for free or reduced-price lunch, an indicator of a family income below 150% of the federal poverty level, is measured at each wave and used as a dichotomous measure approximating low socioeconomic status (*Low SES*)<sup>5</sup>. Other time-varying control variables assessed at each wave include a dummy variable for *biological parents* indicating if an individual lives with both biological parents, and *school adjustment*, which measures individuals' feelings toward the school environment (items shown in Appendix A). Because patterns in peer ties, depressive symptoms, and the importance of peers for mental distress symptoms likely vary as adolescents age (Prinstein and Giletta 2014), a dummy variable is included for each *grade* (which, given survey design, is perfectly collinear with survey wave).

*Friend depression* measures the average level of depressive symptoms of an adolescent's friends (as sent- and received-tie network peers) at each wave on the same scale as the dependent variable. Including this variable enables examining associations of integration and depressive symptoms net of friends' mental distress, as well as testing the moderating effect of friends' distress on these relationships. Including this measure

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<sup>5</sup> This measure is the only assessment of family socioeconomic status in this dataset.

also adjusts for network autocorrelation, or the tendency of friends to have similar mental health profiles.

Other network measures were used as time-varying controls assessed at each wave to further isolate any association of global and local integration with depressive symptoms. *Popularity* is measured by in-degree, the number of friendship nominations a respondent receives. *Gregariousness* is out-degree, the number of nominations a respondent sends. Including these measures means that any association of depressive symptoms with local and global integration is measured net of individuals' raw number of friendship ties. *Out-of-grade friends* is a count variable of the number of close friends a respondent claims outside of their grade or school to adjust for adolescents spending social energy outside of the network. While some youth claim high numbers of out-of-grade friends, this is not unusual when friendships are elicited as a count rather than naming specific individuals.

Descriptive statistics for the analytic sample are shown in Table 2. Statistics for local and global integration align with values of these measures in other adolescent school friendship samples (Falci and McNeely 2009; Moody and White 2003). As expected, depressive symptoms vary by gender, and levels are higher among female students. The prevalence of depressive symptoms in this sample falls within ranges typically found for adolescents (Hankin 2006).

**Table 2. Descriptive Statistics in PROSPER Peers Sample.**

	Mean or Proportion	(SD)	Min.	Max.
Depressive Symptoms	.27	(.43)	0	2
<i>for females</i>	.35	(.46)	0	2
<i>for males</i>	.18	(.38)	0	2
Local Integration	.21	(.22)	0	1
Global Integration	1.9	(1.11)	0	5
Male	46 %	--	0	1
Friend Depression	.34	(.27)	0	2
Popularity	3.11	(2.39)	0	18
Gregariousness	3.21	(2.14)	0	7
Low SES	21%	--	0	1
Biological Parents	61%	--	0	1
School Adjustment	3.62	(.70)	1	5
Out-of-grade Friends	10.45	(6.36)	0	>20
<i>Total Observations</i>	27,091			
Grade 9	7,772			
Grade 10	7,627			
Grade 11	6,013			
Grade 12	5,679			
<i>Total Individuals</i>	11,418			

## **2.4 Analytic Plan**

This analysis uses ordinary least squares regression with individual-level fixed effects and robust standard errors. This method estimates the change in the dependent variable based on the change in the independent variables within individuals. Here, this means coefficients for each integration measure indicate the change in depressive

symptoms associated with changes in integration. Essentially, values for each respondent are de-measured from their personal mean over time on a given measure, to adjust for effects of any unobserved time-invariant individual features. Because fixed effects models inherently adjust for all time-invariant individual characteristics (Allison 2009), the association between integration and depressive symptoms can be measured net of individual or contextual heterogeneity. Netting out unobserved endogeneity in this way is particularly important when examining this research question because many unobserved factors could be affecting both mental health and sociality.

Conceptually, this method is the best choice for providing a strict and conservative assessment of the core research question. With this method, I examine only within-person change in the association between depressive symptoms and integration, rather than assessing broader between-person differences that could be driven by unobserved heterogeneity that would be wrongly attributed to effects of integration. Empirically, results of the Hausman test support the use of fixed rather than random effects, suggesting random effects would be biased in assuming uncorrelated error structure. Wald tests also support the inclusion of the grade variable indicating time fixed effects. Analyses do not establish the causal direction of any association, and no claims about causality are made for any results. All analyses were conducted in Stata 15.

It is worth noting that some recent network studies use stochastic actor oriented models (SAOM's) to examine network processes and behaviors net of higher-order

network features. However, this simulation method does not use the same concept of integration as embeddedness at the global and local levels as used here (instead, focusing on simulating actor choices in dyads). Global integration as examined in this study currently cannot be implemented in an SAOM. Moreover, recent work suggests that SAOM's do not in fact provide a better assessment of networks and behavior compared to well-specified regression models (Ragan et al. 2019). Furthermore, the current study is not attempting to distinguish between selection and influence/contagion of depressive symptoms and friendships, or establish causal pathways between depressive symptoms and network ties, and so is not suited to the main purpose of an SAOM or other similar diffusion-focused models.

Models here do not use lagged variables for several reasons. First, lagged models provide systematically biased estimates, particularly in conjunction with fixed effects or when there is high serial correlation and endogeneity, as would be the case here if fixed effects were not used (Achen 2000; Vaisey and Miles 2017). Conceptually, lagging independent variables of interest specifically is not warranted because integration is assessed in the Spring of a school year, so it is unlikely that last year's social position supersedes the current year's position that an adolescent has experienced for months leading up to the survey, given that school social life is restructured each year starting in the Fall.

Empirically, models including lags of the dependent or independent variables (separately and together, in conjunction with and in lieu of contemporaneous measurements) are not warranted for several reasons. First, lagged models require dropping over 10,000 cases, resulting in significant data loss. Second, when comparing lagged models to models shown here in comparable samples, lagged models have worse model fit indicated by a lower Akaike's Information Criteria, or AIC (and lower  $R^2$  for lagged independent variable models). Moreover, lags do not substantively change results, as associations of interest have the same magnitude, direction, and patterns of statistical significance as results shown here, meaning that including lags provides no conceptual or empirical benefit.

Here, Model 1 shows the association between both types of integration and depressive symptoms, net of controls. Model 2 adds interactions between friends' depressive symptoms and integration and Model 3 interacts integration and gender to test for moderation. To further examine how these associations vary by gender, separate analyses for girls and boys are shown in Models 4 and 5.

## **2.5 Results**

Model 1 in Table 3 shows associations of local and global integration with depressive symptoms net of the included time-varying control variables and time-invariant individual characteristics excluded by the fixed effects model (e.g. effects of gender, race/ethnicity, or grade and school-level characteristics). In this model, local and

global integration do not significantly predict depressive symptoms. However, several significant associations between control variables and depressive symptoms are worth noting.

**Table 3. Fixed Effects Regression Results for Depressive Symptoms on Social Integration in PROSPER Peers.**

	M1	(SE)	M2	(SE)	M3	(SE)
Local Integration	-0.006	(0.01)	0.035	(0.02)	-0.004	(0.03)
Global Integration	-0.003	(0.00)	-0.024***	(0.01)	-0.008	(0.01)
Local Integration x Friend Depression			-0.106*	(0.05)	-0.076	(0.05)
Global Integration x Friend Depression			0.061***	(0.01)	0.050***	(0.01)
Local Integration x Male					0.065*	(0.03)
Global Integration x Male					-0.024***	(0.01)
Friend Depression	0.091***	(0.01)	0.027	(0.02)	0.036	(0.02)
Popularity	0.003*	(0.00)	0.004*	(0.00)	0.003*	(0.00)
Gregariousness	-0.004	(0.00)	-0.004	(0.00)	-0.004	(0.00)
Low SES	-0.004	(0.01)	-0.005	(0.01)	-0.004	(0.01)
Biological Parents	-0.054**	(0.02)	-0.052**	(0.02)	-0.052**	(0.02)
School Adjustment	-0.119***	(0.01)	-0.119***	(0.01)	-0.118***	(0.01)
<i>Grade (Grade 9 Baseline)</i>						
Grade 10	0.000	(0.01)	0.001	(0.01)	0.002	(0.01)
Grade 11	-0.015*	(0.01)	-0.013*	(0.01)	-0.013	(0.01)
Grade 12	-0.038***	(0.01)	-0.036***	(0.01)	-0.035***	(0.01)
Out-of-grade Friends	0.002**	(0.00)	0.002**	(0.00)	0.002**	(0.00)
Intercept	0.709***	(0.03)	0.723***	(0.03)	0.719***	(0.04)
R <sup>2</sup> (Overall)	0.090		0.095		0.111	
AIC	-4133.6		-4197.5		-4227.2	
BIC	-4035.1		-4092.6		-4095.9	
Observations	27,091		27,091		27,091	
Individuals	11,418		11,418		11,418	

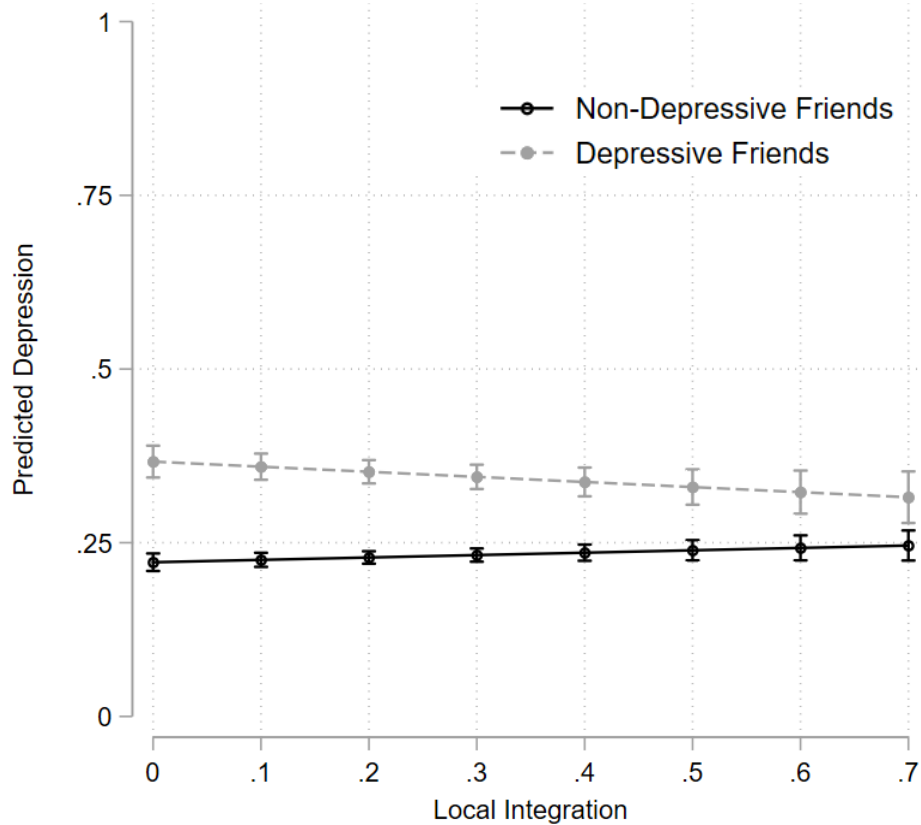
\*p<.05, \*\*p<.01, \*\*\*p<.001

Increases in friends' depressive symptoms, popularity, and the number of out-of-grade friends are associated with increased depressive symptoms. Living with both biological parents and being more attached to school are associated with decreases in depressive symptoms. Depressive symptoms decrease over time in high school, with Grades 11 and 12 predicting significantly lower levels of depressive symptoms compared to Grade 9. These control variables maintain relatively stable and consistent associations with depressive symptoms across models.

Model 2 includes interactions between each type of integration and friends' depressive levels. This model examines whether being more deeply integrated in the network along local and global dimensions relates differently to one's depressive symptoms if friends experience depressive symptoms. Here, the dimensions of integration significantly predict depressive symptoms in different ways.

For local integration, the conditional (non-interacted) effect is nonsignificant, meaning that local integration is not associated with depressive symptoms if friends are not experiencing depressive symptoms. However, when friends *are* symptomatic, local integration is associated with decreased depressive symptoms, suggesting local integration may play a protective role. This association is illustrated in Figure 2. In this figure, values for local integration are shown up to .7 out of the full 0-1 range, and

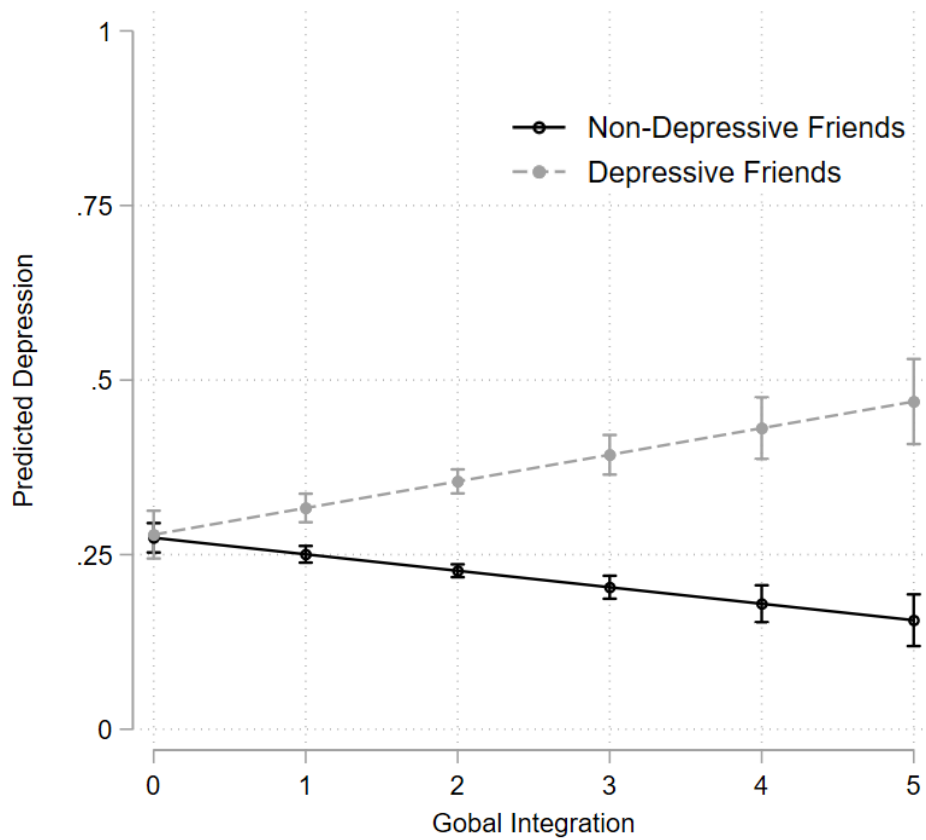
values for friend depression are set at 0 and 1 out of the 0-2 range, to provide a more conservative illustration of associations.



