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### Authors

Sewall, Craig JR  
Girard, Jeffrey M  
Merranko, John  
[et al.](#)

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## A Bayesian multilevel analysis of the longitudinal associations between relationship quality and suicidal ideation and attempts among youth with bipolar disorder

Craig J.R. Sewall<sup>a,\*</sup>, Jeffrey M. Girard<sup>b</sup>, John Merranko<sup>c</sup>, Danella Hafeman<sup>c</sup>, Benjamin I. Goldstein<sup>d</sup>, Michael Strober<sup>e</sup>, Heather Hower<sup>f,g</sup>, Lauren M. Weinstock<sup>f</sup>, Shirley Yen<sup>f</sup>, Neal D. Ryan<sup>c</sup>, Martin B. Keller<sup>f</sup>, Fangzi Liao<sup>c</sup>, Rasim S. Diler<sup>c</sup>, Mary Kay Gill<sup>c</sup>, David Axelson<sup>h</sup>, Boris Birmaher<sup>c</sup>, Tina R. Goldstein<sup>c</sup>

<sup>a</sup>University of Pittsburgh, School of Social Work

<sup>b</sup>University of Kansas, Department of Psychology

<sup>c</sup>Department of Psychiatry, Western Psychiatric Hospital, University of Pittsburgh School of Medicine

<sup>d</sup>Department of Psychiatry, Sunnybrook Health Sciences Centre, University of Toronto Faculty of Medicine

<sup>e</sup>Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, University of California at Los Angeles

<sup>f</sup>Department of Psychiatry and Human Behavior, Warren Alpert Medical School, Brown University

<sup>g</sup>Department of Health Services, Policy, and Practice, Brown University School of Public Health

<sup>h</sup>Department of Psychiatry, Nationwide Children's Hospital and The Ohio State College of Medicine

### Abstract

**Background:** Youth with bipolar disorder (BD) are at high risk for suicidal thoughts and behaviors and frequently experience interpersonal impairment, which is a risk factor for suicide. Yet, no study to date has examined the longitudinal associations between relationship quality in family/peer domains and suicidal thoughts and behaviors among youth with BD. Thus, we investigated how between-person differences--reflecting the average relationship quality across time--and within-person changes, reflecting recent fluctuations in relationship quality, act as distal and/or proximal risk factors for suicidal ideation (SI) and suicide attempts.

**Methods:** We used longitudinal data from the Course and Outcome of Bipolar Youth Study (N=413). Relationship quality variables were decomposed into stable (i.e. average) and varying (i.e. recent) components and entered, along with major clinical covariates, into separate Bayesian

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**Correspondence to:** Craig J.R. Sewall, University of Pittsburgh, School of Social Work, 2117 Cathedral of Learning, 4200 Fifth Ave, Pittsburgh, PA 15260, CJS227@pitt.edu.

\*The lead author had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

multilevel models predicting SI and suicide attempt. We also examined how the relationship quality effects interacted with age and sex.

**Results:** Poorer average relationship quality with parents ( $\beta = -0.33$ , 95% Bayesian Highest Density Interval (HDI)  $[-0.54, -0.11]$ ) or friends ( $\beta = -0.33$ , 95% HDI  $[-0.55, -0.11]$ ) were longitudinally associated with increased risk of SI but not suicide attempt. Worsening recent relationship quality with parents ( $\beta = -0.10$ , 95% HDI  $[-0.19, -0.03]$ ) and, to a lesser extent, friends ( $\beta = -0.06$ , 95% HDI  $[-0.15, 0.03]$ ), were longitudinally associated with increased risk of SI, but only worsening recent relationship quality with parents was also associated with increased risk of suicide attempt ( $\beta = -0.15$ , 95% HDI  $[-0.31, 0.01]$ ). The effects of certain relationship quality variables were moderated by gender but not age.

**Conclusions:** Among youth with BD, having poorer average relationship quality with peers and/or parents represents a distal risk factor for SI but not suicide attempts. Additionally, worsening recent relationship quality with parents may be a time-sensitive indicator of increased risk for SI or suicide attempt.

### Keywords

suicide; bipolar disorder; adolescence; parent-child relationships; peer relationships; Bayesian analysis

## Introduction

Youth with a bipolar spectrum disorder (BD) are at high risk for suicidal thoughts and behaviors (STBs). Lifetime prevalence of suicidal ideation (SI) and suicide attempts among youth with BD are as high as 57% and 21%, respectively (Hauser, Galling, & Correll, 2013). While the causes of suicide are complex and multifactorial, strong evidence indicates that interpersonal discord in peer and/or family relationships is a common risk factor for STBs, especially among youth (Bridge, Goldstein, & Brent, 2006; King & Merchant, 2008). Already at high risk for STBs, youth with BD experience frequent and persistent interpersonal impairment across peer and family relationship domains (Keenan-Miller & Miklowitz, 2011). Despite this confluence of risks, studies of the associations between interpersonal relationship quality and STBs among youth with BD have been rare.

The few studies that have examined this association have found that poorer relationship quality in family (Algorta et al., 2011; Goldstein et al., 2009; Weinstein, Van Meter, Katz, Peters, & West, 2015) and/or peer domains (Sewall et al., 2020) are linked to higher risk of STBs. Importantly, evidence suggests that the association between