**Figure 2. Predicted Depressive Symptoms by Local Integration and Friend Depression, with 95% Confidence Intervals.**

This figure demonstrates that this result is not as counter-intuitive as it might first seem: having depressive friends predicts higher depressive symptoms, but this association is mitigated by greater local integration, so that youth who are nested in tight-knit friend groups, even if those friends are depressive, have similar depressive levels to those with non-depressive friends. Hypothesis 1 (H1) is not supported by results for local integration, as local integration is not generally associated with lower

depressive symptoms when friends are not depressive. This result aligns with H2 as friends' symptomatology does moderate the association between local integration and depressive symptoms, but H2B is not supported, as the moderation is not in the expected direction.



**Figure 3. Predicted Depressive Symptoms by Global Integration and Friend Depression, with 95% Confidence Intervals.**

Results for global integration in Model 2 follow a different pattern, shown in Figure 3 (where friends' depressive symptoms are again shown at 0 and 1). The conditional effect of global integration is negatively associated with depressive

symptoms. This association means that being more deeply nested in the overall network is protective when friends are not experiencing depressive symptoms. However, when friends report depressive symptoms, greater global integration is associated with increased depressive levels. This pattern indicates that greater embeddedness in the overall network benefits mental health, but becomes detrimental if close friends are experiencing depressive symptoms. This pattern supports H1, as global integration is generally associated with lower depressive levels. While H2 expected only local integration to be moderated by friends' depression, this result finds that global integration is also moderated by friends' depressive symptoms, so that greater integration when friends are depressive predicts increased depressive levels.

Model 3 extends this analysis to examine whether integration predicts depressive symptoms differently for adolescent girls and boys. As gender interactions are significant in this model, Models 4 and 5 in Table 4 present separate analyses for each gender to simplify exposition.

Model 4 shows analyses for girls. Patterns for integration in this model mirror those in the full sample. Increased local integration reduces the negative impact of friends' depressive symptoms for girls, while local integration has no association with mental health if friends are not depressive. Higher global integration predicts decreased depressive symptoms for girls, unless friends are depressive, then greater global integration is associated with increased depressive symptoms for girls.

**Table 4. Fixed Effects Regression Results for Depressive Symptoms on Social Integration in PROSPER Peers by Gender.**

	<b>M4</b>	(SE)	<b>M5</b>	(SE)
	<b>Female</b>		<b>Male</b>	
Local Integration	0.034	(0.03)	0.020	(0.03)
Global Integration	-0.023**	(0.01)	-0.016*	(0.01)
Local Integration x Friend Depression	-0.144*	(0.06)	0.025	(0.09)
Global Integration x Friend Depression	0.054***	(0.01)	0.038	(0.02)
Friend Depression	0.057*	(0.03)	0.011	(0.04)
Popularity	0.002	(0.00)	0.004	(0.00)
Gregariousness	-0.000	(0.00)	-0.007**	(0.00)
Low SES	-0.017	(0.02)	0.011	(0.02)
Biological Parents	-0.036	(0.03)	-0.065*	(0.03)
School Adjustment	-0.140***	(0.01)	-0.095***	(0.01)
<i>Grade (Grade 9 Baseline)</i>				
Grade 10	-0.013	(0.01)	0.020*	(0.01)
Grade 11	-0.038***	(0.01)	0.016	(0.01)
Grade 12	-0.072***	(0.01)	0.006	(0.01)
Out-of-grade Friends	0.001	(0.00)	0.002*	(0.00)
Intercept	0.895***	(0.05)	0.530***	(0.05)
R <sup>2</sup> (Overall)	0.129		0.070	
AIC	-965.3		-3499.0	
BIC	-859.0		-3395.1	
Observations	14,709		12,382	
Individuals	5,969		5,449	

\*p<.05, \*\*p<.01, \*\*\*p<.001

For boys, shown in Model 5, only the benefits of global integration remain significant, predicting lower depressive symptoms. Here, local integration and friends'

depressive symptoms are not significantly associated with boys' own depressive symptoms, either independently or when interacted. This pattern supports H3, that local integration is more strongly associated with depressive symptoms for girls compared to boys (with the significant gender interaction for local integration in Model 3 indicating that this difference is significant).

To better understand the scope of these associations, it is helpful to consider ideal types of integrative positions. For example, consider the effect of global integration for boys based on Model 5. For a boy, holding all other covariates at their mean values, moving from the lowest to highest levels of global integration (0 to 5) is associated with a decrease in the predicted probability of depressive symptoms of about .03, from about .19 to .16. A similar increase across the range of global integration (0 to 5) holding all else at the mean for a girl yields a decreased probability of depressive symptoms of .11 if friends are not depressive. But if girls' friends are experiencing depressive symptoms, then this increase in global integration predicts an *increased* probability of depressive symptoms of approximately .42.

However, for girls, understanding the ideal integrative position requires considering local and global integration concurrently. For girls connected to non-depressive peers, the ideal integrated position is high global integration regardless of local integration, as local integration does not significantly predict depressive symptoms if friends are not depressive. If friends are depressive, however, the ideal position is

maximum local integration and minimum global integration. For girls with depressive friends, mental health is best supported by being integrated in a cohesive, dense group of close friends that is not deeply embedded in the overall network.

## **2.6 Robustness Checks**

Results shown here are robust to several alternative specifications. Models using a count variable of depressive symptoms or a logged average of depressive symptoms as the dependent variable show the same patterns of results as presented. The models shown here are preferable as they maximize the available data by decreasing missingness on the dependent variable and providing a more straightforward interpretation of coefficients. Curvilinear effects of both types of integration were tested, but they were non-significant and did not improve model fit (by the AIC). Results are robust to removing outliers. Stepwise addition of each control variable (models available upon request) does not change any of the results, and each control variable used here improves model fit.

While operationalizing local integration as ego-network density is supported by prior literature (Moody and White 2003), using similar measures instead, such as the proportion of reciprocal ego-network ties, yields the same results. Arguably, traditional social network theory (Holland and Leinhardt 1976; Simmel 1950) suggests that capturing nestedness on a local level could be better operationalized using a smaller

social unit than the ego-network, the triad. Further discussion of how to best conceptualize and operationalize triadic local integration is presented in Appendix A.

## **2.7 Discussion**

Social integration in networks can have profound effects on mental health across the life course (Berkman et al. 2000), particularly in the sensitive developmental period of adolescence, when integration among peers plays a critical role in mental well-being (Crosnoe 2000). However, individuals can be integrated in a network along two dimensions of structural embeddedness, local and global, that are rarely disentangled. Adolescents' local integration, capturing the complexity of interconnection or fragmentation in close friend groups, and global integration, indicating the depth of nestedness in the overall network, are two aspects of network structure that represent different facets of adolescents' social position among peers. These structural elements of integration are situated within broader contexts, meaning characteristics such as gender and friends' mental health may shape the association between these structures of network integration and mental health.

This study examines how local and global integration relate to depressive symptoms in adolescence. Disentangling these types of integration and the moderating effects of gender and peer depressive symptoms clarifies the conditions under which network embeddedness predicts benefits or detriments to mental health for youth. Results support the multidimensional nature of social integration as structural

embeddedness. Models measuring within-person change using fixed effects show that local and global integration relate differently to depressive symptoms and in ways that depend on gender and friends' depressive levels.

For girls, local integration is only associated with depressive levels when friends are experiencing depressive symptoms. Connections with depressive friends predict increased depressive symptoms, but this negative association is mitigated when girls are more deeply embedded in cohesive, dense friend groups. Put differently, risks associated with low levels of local integration worsen for girls when friends are experiencing depressive symptoms. While at first this finding appears counter to expectations of H1, this hypothesis did not account for differences based on friends' depressive symptoms, which drives the importance of local integration to mental health here for girls. This finding aligns with prior research finding that imbalanced friend groups are associated with worse mental health for girls (Bearman and Moody 2004). It suggests that non-integrative patterns of ties among friends experiencing depressive symptoms are associated with worse mental health (in either causal direction), perhaps via greater conflict, stressful demands for social support, or other detriments to mental well-being for girls. Alternatively, the benefits of local integration may outweigh the detriments of depressive friends. The increased cohesion of high local integration may ameliorate negative externalities of friendships with depressive peers, or more cohesive friend groups may better distribute demands of depressive friends. H2 is supported by

this result for girls, as friends' depression moderates the association between local integration and mental distress. H2B is not supported, since the moderating effect is not in the expected direction.

For boys, however, local integration is largely unrelated to depressive symptoms, regardless of friends' depressive levels. This result supports H3. Indeed, friends' depressive symptoms do not predict depressive levels or moderate the relationship between integration and symptoms for boys, regardless of network structure. This pattern suggests that girls may be more aware of friends' mental distress than boys, or girls may encounter greater demands for social support or other stressors from depressive friends. Girls may also be more attuned to patterns of connections among friends, so that non-cohesive close friend groups of depressive peers harm mental health, but cohesive integration in these groups can attenuate the negative effects of depressive friends for girls, but not for boys.

Taken together, these findings support the developmental trade-offs and gender socialization theories that expect gender differences in social relationships and what these relationships mean for mental health (Rose and Rudolph 2006; Rosenfield 2012). Understanding these results in light of these theories suggests, for example, that the protective potential of local integration may relate to typical features of female friendships, such as self-disclosure and emotional support (Rose and Rudolph 2006).

Global integration shows a different pattern. Greater global integration predicts lower depressive symptoms for girls connected to non-depressive friends and for boys. Being more deeply nested in the overall social network typically benefits mental health, supporting H1. This finding is consistent with work suggesting that greater integration in the overall peer network yields mental health benefits, for example, through psychosocial boosts from a sense of belonging or high social status (Kornienko and Santos 2014). Note that this association between depressive symptoms and global integration is net of popularity (being named as a friend), gregariousness (naming more friends), and school adjustment. Thus, there is a specific mental health benefit associated with greater nestedness in the peer network. This result aligns with the scant prior work examining structural network embeddedness, which finds that increased nestedness among peers has positive associations for teens in school (Moody and White 2003). This study extends these benefits of structural embeddedness to mental health.

However, global integration is not uniformly protective for girls. For girls with friends experiencing depressive symptoms, greater global integration is associated with higher depressive levels. This pattern persists regardless of the patterns of ties among close friends (i.e., net of local integration). Having friends with depressive symptoms makes being more deeply embedded in the overall network associated with higher mental distress for girls. While no prior work examines structural embeddedness in relation to mental health, this result does align with work finding that high popularity

can be detrimental for girls, creating stress detrimental to mental health (Kornienko and Santos 2014). Depressive friends might increase stressful social demands for girls such that a more nested position produces greater social scrutiny or stress that increases depressive symptoms. Alternatively, girls who are more embedded in their network might invest more of their social identity in school peers generally, so if depressive friends generate stress or conflict, these negative experiences may have a greater impact on globally integrated girls. Further research is needed to clarify the exact mechanisms by which friends' depressive symptoms and being deeply nested in the network structure interact to relate to mental health.

Some limitations are worth noting. This survey does not ask participants about diagnoses or medications, meaning that adolescents receiving mental health treatment may not appear depressive in this sample. The social network measures suffer from the typical limitations of school-based network surveys, including limiting matched friendship nominations to the same-grade school boundary and capturing only one snapshot of friendships each year. The survey also includes only adolescents in semi-rural Iowa and Pennsylvania, which may not be representative of other regions or groups, and data are limited to primarily white samples and binary assessment of male/female gender.

Future research should address these limitations by considering more diverse and representative samples. Future studies should also explore the mechanisms through

which local and global integration affect depressive symptoms, such as co-rumination, stress, perceived social support, and risky health behaviors. Additionally, future research should consider how these processes unfold over time and distinguish the causal direction of associations between local and global integration and mental health.

While further research is needed before making policy recommendations, if these results hold in future studies, practitioners might consider how structural patterns of network integration can identify youth who are at greater risk for depressive symptoms. For example, girls who are deeply embedded in the overall network but with depressive close friends or girls who are in non-cohesive groups of depressive friends may appear socially well-connected. These teens may not fit the standard at-risk profile, but still face significant risks to mental health from their social position.

Results here also recommend to researchers that treating integration as a monolithic concept overlooks important variation in how social positions matter for health. Future research should continue to disentangle local and global network integration to clarify how positions in the peer social space relate to adolescent mental well-being. Further, these structural dimensions present only part of the picture of how integration matters for mental health, because how patterns of social ties relate to such outcomes differs depending on contextual features, such as the mental distress of those one is connected to, or key social status characteristics like gender that permeate social experience. Future work should consider the structure and context of integration

together, beyond questions limited to contagion. Research must also recognize that gender socialization processes induce gender differences in social relations and the effect of social relations for mental health, particularly in this sensitive developmental period.

This work contributes to the research literature by disentangling how distinct levels of social network structure work concurrently with the contextual features of gender and friends' mental health to relate to adolescents' mental health at this pivotal stage of the life course. In doing so, this study informs our understanding of how the structure and context of social ties relate to well-being.

### **3. Social Integration and Self-harm in Adolescence**

Self-harm presents a serious health concern. Rates of intentional, non-fatal, direct self-injurious behavior irrespective of suicidal intent (e.g., cutting or burning oneself) have risen in recent decades among adolescents otherwise free from health disorders (Gillies et al. 2018; Latina and Stattin 2017). Recent conservative estimates place the lifetime prevalence of self-harm for non-clinical adolescents around 15-20% (Gillies et al. 2018; Heath et al. 2009), and adolescence is a critical period in the life course for self-harm (Heath et al. 2009). Beyond the potential danger of the behavior itself, self-harm is associated with health risks, including depression (Prinstein et al. 2010) and subsequent suicidality (Gillies et al. 2018). Like many adolescent health behaviors, self-harm has distinctly interpersonal and relational dimensions (Wadman et al. 2018). However, little research has examined how social contexts condition the behavior (Bentley et al. 2014).

Social integration is one key factor related to health at any life course stage (Durkheim [1897] 2006; Kawachi and Berkman 2001). Adolescents are highly attuned to the social structure of integration among peers (Bearman and Moody 2004), and peer integration relates to teens' health behaviors (Umberson et al. 2010) and mental health (Falci and McNeely 2009). However, it is unclear how structures of peer social integration relate to self-harm.

This study fills this gap in the literature by assessing whether structural network integration relates to self-harm in ways that are further conditioned by gender and by

peers' own engagement in self-harm. By examining integration among peers in close friendships, broader peer groups, and overall networks in the developmental period of adolescence, this study also contributes more broadly to our understanding of how structures of social integration shape health and risky health behaviors in a key life course stage.

### **3.1 Background**

#### **3.1.1 Social Integration**

Social integration is related to health across the life course (Kawachi and Berkman 2001), and in adolescence, integration among peers takes on a critical role in shaping health behaviors and mental health (Bearman and Moody 2004; Umberson et al. 2010). Social network theory examines social integration as structural patterns in the web of interconnected peer social relations (Bearman and Moody 2004; Smith and Christakis 2008). In social network theory, patterns of direct and indirect ties at the individual, group, and whole network levels create positions individuals occupy that relate to norms and behaviors (Granovetter 1973; Lakon and Valente 2012). In contrast to examining contagion or diffusion across networks (Schaefer et al. 2011) or collapsing integration types into a few broad categories (Li et al. 2019), positional social network theories examine social integration as patterns of ties that create more or less integrated positions that individuals occupy within the network structure (Haynie 2001). Positions of greater integration generally predict better mental well-being (Kawachi and Berkman

2001), while social isolation increases mental distress (Bearman and Moody 2004) and self-harm (Quigley, Rasmussen, and McAlaney 2017). This pattern suggests the first hypothesis:

**H1: Greater integration is associated with lower levels of self-harm.**

However, social integration is not uniformly beneficial, as over-integration among peers can increase depression (Falci and McNeely 2009) and suicidality, especially if peers are suicidal (Baller and Richardson 2009; Mueller and Abrutyn 2015). Social network theory suggests that any effect of network structure likely also depends on the content within that structure, such as peer behavior (Li et al. 2019; Pescosolido 2006). Specifically, peer self-harm may alter the way that network positions relate to self-harm by modeling or normalizing the behavior (You et al. 2013), or introducing opportunities for using self-harm to signal group identity or increase bonding (Walsh 2006)<sup>6</sup>. Consequently, friends' self-harm may moderate any beneficial association between higher levels of integration and self-harm:

**H2: Greater integration is associated with higher levels of self-harm if friends self-harm.**

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<sup>6</sup> While some network research considers contagion of self-harm (e.g., Giletta et al. 2013), the current study does not attempt to disentangle the causal direction of friendships and self-harm behavior, or selection from influence/contagion. Simply, this study tests whether any association between network structure and self-harm differs depending on the proportion of one's friends who self-harm, saving questions of contagion for future work.

Integration is multilayered, however, with adolescents simultaneously occupying positions at multiple levels in the network structure. Most teens maintain relationships with close friends (what social network research calls ego-networks), which are nested within broader peer groups (groups of indirectly tied friends-of-friends), which are embedded within the overall network (Cillessen 2007). Positions of more or less integration at each level create embedded social contexts among peers that shape health behaviors and mental well-being (Umberson et al. 2010).

For example, cohesive close friend groups can benefit mental well-being by providing greater social support (Guan and Kamo 2016), while fragmented groups where friends are not friends with each other can increase suicidality for girls (Bearman and Moody 2004). Stigma surrounding self-harm (Quigley et al. 2017) makes discussing the behavior more likely among intimates than indirectly connected network peers (You et al. 2013), meaning close friendships may provide a critical site for social support reducing the impetus to self-harm (Muehlenkamp et al. 2013) or for using self-harm to increase intimacy (Walsh 2006).

Similarly, belonging to a larger peer group can provide a sense of belonging that supports mental health, but also increase social modeling and normalization of self-harm (You et al. 2013). In these broader peer groups, self-harm can serve to express group identity or increase in-group bonding (Adler and Adler 2011). In the overall network, a highly integrated position indicates high social status among peers that

typically predicts lower mental distress (Ueno 2005). However, having many peer ties can generate stressful demands or pressure to maintain high status (Haynie 2001), such that higher overall network integration predicts greater mental distress (Falci and McNeely 2009) and self-cutting (Copeland et al. 2019).

Implicitly examining only one or two levels of network structure (e.g., considering only best friend dyads or peer groups) would only show part of the picture of how social networks relate to self-harm, despite prior research indicating that social processes among close friends, peer groups, and the overall network matter for teens' self-harm. Because these levels of integration have not been examined in relation to self-harm in a structural network context, considering individuals' positions in these levels of network structure in tandem with peer self-harm can clarify the social network contexts of the behavior.

### **3.1.2 Considering Gender**

As with friends' self-harm, the meaning of each level of network structure likely varies with context, specifically, gender. As a major status characteristic structuring interactions throughout society, gender conditions both characteristics of peer relations and how peer integration relates to mental health for teens (Ridgeway and Correll 2004; Rose and Rudolph 2006). From an early age, gender socialization leads adolescent girls to become highly attuned to others' ties, social status, emotions, and behaviors in social relationships, to the point of prioritizing others over the self (Rosenfield 2012; Turner

and Turner 1999). As a result, peer ties play a substantial role in girls' self-concept and mental well-being (Soller 2014).

Socialization leads to gender differences in the salience of each level of network structure, particularly close friend and peer groups. Girls are more likely to invest deeply in close friendships characterized by high emotional disclosure, and girls are highly sensitive to patterns of ties in close friend networks, with non-cohesive close friend groups increasing mental distress for girls (Bearman and Moody 2004; Kornienko and Santos 2014). Alternatively, boys are typically less focused on close friendships and more attuned to broader activity-focused peer groups (Giordano 2003; Kornienko and Santos 2014). The differential salience of each level of network structure by gender means that girls and boys may be differentially attuned to each level of structure in relation to self-harm. Gender differences are less clear for overall network integration, which has been shown to predict mental distress and self-cutting for both genders (Copeland et al. 2019; Falci and McNeely 2009). These differences suggest another hypothesis:

**H3A: Close friendship structures are associated with self-harm for girls, and peer group structures are associated with self-harm for boys.**

Gender socialization may also shape the disclosure, awareness, or impact of self-harm among peers. Girls' emphasis on emotional intimacy in close friendships means girls are often more aware of peer behavior, particularly stigmatized states and

behaviors like mental distress and self-harm (Prinstein et al. 2010). Boys' peer groups typically sanction emotional disclosure and police behavior to enforce masculine norms, leading to lower support-seeking and discussion of mental distress in boys' peer groups (Giordano 2003; Kornienko and Santos 2014). Because self-harm is generally considered a feminized behavior related to emotional distress (Chandler, Myers, and Platt 2011), enforcement of masculine behavior in boys' peer groups may prohibit sharing or discussing self-harm, leading boys to be less aware of self-harm among peers. If gender socialization fosters self-harm disclosure for girls and socially prohibits such disclosure for boys, differential awareness of self-harm suggests the final hypothesis:

**H3B: Friend self-harm moderates associations of integration and self-harm for girls only.**

In sum, this study connects the rich research tradition establishing how adolescent social networks shape health to the growing literature on self-harm to ask whether integration in three levels of peer network structure predict self-harm, moderated by gender and friend self-harm.

## **3.2 Method**

### **3.2.1 Data**

Data come from the PROSPER (PROmoting School-university-community Partnerships to Enhance Resilience) Project. PROSPER is a randomized controlled trial evaluating a partnership-based delivery system for evidence-based preventive

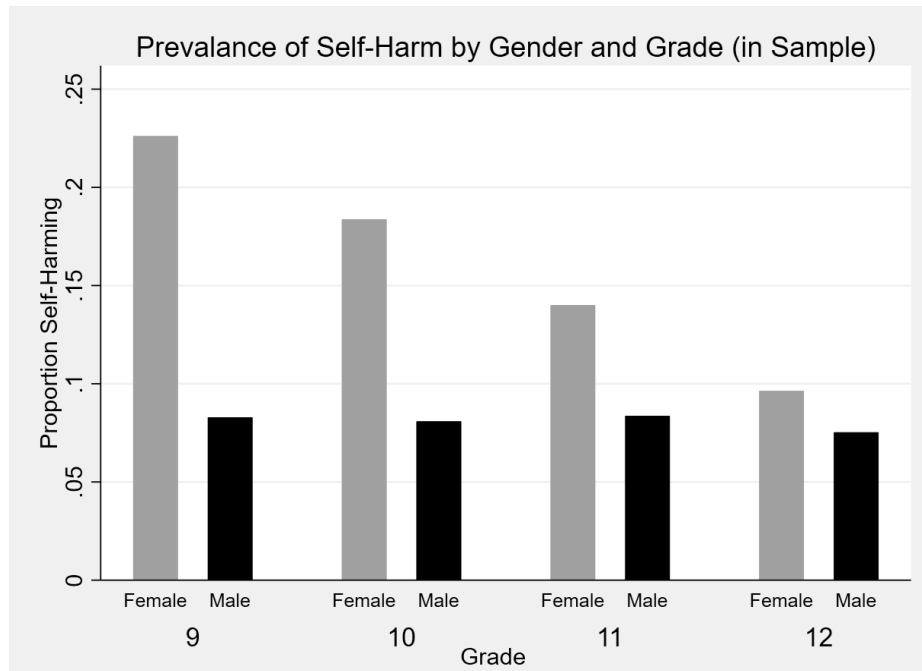
interventions (Spath et al. 2004, 2011). Sampled school districts are located in rural and semi-rural Pennsylvania and Iowa, and districts have predominantly white student populations, enrollments between 1,500 and 5,200, and at least 15% of students from low-income families. I use data from the in-school pencil-and-paper survey within the broader PROSPER project. All students in a given grade for two cohorts in successive calendar years who were present at any wave of survey administration were invited to participate. School districts completing the social network survey (n=27) are included in the current study. The first survey was in the Fall of 6<sup>th</sup> grade and then every Spring through 12<sup>th</sup> grade, producing eight waves of data. The current study includes only four survey waves, waves 5-8, as self-harm was not assessed in earlier waves. Thus, students are in grades 9-12 in 2006-2011, with an average survey response rate of 81%.

Social network data come from a friendship nomination process, where students wrote the names of up to seven best or close friends in their grade in school. Nominations were then matched (total match rate=79%) so that survey responses from peers nominated as friends are linked. This design provides sociocentric networks of friendships for the entire grade in each year of the survey, which allows examination of broader structural network patterns beyond close friendships. This design also provides peers' reports of their own behavior rather than adolescents' perceptions of peer behavior, which are often biased (Prinstein et al. 2010). With peer networks of the entire grade assessed at each wave for two cohorts in each school, this dataset includes 216

(cohort-school-wave) sociocentric networks. While these data are not nationally representative, they provide, to the author's knowledge, the most expansive survey to date of sociocentric networks and self-harm, enabling a more detailed and comprehensive examination of these questions than previously seen in this literature.

### **3.2.2 Outcome**

The dependent variable *self-harm* comes from two survey questions at each wave, asking, "During the past 12 months, how many times have you tried cutting yourself?" with responses of "Never, Once, Twice, Three or Four times, and Five or more times" and "How true is each of these for you now or within the past 6 months? ...I deliberately try to hurt myself" as "Not true, Somewhat or sometimes true, Very true or often true." Responses from these two items were dichotomized and combined to indicate any or no self-harm at each wave, consistent with previous research given the serious nature of any engagement in self-harm (You et al. 2013). Prevalence of self-harm in the analytic sample is shown by gender and grade in Figure 4. These rates of self-harm align with other studies of non-clinical adolescents using similar survey questions, including higher rates for girls in mid adolescence (Swahn et al. 2012).



**Figure 4. Prevalence of Self-Harm in Past 12 Months in PROPSER Peers by Gender and Grade.**

### 3.2.3 Network Position

The network variables in the survey are constructed from the matched friendship nomination network at each wave. *Close friend cohesion* is a continuous measure of the tight-knittedness, or transitivity, of close friendship ties that measures the proportion of friends-of-friends who are also the respondent's friends (as measured by sent and received ties). Research shows that this measure predicts mental health (Bearman and Moody 2004). *Peer group – core* is a dichotomous indicator of whether an individual is in the core (formally, largest bi-component) or periphery of their peer group. Adolescents' peer groups are determined at each wave by the CROWDS algorithm that iteratively tests each adolescent for membership within separate group boundaries to maximize in-

group ties and minimize cross-group ties (Moody 2001). Practically, this measure assesses whether adolescents are in a peer group, and if so, are central members, compared to hangers-on at the fringe of the group. This measure is similar to other core/periphery measures used to test network integration and health (Li et al. 2019), but at the peer group level. *Prestige* is a continuous variable measured by Bonacich centrality that captures integration in the overall network by measuring popularity and the popularity hierarchy of successive ties. A focal adolescent's prestige value considers their popularity, their friends' popularity, friends-of-friends' popularity, and so on to capture position in the overall network. This measure provides the best assessment of overall network integration because it situates an individual in the hierarchy of the entire pattern of network ties, rather than only local pockets of relative popularity.

Conceptually, these measures represent different facets of network integration. For example, teens may have tight-knit close friends that are relatively unpopular (high cohesion, low prestige), or be highly popular among popular peers who are not friends with each other (low cohesion, high prestige). These types of integration are also empirically distinct, as shown by correlations between network measures and self-harm in Appendix A.

### **3.2.4 Moderators**

*Male* provides a dichotomous measure of gender. *Friend self-harm* is a continuous measure of the average of respondents' friends' self-harm at each wave, enabling me to

test for moderation and to adjust for the tendency of teens to have similar self-harm behavior as their friends (i.e., to address network autocorrelation of self-harm). For this measure, each self-report of self-harm, assessed in the same way as the dependent variable, is averaged for a respondent's sent and received ties to create one score of friends' self-harm for each respondent.

### 3.2.5 Covariates

Control variables account for factors that might shape self-harm and sociality. I conduct a conservative test of associations between self-harm and network integration by adjusting for depressive symptoms, one of the most robust predictors of self-harm (Walsh 2006). *Depression* is a continuous measure of the average of respondents' depression and anxiety symptoms with a scale of 9 items ( $\alpha=.91$ ) assessing internalizing symptoms consistent with American Psychiatric Association guidelines (American Psychiatric Association 2000), described in prior work using this dataset (Siennick and Picon 2019)<sup>7</sup>. *White* provides a time-invariant dichotomous measure of race (in this predominantly white sample there is insufficient sample size to further detail racial/ethnic variation). *Gregariousness* is a measure of adolescents' sent ties, or out-degree, at each wave, ranging from 0 to 7, included to further isolate effects of integration. *Grade* is a dummy variable for respondent's current grade in school (9-12),

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<sup>7</sup> The exact items of this scale are available for reviewers and editors during review, but due to copyright, cannot be published in the manuscript text.

which, due to survey design, also represents calendar year and survey wave. *Low SES* is a dichotomous measure indicating a low socioeconomic background by eligibility for free or reduced-price lunch at school. This measure is a proxy for having a family income under 150% of the federal poverty line that is suitable for adolescent respondents and the only SES measure available in this survey. *Biological parents* adjusts for family structure differences as a dichotomous variable indicating if a respondent lives with both biological parents.

Other variables adjust for survey design. *RCT Treatment* is a time-invariant dichotomous indicator of whether the respondent's school was in the randomly selected treatment condition of the PROSPER substance use prevention trial. *Out-of-grade friends* is a count variable drawn from questions at each wave asking how many friends a respondent has outside of their school or grade who are as close or closer than the in-grade friends nominated in the survey. This variable adjusts for teens who spend much social energy outside of the observed network.

### **3.3 Analytic Strategy**

In this study, I measure the association between network features and self-harm using multilevel logistic regression. I estimate a random intercept model accounting for repeated observations within individuals with random effects. The theoretical interest here in establishing what types of network positions adolescents who self-harm occupy requires investigating between-person differences. Empirically, the between-person

variance of self-harm is more than double the observed within-person variance, and very few teens begin self-harming in the sample, making random effects the best method for investigating between-person differences in self-harm. Dummy variables for each wave (as successive grades) adjust for changing rates of self-harm over time. In all analyses, variance inflation factors suggest no concerns of multicollinearity (mean VIF < 2, highest individual VIF < 4).

Given challenges of imputation for sociocentric network data and network measures' robustness to missingness (Smith et al. 2017), I use listwise deletion to reduce to complete cases. Thus, person-wave observations from individuals are included for each wave for which they provide information on every variable (but individuals need not be present in all four waves to be included). The resulting analytic sample is 25,002 person-waves of 10,615 unique respondents.

I considered alternative model specifications. A model adding a random intercept at the school-level indicates that less than .008 percent of the residual variance is at the school-level, and the likelihood ratio test examining the significance of school-level clusters is nonsignificant, suggesting patterns observed here do not vary by school. Thus, school-level intercepts are not included in current models. Controlling for previous self-harm (a lag of the dependent variable) was considered but not implemented, as doing so would lead to severe bias in the random-intercept logistic regression models used here (Allison 2015). Gender differences are presented in gender

stratified models for ease of interpretation. Although random effects logistic regression does not permit direct comparison of coefficients in different models, several assessments suggest gender differences are significantly different, including likelihood ratio tests, gender-interacted models, and post-estimation probabilities of outcomes of interest by gender (the latter shown in Appendix B, other models available upon request). All analyses are conducted in Stata 15.

Model 1 provides a baseline association between self-harm and network variables net of controls. Model 2 adds interactions between network measures and friends' self-harm. Models 3 and 4 show gender stratified models for girls and boys, respectively.

### **3.4 Results**

Descriptive statistics are shown in Table 5. As discussed above, rates of self-harm are higher for girls. Close friend cohesion indicates that the average proportion of ties where a friend-of-a-friend is also the respondent's friend is about .24. 75% of adolescents are in the core of a peer group. Prestige, as a measure of hierarchy, is skewed, with an average of .84 though some youth have a prestige score of 4.5. While rates for close friend cohesion and prestige may appear low, they match averages reported in other peer networks (Bearman and Moody 2004; Reynolds and Crea 2015). The final sample is slightly more female than male, predominantly white, not low socioeconomic status, and living with both biological parents.

**Table 5. Descriptive Statistics for PROSPER Peers Sample (grades 9-12).**

	Mean or Proportion	(St. Dev.)	Min.	Max.
Self-Harm	13.2%	--	0	1
<i>for females</i>	17.2%	--	0	1
<i>for males</i>	8.3%	--	0	1
Close Friend Cohesion	.23	(.24)	0	1
Peer Group Core	.75	(.43)	0	1
Prestige	.84	(.60)	0	4.5
Depressive Symptoms	2.94	(3.67)	0	16
Friend Self-harm	.13	(.21)	0	1
Male	44%	--	0	1
White	86%	--	0	1
Low SES	20%	--	0	1
Biological Parents	62%	--	0	1
Gregariousness	3.41	(2.05)	0	7
Out-of-grade Friends	10.5	(6.27)	0	>20
RCT Treatment	48%	--	0	1
Grade 9	7,438			
Grade 10	7,080			
Grade 11	5,561			
Grade 12	4,923			
<i>Total Observations</i>	25,002			
<i>Unique Respondents</i>	10,615			

Respondents nominate about 3.4 friends in the network on average (gregariousness) and claim about 10.5 out-of-grade friends.<sup>8</sup> The number of respondents observed at each wave declines over time, showing attrition in the sample and warranting controlling for grade in analyses.

Results of analyses are shown in Table 6 and Table 7. Model 1 in Table 6 shows the baseline associations between characteristics of individuals' social network integration and self-harm. Being in the peer group core is positively associated with odds of self-harm (OR=1.19,  $p<0.05$ ) but prestige and close friend cohesion are not associated with self-harm in this model. Friend self-harm is associated with higher odds of self-harm, and boys have lower odds of self-harm than girls. Depressive symptoms are associated with higher odds of self-harm, while grades 10-12 are associated with lower odds of self-harm relative to grade 9. Being white, living with both biological parents, and higher gregariousness are associated with lower odds of self-harm. Low SES students and those with more out-of-grade friends have higher odds of self-harm. RCT Treatment is non-significant in this and all subsequent models, indicating that the associations examined here were not influenced by the broader PROSPER intervention.

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<sup>8</sup> A higher number of friends when choosing a number of friends compared to the matched named friends that generate the network is unsurprising. The salience of in-grade friends in adolescence (Cheadle and Goosby 2012), importance of in-grade friends for health (Siennick and Picon 2019), and unavailability of data assessing out-of-school friends in a network framework means that analyses here enable valuable insight into the research question at hand, particularly given the richness provided by this saturated in-grade network sample and the ability to control for the number of out-of-grade friends claimed.

Model 2 adds interactions between network variables and friend self-harm. Both interactions and conditional (non-interacted) associations are significant for prestige and close friend cohesion. Higher prestige and cohesion are associated with lower odds of self-harm (OR=.79,  $p<0.05$ ; OR=.51,  $p<.0.01$ , respectively), unless friends are self-harming, then greater prestige and cohesion are associated with higher odds of self-harm (OR=4.25,  $p<0.001$ ; OR=12.38,  $p<.0.001$ ). Note that while the odds ratios appear quite high, the low overall probability of the behavior means that the predicted probability of self-harm is within a reasonable range. This pattern suggests that integration among close friends and in the overall network is generally associated with lower self-harm, partially supporting H1. However, this association reverses if friends self-harm, so that greater cohesion and prestige are associated with greater self-harm, supporting H2. In Model 2, the conditional association of friend self-harm becomes non-significant, suggesting that cohesion and prestige are major pathways through which friend self-harm relates to adolescents' own self-harm. Being in the peer group core is not associated with self-harm in this model, failing to support Hypotheses 1 and 2.

Models 3 and 4 in Table 7 examine these relationships separately by gender. Here, prestige and cohesion remain significant only for girls, shown in Model 3. As in Model 2, patterns for cohesion and prestige support Hypotheses 1 and 2, relating to lower odds of self-harm (OR=.68,  $p<0.01$ ; OR=.41,  $p<.0.01$ ) unless friends self-harm, then

greater integration among close friends and in the overall network is associated with higher odds of self-harm (OR=4.6,  $p<0.001$ ; OR=13.67,  $p<0.01$ ).

**Table 6. Multilevel Logistic Regression of Self-Harm on Peer Network Integration in PROSPER Peers.**

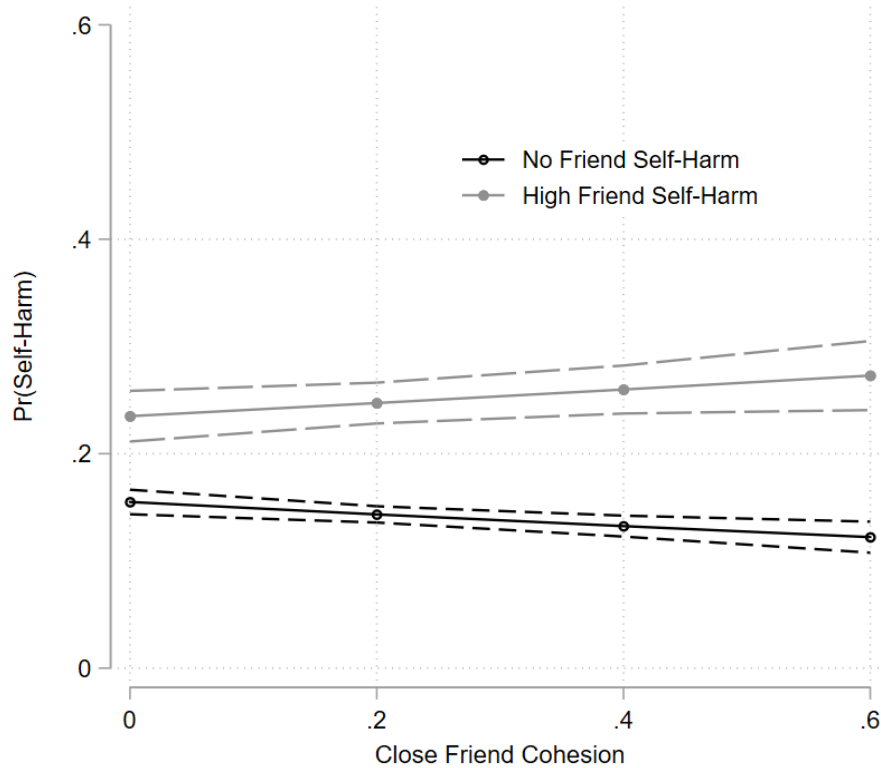
	M1		M2	
	OR	(SE)	OR	(SE)
Close Friend Cohesion	0.831	(0.15)	0.506**	(0.12)
Peer Group Core	1.192*	(0.10)	1.119	(0.12)
Prestige	0.931	(0.08)	0.792*	(0.08)
Friend SH X Close Friend Cohesion			12.38***	(8.39)
Friend SH X Peer Group Core			1.284	(0.42)
Friend SH X Prestige			4.249***	(2.01)
Depressive Symptoms	1.583***	(0.02)	1.578***	(0.02)
Friend Self-Harm	4.566***	(0.62)	1.385	(0.29)
Grade 10	0.704***	(0.05)	0.727***	(0.05)
Grade 11	0.546***	(0.05)	0.577***	(0.05)
Grade 12	0.428***	(0.04)	0.451***	(0.04)
Male	0.702***	(0.05)	0.722***	(0.06)
White	0.784*	(0.08)	0.783*	(0.08)
Low SES	1.213*	(0.10)	1.211*	(0.10)
Biological Parents	0.715***	(0.05)	0.726***	(0.05)
Gregariousness	0.909***	(0.02)	0.906***	(0.02)
Out-of-grade Friends	1.051***	(0.01)	1.050***	(0.01)
RCT Treatment	0.923	(0.07)	0.935	(0.07)
Intercept	0.011***	(0.00)	0.014***	(0.00)
<i>Random Effects Parameters</i>				
Individual-Level	3.740***	(0.27)	3.671***	(0.27)
Observations	25,002		25,002	
Respondents	10,615		10,615	
AIC	13180.0		13116.1	
BIC	13318.2		13278.7	

OR=Odds Ratio; \* $p<0.05$ , \*\* $p<0.01$ , \*\*\* $p<0.001$

**Table 7. Multilevel Logistic Regression of Self-Harm on Peer Network Integration in PROSPER Peers by Gender.**

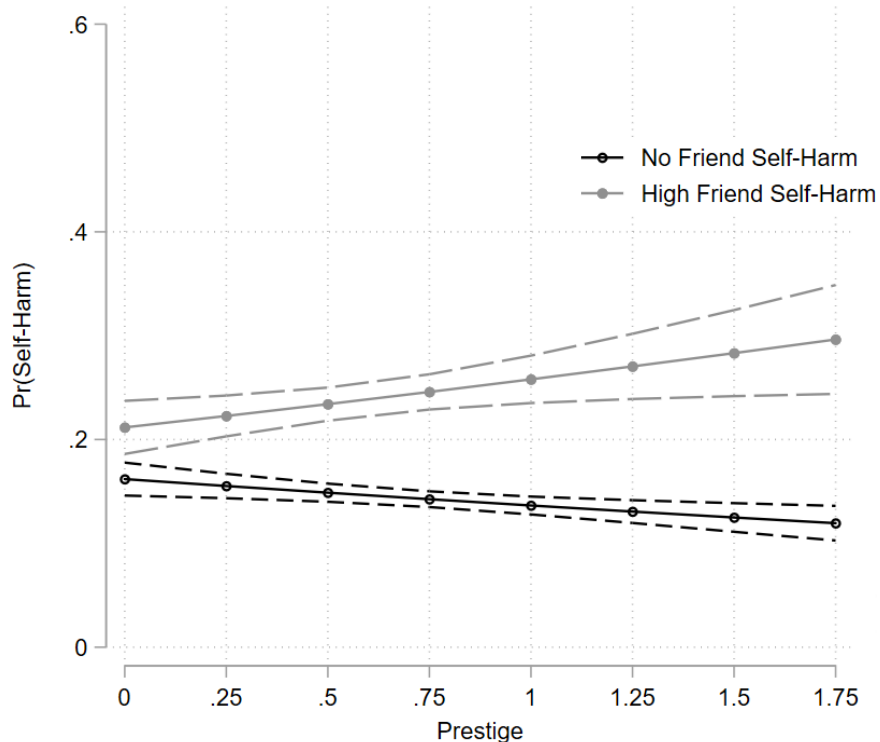
	M3		M4	
	Female Subsample		Male Subsample	
	OR	(SE)	OR	(SE)
Close Friend Cohesion	0.408**	(0.12)	0.823	(0.28)
Peer Group Core	0.951	(0.13)	1.427*	(0.23)
Prestige	0.675**	(0.09)	0.966	(0.14)
Friend SH X Close Friend Cohesion	13.67**	(11.14)	5.570	(7.78)
Friend SH X Peer Group Core	1.432	(0.57)	1.223	(0.79)
Friend SH X Prestige	4.588**	(2.01)	2.326	(1.62)
Depressive Symptoms	1.557**	(0.02)	1.614**	(0.03)
Friend Self-Harm	1.232	(0.32)	1.651	(0.58)
Grade 10	0.679**	(0.06)	0.835	(0.11)
Grade 11	0.458**	(0.05)	0.902	(0.13)
Grade 12	0.322**	(0.04)	0.788	(0.13)
White	0.907	(0.12)	0.636**	(0.10)
Low SES	1.192	(0.12)	1.247	(0.17)
Biological Parents	0.654**	(0.06)	0.881	(0.11)
Gregariousness	0.965	(0.03)	0.820**	(0.03)
Out-of-grade Friends	1.052**	(0.01)	1.043**	(0.01)
RCT Treatment	0.914	(0.09)	0.969	(0.12)
Intercept	0.015**	(0.00)	0.009**	(0.00)
<i>Random Effects Parameters</i>				
Individual-Level	4.087**	(0.36)	2.998**	(0.44)
Observations	13,973		11,029	
Respondents	5,713		4,902	
AIC	8737.8		4333.3	
BIC	8881.1		4472.2	

OR=Odds Ratio; \*p<.05, \*\*p<.01, \*\*\*p<.001



**Figure 5. Predicted Probability of Self-Harm on Close Friend Cohesion, Female Subsample.**

Figure 5 and Figure 6 illustrate these interactions for girls. To depict comprehensive but conservative estimates, close friend cohesion and prestige are shown to the 90<sup>th</sup> percentile and average friend self-harm is shown at .6 from the 0-1 range. Patterns are consistent across the full range of each network measure and different values of friend self-harm, as additional figures with different values show in Appendix B. Here, the downward slopes of the darker lines show greater cohesion and prestige are associated with lower odds of self-harm if friends are not self-harming. The upward slopes of the lighter lines indicate that as a higher proportion of friends self-harm, greater integration predicts higher odds of self-harm.



**Figure 6. Predicted Probability of Self-Harm on Prestige, Female Subsample.**

Moreover, each level of network integration is not experienced in isolation.

Rather, teens are simultaneously more or less integrated among close friends, peer groups, and the overall network, meaning that the true range of the association between network integration and self-harm requires considering combinations of integration at each level. Figure 7 demonstrates this by showing predicted probabilities of self-harm for girls based on friend self-harm and either no or high integration on both cohesion and prestige (because being in the peer group core is nonsignificant for girls, it is not included in this figure, and including it does not change the pattern observed). Here, moving from no to high integration when friends are not self-harming reduces the

probability of self-harm by 7.4 percentage points (.176 to .102). The same change from non-integrated to highly integrated when friends are self-harming *increases* the probability of self-harm by 12.3 percentage points (.198 to .321).

In contrast, for boys, shown in Model 4, being in the core of a peer group is associated with higher self-harm (OR=1.43,  $p<0.05$ ), although this association is quite small in magnitude, as it predicts a 1.5 percentage point increase in self-harm (from .073 to .088). Friend self-harm is not significantly associated with self-harm in either the conditional or interacted effects for boys. These gender differences support H3A, as close friend cohesion is associated with self-harm for girls only, and peer group structure is associated with self-harm for boys only. These patterns also support H3B, as friend self-harm is only significant for girls. Predicted probabilities of network measures interacted with friend self-harm by gender show non-overlapping confidence intervals when friends self-harm, substantiating gender differences (shown in Appendix B).

### **3.4.1 Expanded Network Measures**

Results thus far indicate that network positions among close friends, peer groups, and the overall network relate to self-harm. Given that little sociological research to date has examined self-harm in relation to network structure, it is worth considering if results generalize to a broader set of measures. To that end, analyses in Appendix B explore the same models as shown here with a wider battery of demographic and network measures.

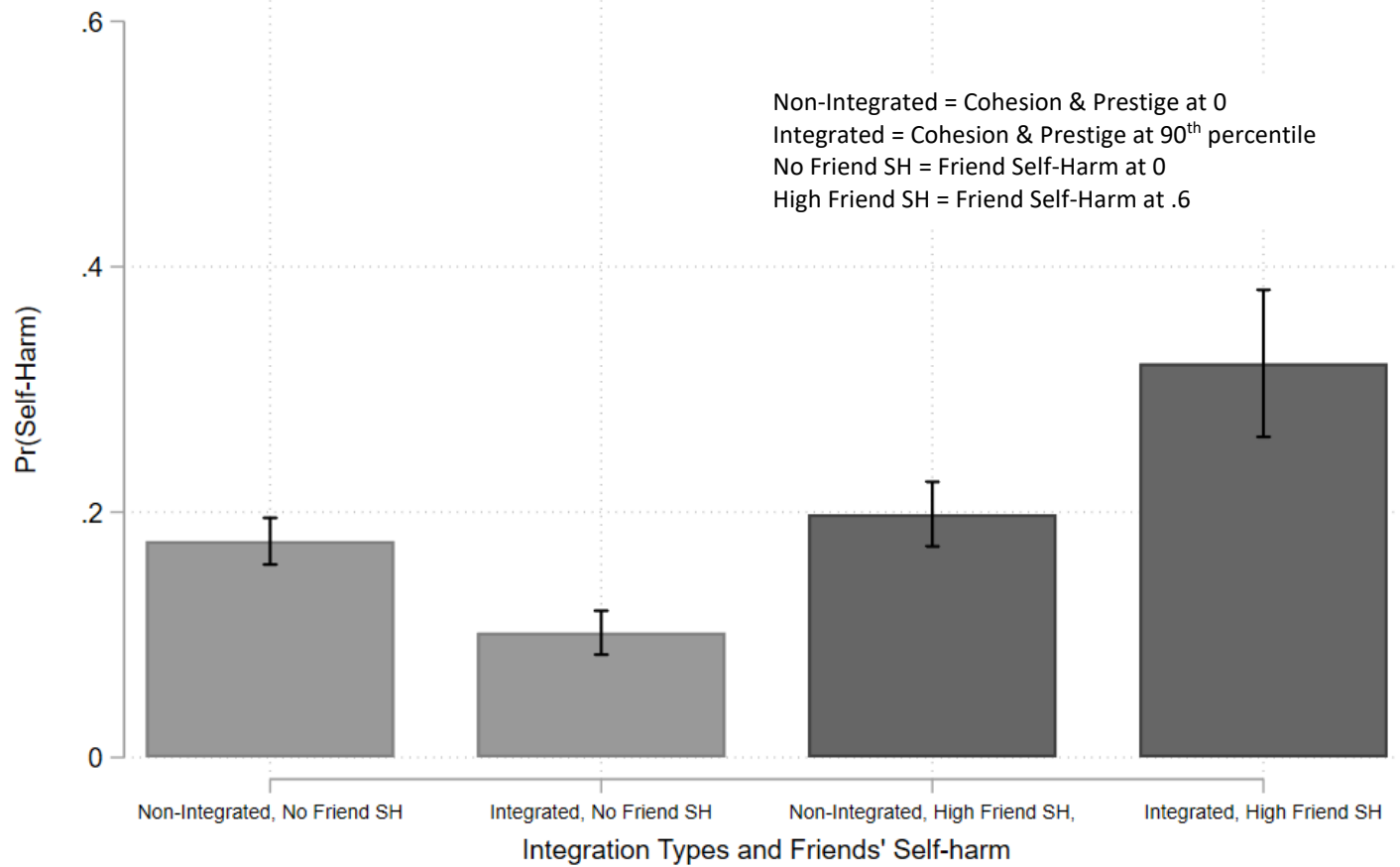


Figure 7. Predicted Probability of Self-Harm on Combined Integration by Friend Self-Harm, Female Subsample.

While results are discussed in detail in Appendix B, it is worth noting that even with a more comprehensive set of network measures, measures at the overall network, peer group, and close friend levels continue to relate to self-harm both positively and negatively depending on the network position and friend self-harm. Withdrawn isolation also predicts higher odds of self-harm, suggesting a specific relationship between not seeing oneself as part of the peer network and self-harm.

### **3.4.2 Sensitivity Analyses**

Results are robust to several specifications that are non-significant and do not change patterns of results, including: interacting network variables; adding three-way interactions between gender, friend self-harm, and network measures; using a dichotomous (rather than average) measure of any friend self-harm; controlling for a scale of family relationship quality; including average peer group self-harm in addition to friends' self-harm; and adding peer group mean demographic characteristics (e.g. gender, SES) and interactions between mean demographics and peer group network features. Results are robust to removing outliers, adjusting for each individual's contributed number of waves, and analyzing only respondents who are in all waves.

Results are also robust to including additional network measures, including measures of overall network integration of popularity, total number of friends, average distance to others (closeness centrality), and the extent to which an individual connects others (betweenness centrality); peer group measures of closeness centrality, size,

density, and transitivity; and close friend measures of density and reciprocity. The measures used here are theoretically and empirically superior to these alternative network measures, as they most closely operationalize integrative positions and provide the best model fit as indicated by the AIC and BIC. Transformations of independent variables, including standardizing, logging, and normalizing depression, friend self-harm, and network measures, did not alter results, and so are not shown here to ease interpretation.

### ***3.5 Discussion***

Self-harm in adolescence presents a substantial health risk with explicitly social dimensions (Bentley et al. 2014), but the associations between self-harm and structural features of social integration are unclear. This paper addresses this gap by examining self-harm and social integration at three structural levels of adolescent peer networks: close friendships, larger peer groups, and the overall peer network, and further considering how any association is shaped by gender and friend self-harm.

Results support peer network structure as a salient social context of self-harm, but associations are conditioned by contextual features of friend self-harm and gender. Notably, positions at all three levels of network integration are significant for either boys or girls net of depressive symptoms, suggesting that social integration relates to self-harm beyond any intervening association with psychological distress. In final models, close friend cohesion and prestige are associated with lower self-harm for girls,

supporting H1. Analyses do not enable causal claims or distinguish peer influence from selection, so this finding could indicate that girls derive mental health benefits from social support or status associated with cohesion and prestige, or that girls who are not engaging in a stigmatized behavior like self-harm are more likely to maintain tight-knit friendships and occupy high status positions.

However, results indicate that if friends are self-harming, then greater cohesion and prestige are associated with greater self-harm for girls, supporting H2. This pattern aligns with prior findings of peer engagement in self-harm normalizing and modeling self-harm as a maladaptive coping or bonding mechanism (Curtis 2016). Alternatively, if self-harm does increase intimacy as a shared secret among friends, then higher self-harm by focal adolescents and friends may help to maintain tight-knit friend groups (Walsh 2006). For prestige, high status positions can create scrutiny and constraint that stresses mental health, particularly for girls (Haynie 2001), which may be exacerbated by friends engaging in a highly stigmatized behavior like self-harm. The alternative explanation for this finding, that high individual and friend self-harm increase prestige for girls, is unlikely given the stigma surrounding self-harm. However, this result aligns with prior work finding that compared to less popular peers, highly popular youth are more socially attuned to peers and more emotionally invested in their social network (Reynolds and Crea 2015). This investment then makes popular youth more vulnerable

to detrimental effects of others' negative behaviors (Reynolds and Crea 2015), which could explain both high prestige and high self-harm when friends are self-harming.

For boys, network position is largely unassociated with self-harm, with only being in the core of a peer group predicting a less than 2% increase in self-harm. Though this association is small, it is consistent with prior research finding that if boys are attuned to any network level, it is the peer group, providing support for H3A. This finding aligns with work showing that for boys, peer groups impose behavioral sanctions, such as pressures to follow masculine norms to suppress support-seeking or emotional disclosure, that can be detrimental to mental health (Kornienko and Santos 2014). Additionally, friend self-harm is not significantly associated with boys' own self-harm, suggesting that boys are less aware of or impacted by friends engaging in this stigmatized behavior, or that exposure to friends' self-harm is generally unrelated to boys' self-harm.

Overall, gender differences shown by results align with prior social networks research finding that girls are more likely to invest in intimate, close friendships (Kornienko and Santos 2014) and reap mental health benefits to cohesive close friend groups (Bearman and Moody 2004), while boys are more focused on broader peer groups (Kornienko and Santos 2014). Patterns also support gender socialization theories that suggest girls are more highly attuned to both the patterns of connections between peers and peers' emotions and behaviors (Turner and Turner 1999). Results here extend

these patterns to self-harm, and suggest that positions in the overall network may also exhibit differential associations with mental health by gender, as prestige is only associated with self-harm for girls.

Several limitations are worth noting. First, self-harm as assessed here provides little detail on method or intent, and the survey does not ask about diagnosis or treatment for any form of mental distress. This sample is limited to youth from semi-rural Pennsylvania and Iowa, providing only binary measures of gender as biological sex and little racial/ethnic variation. Patterns may differ in more diverse settings. Integration is only observed among matched friends within the network boundary, so other relationships are not assessed, although number of out-of-grade friends was statistically controlled. This study does not establish causality between network position and self-harm or examine mechanisms of self-harm diffusion through peer networks. Future research should examine these associations in larger representative samples and build upon the between-person differences established here to examine changes in network processes of self-harm over time, particularly how networks influence the onset, duration, or diffusion of self-harm.

Although a single study cannot make strong recommendations for practice, results suggest that policy-makers and professionals should view self-harm as a social rather than solely intrapersonal behavior, particularly for girls. Practitioners should consider both unintegrated and highly integrated girls at increased risk of self-harm,

while being deeply embedded in the core of a given peer group may hold additional risks for boys. Mental health professionals should also consider ways to foster resilience against the normalization, stigmatization, or social instrumentation of self-harm for girls with friends who self-harm. Finally, researchers and practitioners examining social dimensions of self-harm should not focus only on close friendship dyads or peer groups, as overall network position also relates to self-harm.

Overall, this study provides the first large-scale comprehensive sociological examination of the associations among self-harm and network integration. Results indicate that for girls, self-harm relates to close friend cohesion and overall prestige, moderated by peer self-harm, and peer group integration predicts self-harm for boys. This study provides a next step in clarifying the social worlds of adolescent self-harm.

## 4. Conclusion

This work demonstrates the importance of multidimensional structural and contextual facets of social integration to mental well-being. In adolescence, distinct levels of integration in the structure of close friend groups, peer groups, and the overall network relate to depressive symptoms and self-harm. However, how integration in these levels of the network relates to mental health is best clarified by examining structural positions in tandem with network context. As gender shapes social ties and how social ties relate to mental health, and any association between mental health and network ties likely depends on the mental health of the friends to whom an adolescent is tied, gender and friends' mental distress provide two examples of contextual features that can shape associations between integration and mental well-being.

Here, Chapter 2 tests how local and global integration relate to depressive symptoms in adolescence. While global integration predicts decreased depressive levels for both boys and girls, greater global integration becomes detrimental for girls if friends are experiencing depressive symptoms. Local integration relates to depressive levels only for girls, with greater local cohesion providing a protective resource that is associated with decreased depressive symptoms when girls are integrated among depressive friends.

Chapter 3 shows that self-harm is related to social integration in peer networks. Integration among close friends, peer groups, and the overall network all relate to self-

harm in different ways. For boys, being in the core of the peer group predicts higher self-harm, though the associated effect is quite small. For girls, peer groups do not relate to self-harm net of integration among close friends and the overall network, which are typically beneficial. However, girls face increased risks from friends' self-harm, as greater integration when friends are self-harming is associated with higher self-harm.

Overall, this research shows that structural features of peer integration matter for teen mental health, including the understudied behavior and growing public health concern of self-harm. To understand how structural integration relates to mental health, integration needs to be conceptualized as distinct, but concurrently experienced structures at local, peer group, and global network levels. This framework provides a more holistic view of the social relationships teens navigate in their peer networks, and can be generalized in principle to any network setting. This dissertation also shows that any view of the complex association between network structure and mental health is likely incomplete without considering contextual differences in networks according to salient social characteristics, such as gender, or the content of networks, such as friends' mental distress. This work highlights the importance of considering differential effects of integration by gender in the developmental stage of adolescence, as what network structures matter for mental health and in what way differs for young women and men. Future work should examine the exact mechanisms by which structural levels of

network integration relate to mental health, and how networks and mental health develop over time to shape the long-term course of mental well-being.

By examining how peer social network structures and contexts relate to depressive symptoms and self-harm in adolescence, this work helps to clarify the importance of social integration for mental health and how our social connections with others relate to well-being more broadly.

## **Appendix A. Additional Information for Chapter 2.**

### ***A.1 School Adjustment Scale***

The measure *school adjustment* comes from the School Adjustment and Bonding Scale. Items are rated 1-5, (1=Never true, 2=Seldom true, 3=Sometimes true, 4=Usually true, 5=Always true) and (R) indicates reverse coded. Items include:

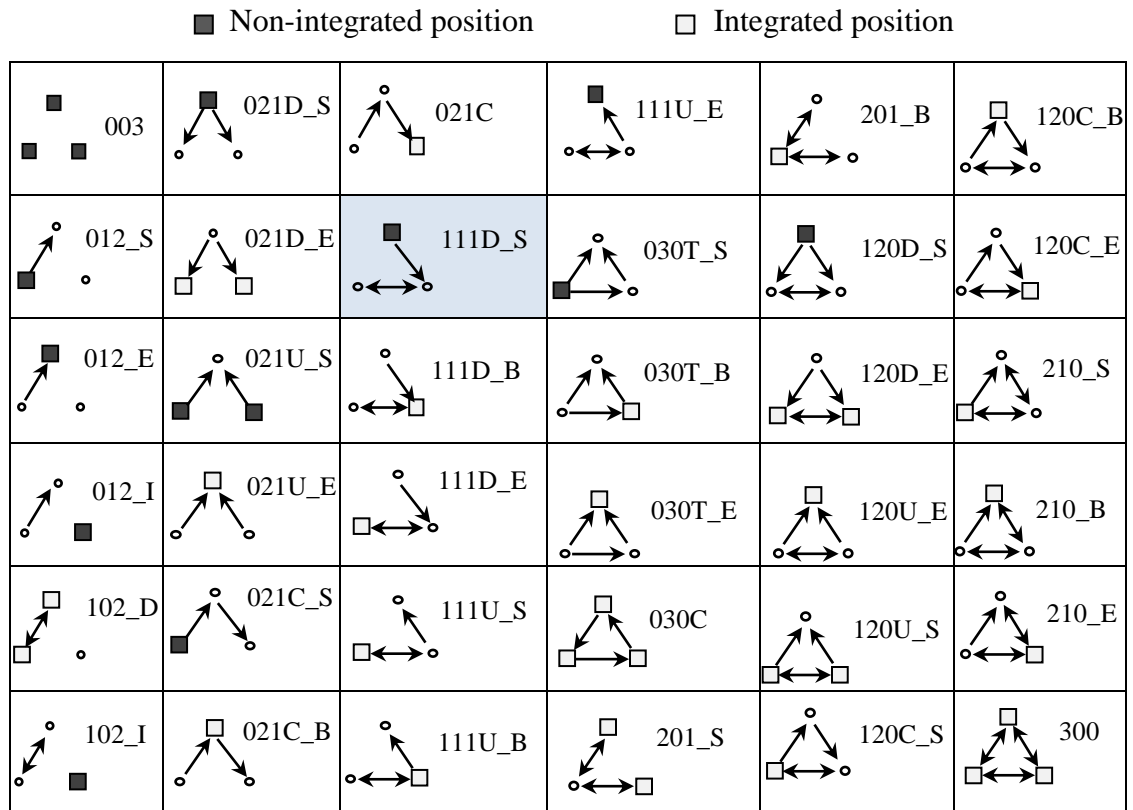
- I like school a lot
- I try hard at school
- Grades are very important to me
- School bores me (R)
- I don't feel like I really belong at school (R)
- I feel very close to at least one of my teachers
- I get along well with my teachers
- I feel that teachers are picking on me (R)

### ***A.2 Exploring Local Integration***

While the measure of local integration outlined in this study captures structures of cohesion in ego-networks, another conceptualization of local integration can be generated from triads. A long research tradition recognizes the sociological importance of considering groups of three actors, represented structurally by a network triad (Martin 2009; Simmel 1950). Triads in directed networks indicate patterns of reciprocity, sent/received ties, and transitive closure (or the likelihood that a friend of a friend is a friend) between ego (the focal individual) and two alters (ego's network peers).

Triads can be used to create one composite structural measure of local integration for individuals based on their position in every possible group of three actors in the network. The triad census counts 16 possible triads in directed networks (Holland

and Leinhardt 1976), which can be further enumerated into 36 unique positions a node could possibly occupy in directed triads, creating a node-level triad role census (Burt 1990). Figure 8 shows these 36 theoretically possible node-level positions in the directed triad census.



**Figure 8. Directed Triad Census Integration Positions.**

Using a set of decision rules that consider patterns of sent, received, and reciprocal ties between all three actors in a triad, each position in the node-level triad census can be classified as integrated or non-integrated. These rules are described in further detail in Table 8. As an example, the focal individual in triad 111\_D\_S (highlighted in Figure 8) sends unreciprocated ties to alters who are reciprocally tied.

Ego (the focal individual of a network) occupies a non-integrated position in this triad, as this position lacks in-degree and reciprocity within this triad, and includes exclusion given that the alters (network peers from ego's perspective) that ego nominated as friends nominate each other, but not ego. This facet of exclusion via patterned asymmetry would not be captured by traditional measures of cohesion (such as ego-network density).

**Table 8. Decision Rules for Integration Classification of the Directed Triad Census Positions.**

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**Description:** Positions are integrated if ego receives a reciprocated nomination, receives nominations from both alters in the triad, sends an unreciprocated nomination to an alter who receives a nomination from the second alter, or is in a cyclical triad, all positions that indicate combinations of popularity, expansiveness, and non-exclusion. Remaining triad census positions are non-integrated, including isolates, ego sending unreciprocated nominations to one or two alters who share a reciprocated tie, and remaining positions that lack reciprocal ties and in-degrees. This concept of integration is captured by classifying each of the 36 positions in the directed triad census as integrated or non-integrated follow these successive and mutually exclusive rules:

---

1. Ego has reciprocal tie with either alter in triad	→	<b>Integrated</b>
2. Ego is an isolate in the triad	→	<b>Non-Integrated</b>
3. Ego receives ties from both alters in triad	→	<b>Integrated</b>
4. Ego sends asymmetric ties to one or two alters who share a symmetric tie	→	<b>Non-Integrated</b>
5. Ego sends asymmetric ties to one or two alters who are not symmetrically tied:		
5a. Ego sends tie to alter who also receives tie from other alter in triad	→	<b>Integrated</b>
5b. Ego is in a cycle involving all three members	→	<b>Integrated</b>
6. All other ego positions and tie patterns	→	<b>Non-integrated</b>

In this way, this measure of triadic local integration conceptually combines features of reciprocity (mutual friendship nomination), popularity (in-degrees), and gregariousness (out-degrees) in a meaningful unit of social structure, the triad. By considering individuals' positions through both their ties with two triadic alters and alters' ties between each other, this measure also captures features of exclusion/non-exclusion among peers. This provides an additional layer to the meaning of local (non)integration which may be particularly meaningful in adolescence when youth are highly attuned to patterns of ties among others. Arguably, being excluded may be qualitatively different than simply being integrated at a low level, so the ability to consider both here is valuable to understanding the scope of network integration. By combining multiple facets of triadic relations among peers, this measure provides a uniquely suited operationalization of the concept of local integration.

To utilize the conceptual strengths of this measure, the analyses presented in this study above can be re-evaluated using a measure of *triadic local integration*. To do so, first I calculate each individual's positions in the directed triad census. Functionally, the number of triad positions any adolescent could potentially occupy varies with network size. To adjust for this difference, each respondent's count of triad positions was first standardized within their school so that school size differences did not affect rates of integrated positions (results using a measure standardized within each grade and school show the same results, but worse model fit). The standardized values for the integrated

positions are summed, then non-integrated positions are summed for each respondent (note that the null triad, 003, where there are no ties, is excluded). This creates one score of integration and one score for non-integration for each respondent in each wave. This process can be represented formally:

In the set of all triad positions,  $\theta_x$ , in the graph,  $G$ , standardize within each triad position to account for volume differences:

$$(1) \quad Z_x = G\left\{\frac{\theta_x - \bar{\theta}_x}{\theta_x}\right\}$$

Then let the set of integrated positions equal,

$$(2a) \quad P_I = \{102\_D, 021D\_E, 021U\_E, 021C\_B, 021C\_E, 111D\_B, 111D\_E, 111U\_S, 111U\_B, 030T\_B, 030T\_E, 030C, 201\_S, 201\_B, 120D\_E, 120U\_E, 120U\_S, 120C\_S, 120C\_B, 120C\_E, 210\_S, 210\_B, 210\_E, 300\}$$

and the set of non-integrated positions equal,

$$(2b) \quad P_U = \{012\_S, 012\_E, 012\_I, 102\_I, 021D\_S, 021U\_S, 021C\_S, 111D\_S, 111U\_E, 030T\_S, 120D\_S\}$$

Summing within sets to generate one score per individual:

$$(3a) \quad \text{Triadic Local Integration} = \sum Z_x P_I$$

$$(3b) \quad \text{Triadic Local Non-Integration} = \sum Z_x P_U$$

To generate one score for each respondent that accounts for the conceptual benefits of integration and detriments of non-integration, I then subtract the non-integration score (3b) from the integration score (3a). This yields one measure of triadic

local integration, where positive values represent greater integration, and negative numbers represent greater non-integrative, or excluded, positions for an adolescent. Because this measure is highly skewed, it is then normalized to ease interpretation of results (though patterns of results are the same with non-normalized values or values normalized separately for each gender sub-sample).

Descriptive statistics for this measure are shown in Table 9. Triadic local integration is higher for girls than for boys in this sample, indicating that girls are more often in integrative positions within triads. The average score for boys is negative, suggesting that more boys are often in non-integrative triad positions than integrative.

**Table 9. Descriptive Statistics for Triadic Local Integration in PROSPER Peers.**

	Mean	(SD)	Min.	Max.	Obs.
Triadic Local Integration	.05	(1.04)	-4.77	6.39	28,260
<i>for females</i>	.19	(0.99)	-3.99	6.34	15,556
<i>for males</i>	-.12	(1.03)	-4.77	6.39	13,064

Models in Table 10 use the analytic strategy of those in the main body of Chapter 2, but replace triadic integration for ego-network density as the measure of local integration. Note that there is less missingness when using this triadic measure, so model fit indices (AIC, BIC) here are not directly comparable to the main models above. However, examining this measure in the same analytic sample where fit indices can appropriately be compared shows that this measure provides better model fit. As above,

gender interactions warrant separating models by gender, so those final models are shown here, so that models in Table 10 mirror Table 4 above.

**Table 10. Fixed Effects Regression of Depressive Symptoms on Triadic Local Integration in PROSPER Peers by Gender.**

	<b>M1</b>		<b>M2</b>	
	<b>Female</b>	(SE)	<b>Male</b>	(SE)
Triadic Local Integration	-0.024*	(0.01)	-0.001	(0.01)
Global Integration	-0.016*	(0.01)	-0.003	(0.01)
Triadic Local Integration x Friend Depression	0.043*	(0.02)	0.016	(0.02)
Global Integration x Friend Depression	0.031*	(0.01)	0.023	(0.02)
Friend Depression	0.057*	(0.02)	0.044	(0.03)
Popularity	0.004	(0.00)	0.003	(0.00)
Gregariousness	0.001	(0.00)	-0.009**	(0.00)
Low SES	-0.013	(0.01)	0.009	(0.02)
Biological Parents	-0.041	(0.03)	-0.081**	(0.03)
School Adjustment	-0.144***	(0.01)	-0.093***	(0.01)
<i>Grade (Grade 9 Baseline)</i>				
Grade 10	-0.017*	(0.01)	0.022**	(0.01)
Grade 11	-0.039***	(0.01)	0.020*	(0.01)
Grade 12	-0.077***	(0.01)	0.014	(0.01)
Out-of-grade Friends	0.001	(0.00)	0.002**	(0.00)
Intercept	0.908***	(0.05)	0.514***	(0.05)
R <sup>2</sup> (Overall)	0.13		0.07	
AIC	-280.6		-3183.9	
BIC	-173.5		-3079.2	
Observations	15,556		13064	

\*p<.05, \*\*p<.01, \*\*\*p<.001

Results indicate similar patterns to those shown in models above, with a few key differences. Looking first to the female subsample in Model 1, here triadic local integration is negatively associated with depressive symptoms in the conditional effect and positively associated in the interaction. This pattern means that triadic local integration is generally associated with lower symptoms, unless friends are depressive, then the beneficial association of integration is largely mitigated. This pattern is shown in Figure 9 (where friends' depressive values are shown at 0, .4, and 1 of the 0-2 range). This differs from results using ego-network density above, where greater local integration was beneficial, even if friends are depressive.

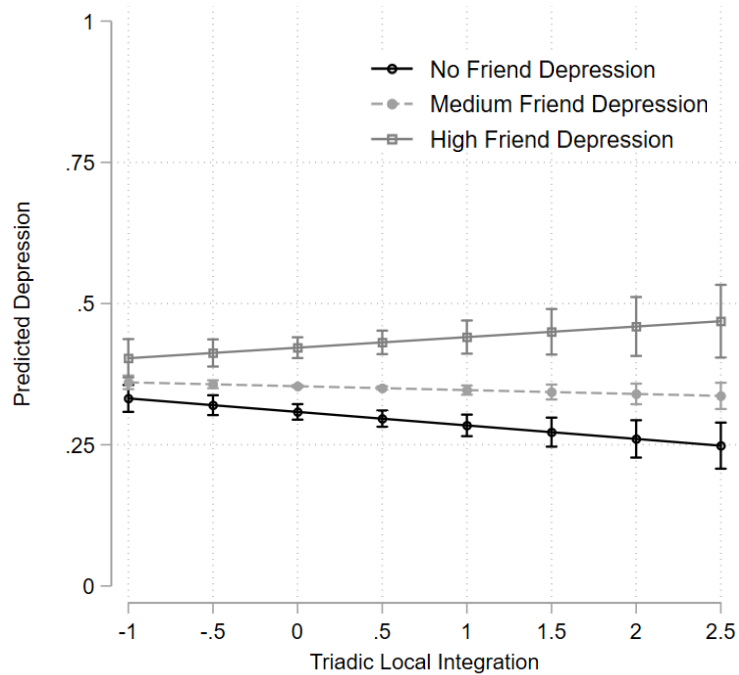


Figure 9. Predicted Depressive Symptoms by Triadic Local Integration and Friend Depression, with 95% Confidence Intervals.

Here, for girls, global integration patterns match those above, with higher global integration associated with lower depressive symptoms when friends are not depressive, but predicting higher depressive levels when friends are experiencing depressive symptoms.

For boys in Model 2, integration does not predict depressive symptoms, unlike models above where global integration predicts fewer symptoms. However, global integration does predict depressive symptoms as before if variables with high missingness, such as out-of-grade friends, are excluded, suggesting a similar overall pattern for boys.

Model 3 shows that for girls, associations of depressive symptoms with triadic local integration persist even net of ego-network density, the measure of local integration used above. Ego-network density also maintains its protective association with depressive symptoms when friends are depressive. As in Model 2, results from Model 4 show integration is not significantly related to depressive symptoms for boys when all three measures are included.

Overall, these results indicate that measuring (non-)integration within triad positions represents a meaningful way to conceptualize local integration in relation to depressive symptoms. For girls, being in more triadic integrative positions is associated with lower symptoms, unless friends are depressive, then greater local integration becomes detrimental. This may indicate that there is something qualitatively distinct

**Table 11. Fixed Effects Regression of Depressive Symptoms on Triadic Local Integration and Ego-Network Density in PROSPER Peers by Gender.**

	<b>M3</b>		<b>M4</b>	
	<b>Female</b>	(SE)	<b>Male</b>	(SE)
Triadic Local Integration	-0.022*	(0.01)	0.001	(0.01)
Global Integration	-0.018*	(0.01)	-0.015	(0.01)
Triadic Local Integration x Friend				
Depression	0.041*	(0.02)	0.010	(0.02)
Global Integration x Friend Depression	0.039*	(0.02)	0.036	(0.02)
Friend Depression	0.081**	(0.03)	0.018	(0.04)
Popularity	0.004	(0.00)	0.003	(0.00)
Gregariousness	0.001	(0.00)	-0.008**	(0.00)
Low SES	-0.017	(0.02)	0.011	(0.02)
Biological Parents	-0.037	(0.03)	-0.065*	(0.03)
School Adjustment	-0.140***	(0.01)	-0.095***	(0.01)
<i>Grade (Grade 9 Baseline)</i>				
Grade 10	-0.014	(0.01)	0.020*	(0.01)
Grade 11	-0.039***	(0.01)	0.015	(0.01)
Grade 12	-0.072***	(0.01)	0.005	(0.01)
Out-of-grade Friends	0.001	(0.00)	0.002*	(0.00)
Ego-Network Density	0.041	(0.03)	0.017	(0.03)
Ego-Network Density X Friend Depression	-0.153**	(0.06)	0.020	(0.09)
Intercept	0.881***	(0.05)	0.532***	(0.05)
R <sup>2</sup> (Overall)	0.13		0.07	
AIC	-972.5		-3496.5	
BIC	-850.9		-3377.7	
Observations	14709		12382	

\*p<.05, \*\*p<.01, \*\*\*p<.001

about girls' position among the wider network of peers, as measures that use structural information from the whole network (i.e. triadic local integration and global integration, as opposed to ego-network density), relate to higher protective associations with integration but greater stress or exposure from peer depressive symptoms for girls.

These results also speak to the theoretical importance of measuring local integration through triad position. First, this measure presents an attractive alternative to ego-network measures because it can capture exclusion, or non-integration in a novel way. Second, triadic local integration is also clearly distinct from measures of ego-network cohesion, at least for girls, as both measures predict depressive symptoms differently when modeled net of each other. Third, because triadic integration scores are derived from individual's positions in every possible triad in a network (excluding the completely null 003 triad), it provides a different way of viewing the "local" component of local integration. Here, individuals are considered in relation to all peers, using the full information of the network, similar to the global measure of structural embeddedness, rather than only information about direct friends in ego-networks. Yet, this measure is based in one of the smallest units of meaningful social structure, the triad, so that it considers an individual's local position in this social unit throughout the overall network. Future work should continue to explore potential applications of triad positions as conceptual tools for understanding social integration in networks.

## Appendix B. Additional Information for Chapter 3.

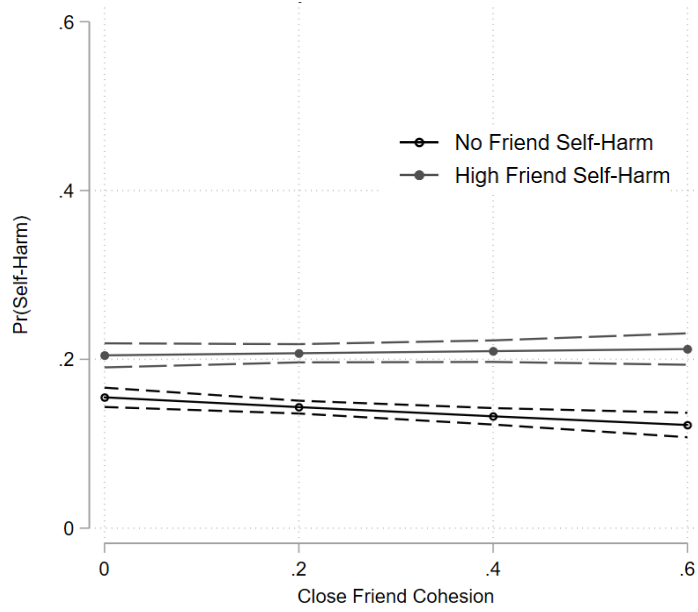
### *B.1 Correlations and Figures.*

Here, Table 12 shows the correlations between self-harm and the three network measures representing three levels of network structure used in main analyses. While the network measures are moderately correlated, indices assessing multicollinearity suggest no concerns for modelling, as described above.

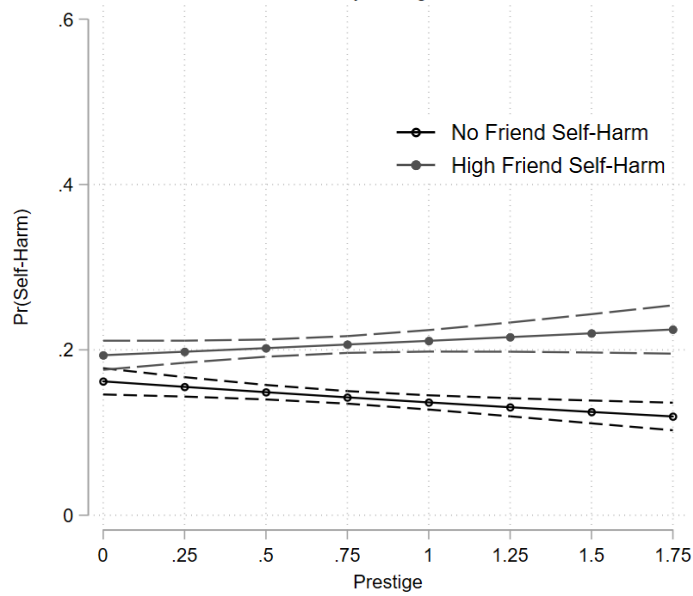
**Table 12. Correlation of Self-Harm and Network Integration Measures.**

	(1)	(2)	(3)	(4)
(1) Self-harm	1.00			
(2) Close Friend Cohesion	-0.03	1.00		
(3) Peer Group Core	-0.06	0.45	1.00	
(4) Prestige	-0.09	0.45	0.42	1.00

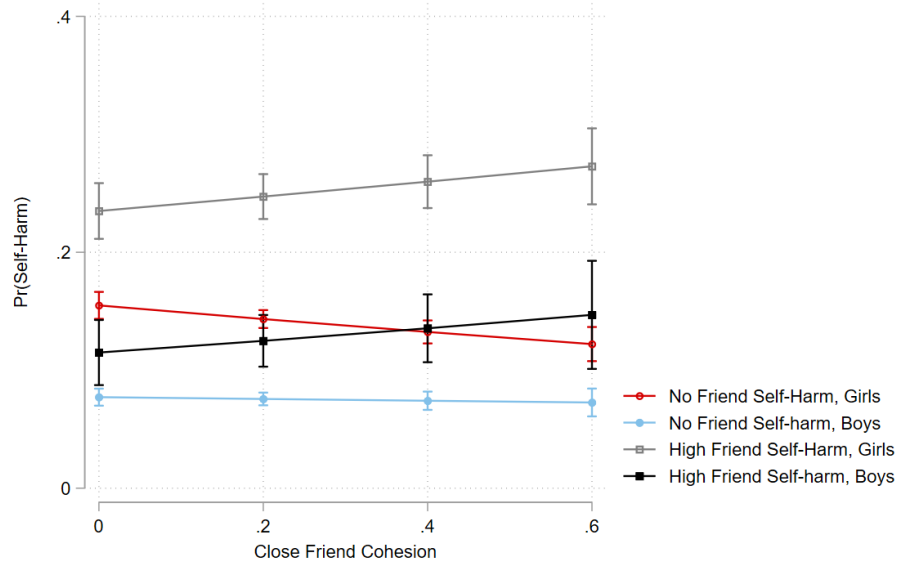
Additional figures illustrate predicted probabilities of self-harm from the main models above. Figures 10 and 11 are comparable to Figures 5 and 6, but with average friend self-harm set at .4 of the 0-1 range. Figures 12 and 13 show predicted self-harm based on cohesion and prestige from Models 3 and 4 in Table 7 above for both girls and boys, showing differences in these associations by gender. Figure 14 shows the predicted probability of self-harm based on combined integration types and friend self-harm levels for boys only, comparable to Figure 7.



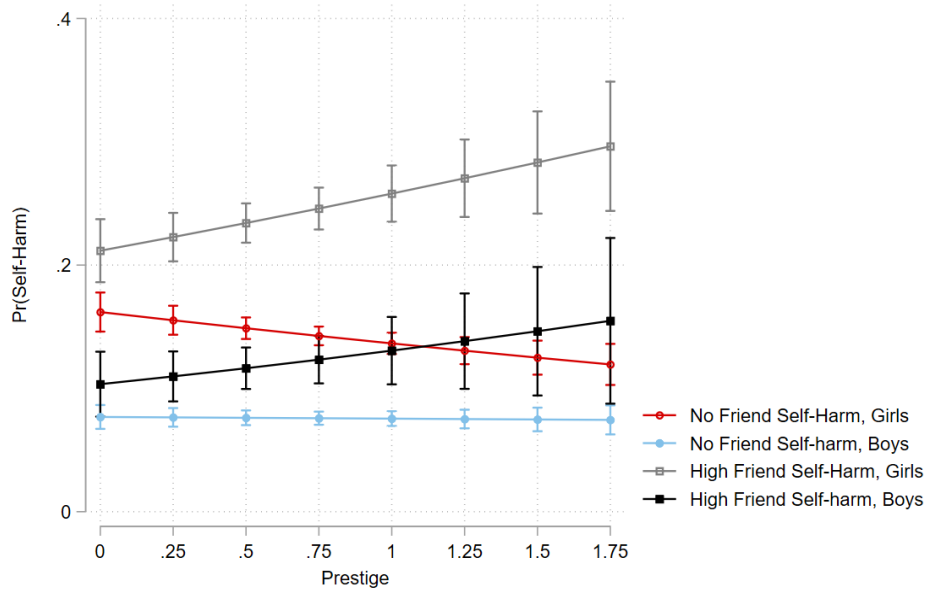
**Figure 10. Predicted Probability of Self-Harm on Close Friend Cohesion by Friend Self-Harm, Female Subsample.**



**Figure 11. Predicted Probability of Self-Harm on Prestige by Friend Self-Harm, Female Subsample.**



**Figure 12. Predicted Probability of Self-Harm on Close Friend Cohesion and Friend Self-Harm by Gender.**



**Figure 13. Predicted Probability of Self-Harm on Prestige and Friend Self-Harm by Gender.**

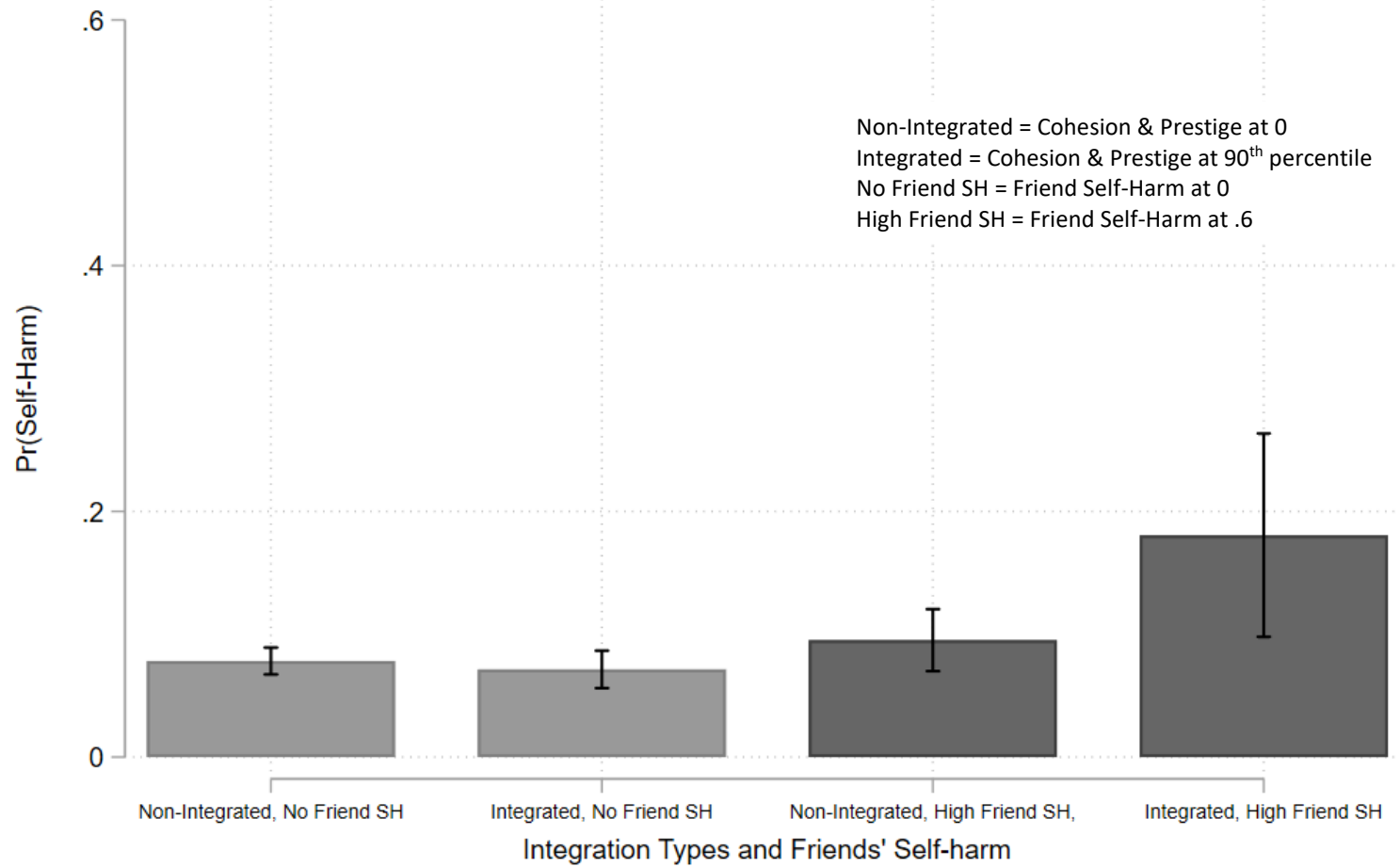


Figure 14. Predicted Probability of Self-Harm on Combined Integration Types by Friend Self-Harm, Male Subsample.

## ***B.2 Self-Harm and Extended Demographic Characteristics.***

Because self-harm has yet to be thoroughly explored quantitatively in sociology, it is worth considering further description of self-harm, self-cutting, and a wider array of demographic and social network position characteristics.

First, as described above, self-harm in this survey includes one item assessing self-cutting, and one item assessing if respondents “deliberately hurt” themselves. Among those who report self-cutting, 41% of girls and 43% of boys report *not* deliberately hurting themselves. Among those who report deliberately hurting themselves, 24% of girls report no self-cutting and 54% of boys report no self-cutting. This pattern suggests that self-harm may more often take the form of self-cutting for girls compared to boys, but surprisingly, not all youth who report self-cutting also report that they deliberately hurt themselves. This could suggest self-cutting being a singular method of self-harm for some youth, or that youth engaging in self-cutting view the behavior as serving other functions rather than deliberately inflicting pain.

Second, Table 14 shows the association between self-harm and additional demographic, psychological, and behavioral variables, mirroring the analytic methods used in Chapter 3. These measures are described in Table 13. As noted in the robustness checks above, including many of these measures does not alter results of interest. Though many of these measures have high missingness or lack theoretical motivation for inclusion in the main analyses, they can still illuminate important dimensions of self-

harm in adolescence. Additionally, this analysis provides a way to accurately explore differences between self-harming and non-self-harming youth in the sample, as assessing the statistical significance between groups is not straightforward in four waves of panel data.

**Table 13. Descriptive Statistics for Extended Demographic Characteristics in PROSPER Peers.**

	Mean or Proportion	(St. Dev.)	Min.	Max.	Definition
Family Relations	-.16	.41	-1.40	.83	Scale of items measuring respondent's parental affection and supervision
Grades	4.05	.87	1	5	Receiving mostly <D's (=1) to mostly A's (=5) in school subjects
School Adjustment	3.66	.69	1	5	Scale of items measuring respondent's feelings toward school
Any Substance Use	.47	.50	0	1	Any illicit substance use in the past month (Yes/No)
Same-Gender Friends	.86	.22	0	1	Of respondent's sent/received ties, proportion that are the same gender as the respondent
<i>Observations</i>	24,497				

Table 14 shows that several additional protective associations emerge. Of the newly assessed variables, having closer family relationships, higher grades in school classes, greater school adjustment, and a higher proportion of friends who are the same-gender as the respondent are all associated with lower odds of self-harm. However, reporting any illicit substance use in the past month is associated with higher odds of

self-harm. This analysis suggests that self-harm may be tightly linked to other social-psychologically rooted behaviors in adolescence beyond the usual battery of internalizing symptoms, including drug use and connections with same-gender versus cross-gender peers. Future work should consider the mechanisms through which these social, psychological, and behavioral characteristics can relate to self-harm for youth.

**Table 14. Logistic Regression of Self-Harm in PROSPER Peers with Extended Demographic Characteristics.**

	M1	
	OR	(SE)
Depressive Symptoms	1.547***	(0.02)
Grade 10	0.675***	(0.05)
Grade 11	0.492**	(0.04)
Grade 12	0.379***	(0.04)
Male	0.510**	(0.04)
White	0.802*	(0.08)
Low SES	1.297**	(0.11)
Biological Parents	0.856*	(0.07)
Out-of-grade Friends	1.040**	(0.01)
RCT Treatment	0.951	(0.07)
Family Relations	0.748**	(0.07)
Grades	0.863***	(0.04)
School Adjustment	0.527***	(0.03)
Any Substance Use	2.285***	(0.17)
Same-Gender Friends	0.635**	(0.09)
Intercept	0.201***	(0.06)
<i>Random Effects Parameters</i>		
Individual-Level	3.689***	(0.28)
Observations	24497	
AIC	12448.4	
BIC	12586.2	

OR=Odds Ratio; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Additionally, about 85% of youth who report self-harming have average or higher than average depressive levels, meaning 15% of self-harming teens report below-average depressive levels.

**Table 15. Logistic Regression of Self-Harm at Low Depressive Levels on Extended Demographic Characteristics in PROSPER Peers.**

	M1	
	OR	(SE)
Prestige	0.839	(0.10)
Peer Group - Core	1.426*	(0.21)
Close Friend Cohesion	0.666	(0.18)
Grade 10	0.713**	(0.09)
Grade 11	0.634**	(0.09)
Grade 12	0.633**	(0.10)
Male	0.868	(0.10)
White	0.740*	(0.11)
Low SES	1.051	(0.14)
Biological Parents	0.911	(0.11)
Out-of-grade Friends	1.030***	(0.01)
RCT Treatment	1.110	(0.12)
Family Relations	0.869	(0.12)
Grades	0.940	(0.06)
School Adjustment	0.643***	(0.06)
Any Substance Use	2.175***	(0.26)
Same-Gender Friends	0.733	(0.17)
Friend Self-Harm	1.723*	(0.37)
Intercept	0.036***	(0.02)
<i>Random Effects Parameters</i>		
Individual-Level	2.517***	(0.41)
Observations	24497	
AIC	4452.4	
BIC	4614.5	

OR=Odds Ratio; \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

This unexpected crossover between mental health status (self-harming, but low depressive symptoms) is significantly predicted by several of the characteristics examined thus far, shown in Table 15. Low-depressive self-harming is negatively associated with grade in school (i.e., declines over time), being white, and feeling more attached to the school environment. Self-harming with low depressive levels is positively associated with having more out-of-grade friends, reporting illicit substance use in the last month, having friends who self-harm, and being in the core of a peer group. These patterns suggest that there are social components of self-harm beyond any specific manifestation of psychological distress as depressive symptoms. Future work should further explore drivers and long-term consequences of self-harm among youth with low depressive levels.

### ***B.3 Self-Harm and Extended Network Measures.***

Another avenue of exploration in this nascent literature on self-harm and peer networks is how self-harm relates to a more comprehensive battery of structural network measures. Intuitive definitions for these measures are provided in Table 16, and descriptive statistics are shown in Table 17. Table 18 shows results of extended network variables in analyses using the same methods presented in the main body of the paper. Table 19 examines isolation separately (as it is perfectly collinear with having a 0 on all other network measures).

**Table 16. Definitions of Extended Network Measures.**

	Network Measure	Meaning
<i>Overall Network</i>		
Prestige	Bonacich Centrality	Ego is well-connected among well-connected peers
Popularity	In-degree	Number of incoming ties (received nominations)
Gregariousness	Out-degree	Number of outgoing ties (sent nominations)
Closeness	Closeness Centrality	Ego's distance to all nodes in network (sum of shortest paths to each alter)
Bridging	Betweenness Centrality	Ego is on shortest path between two alters
<i>Peer Group</i>		
Peer Group Core	In Largest Bi-component of Peer Group	Ego is in central the core (not periphery) of a peer group
Peer Group Closeness	Closeness Centrality within Peer Group	Ego's distance to all other nodes in peer group (sum of shortest paths to peer group alters)
<i>Close Friendships</i>		
Close Friend Cohesion	Ego-Network Transitivity	Proportion of friends' friends who are ego's friends (net of ego-network density, indicates hierarchy in the ego-network)
Close Friend Reciprocity	Ego-Network Reciprocity	Proportion of ego's sent ties that are reciprocal (friend also nominated ego)
Close Friend Density	Ego-Network Density	Proportion of ego's friends who are also friends with each other
<i>Isolation</i>		
Complete Isolation	Complete Isolate	No ties in network
Avoided Isolation	In-degree Isolate	No incoming ties (0 received nominations)
Withdrawn Isolation	Out-degree Isolate	No outgoing ties (0 sent nominations)

**Table 17. Descriptive Statistics for Extended Network Measures in PROSPER Peers (grades 9-12).**

	Mean or Proportion	(St. Dev.)	Min.	Max.
<i>Overall Network</i>				
Prestige	.88	.60	0	4.5
Popularity	3.39	2.36	0	18
Gregariousness	3.54	2.02	0	7
Closeness	.25	.06	.004	.47
Bridging	.15	1.06	-.67	14.39
<i>Peer Group</i>				
Peer Group Core	.80	.40	0	1
Peer Group Closeness	.55	.17	.12	1
<i>Close Friendships</i>				
Close Friend Cohesion	.25	.24	0	1
Close Friend Reciprocity	.47	.35	0	1
Close Friend Density	.24	.22	0	1
<i>Observations</i>	23,106			
<i>Isolation</i>				
Complete Isolation	6%	--	0	1
Avoided Isolation	15%	--	0	1
Withdrawn Isolation	14%	--	0	1
<i>Observations</i>	27,935			

Results in Table 18 indicate that even when assessing a wider battery of network measures net of each other, network position at all three network levels relates to self-harm. In the final model, being in the peer group core continues to predict higher odds of self-harm, as does bridging others and popularity when friends self-harm. Lower odds of self-harm are associated with greater gregariousness, closeness, and close friend reciprocity. Overall, results suggest that greater overall network integration can be beneficially associated with self-harm (e.g., higher gregariousness and closeness), but

**Table 18. Multilevel Logistic Regression of Self-Harm on Extended Network Variables in PROSPER Peers.**

	M1		M2	
	OR	(SE)	OR	(SE)
Prestige	0.672**	(0.09)	0.776	(0.13)
Popularity	1.123***	(0.03)	1.039	(0.04)
Gregariousness	0.937*	(0.03)	0.895**	(0.04)
Closeness	0.145*	(0.12)	0.084*	(0.08)
Bridging	1.134***	(0.04)	1.142**	(0.05)
Peer Group Core	1.156	(0.12)	1.129	(0.14)
Peer Group Closeness	0.784	(0.18)	1.030*	(0.31)
Close Friend Cohesion	0.873	(0.18)	0.624	(0.17)
Close Friend Reciprocity	0.654**	(0.09)	0.631**	(0.10)
Close Friend Density	1.129	(0.22)	1.098	(0.26)
<i>Friend Self-Harm X Network</i>				
Friend SH X Prestige			0.669	(0.44)
Friend SH X Popularity			1.534*	(0.23)
Friend SH X Gregariousness			1.284	(0.19)
Friend SH X Closeness			14.91	(49.64)
Friend SH X Bridging			0.943	(0.18)
Friend SH X Peer Group Core			1.059	(0.43)
Friend SH X Peer Group Closeness			0.293	(0.31)
Friend SH X Close Friend Cohesion			5.019	(4.77)
Friend SH X Close Friend Reciprocity			1.373	(0.74)
Friend SH X Close Friend Density			1.096	(0.83)
Depressive Symptoms	1.591***	(0.02)	1.584***	(0.02)
Friend Self-Harm	5.677***	(0.88)	0.821	(0.64)
Grade 10	0.719***	(0.06)	0.752***	(0.06)
Grade 11	0.544***	(0.05)	0.577***	(0.06)
Grade 12	0.435***	(0.05)	0.452***	(0.06)
Male	0.718***	(0.06)	0.740***	(0.06)
White	0.835	(0.09)	0.832	(0.09)
Low SES	1.268**	(0.11)	1.256*	(0.11)
Biological Parents	0.749***	(0.06)	0.762***	(0.06)
Out-of-grade Friends	1.053***	(0.01)	1.052***	(0.01)
RCT Treatment	0.905	(0.07)	0.912	(0.07)
Intercept	0.016***	(0.00)	0.022***	(0.01)
Individual-Level Random Effects	3.916***	(0.30)	3.830***	(0.30)
Observations	23,106		23,106	
AIC	12010.7		11955.2	
BIC	12195.8		12220.8	

OR=Odds Ratio; \*p<.05, \*\*p<.01, \*\*\*p<.001

certain positions of integration (e.g., bridging others, being popular when friends self-harm) are related to higher self-harm. Having strong reciprocal close friendships and being in the core of a peer group introduce further protective and detrimental associations with self-harm.

Because both isolation and self-harm are relatively rare events in adolescent networks, it is worth briefly noting the isolated, self-harming sample. In this sample, 1,559 cases are complete isolates, 275 of whom report self-harm. Of 3,987 withdrawn isolate cases (those sending no friendship nominations), 702 self-harm. For avoided isolates (those receiving no friendship nominations), 607 of 4,070 cases report self-harm.

Results for isolation in Table 19 paint a clear picture of risks of isolation related to self-harm. Youth who are completely isolated in their peer network have higher odds of self-harm. If isolation is further decomposed into avoided isolation and withdrawn isolation, only withdrawn isolation is significantly associated with increased odds of self-harm. This result suggests that not seeing oneself as part of the peer network is especially linked with self-harm, though this could represent either self-harm increasing withdrawal from peers, or withdrawal from peers prompting self-harm. Future work should examine this relationship further to determine the timing and causal nature of associations between self-harm and isolation.

**Table 19. Multilevel Logistic Regression of Self-Harm on Isolation Types in PROSPER Peers.**

	M1		M2	
	OR	(SE)	OR	(SE)
<i>Isolation</i>				
Complete Isolation	1.708**	(0.21)		
Avoided Isolation			1.001	(0.09)
Withdrawn Isolation			1.712**	(0.15)
Depressive Symptoms	1.599**	(0.02)	1.596**	(0.02)
Grade 10	0.712**	(0.05)	0.697**	(0.05)
Grade 11	0.552**	(0.04)	0.538**	(0.04)
Grade 12	0.441**	(0.04)	0.424**	(0.04)
Male	0.691**	(0.05)	0.668**	(0.05)
White	0.808*	(0.08)	0.828*	(0.08)
Low SES	1.294**	(0.10)	1.298**	(0.10)
Biological Parents	0.666**	(0.05)	0.673**	(0.05)
Out-of-grade Friends	1.052**	(0.01)	1.053**	(0.01)
RCT Treatment	0.886	(0.06)	0.894	(0.06)
Intercept	0.011**	(0.00)	0.010**	(0.00)
<i>Random Effects Parameters</i>				
Individual-Level	3.869**	(0.26)	3.851**	(0.26)
Observations	27,935		27,935	
AIC	15148.9		15128.8	
BIC	15256.0		15244.1	

OR=Odds Ratio; \*p<.05, \*\*p<.01, \*\*\*p<.001

In sum, results in this section indicate both that a wider battery of demographic and behavioral characteristics relates to self-harm net of psychological distress in ways that can further describe self-harming youth. Results with extended network measures and isolation indicate that there is certainly more to disentangle about how different network structures relate to self-harm.

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## Biography

Molly Copeland received a B.A. in Linguistics from The College of William and Mary in 2011 and an M.A. in Sociology from Duke University in 2017. At Duke, Molly was a recipient of the James B. Duke, University Scholars, Education and Human Development, and Katherine Goodman Stern fellowships and the Vorsanger-Smith Scholar Award. She is lead co-author of three peer reviewed publications: “Dynamic Associations of Network Isolation and Smoking Behavior” in *Network Science* (2017), “Different Kinds of Lonely: Dimensions of Isolation and Substance Use in Adolescence” in *Journal of Youth & Adolescence* (2018), and “Social Ties Cut Both Ways: Self-Harm and Adolescent Peer Networks” in *Journal of Youth & Adolescence* (2019). After completing her Ph.D. at Duke University, Molly will join Michigan State University as an Assistant Professor in the Department of Sociology.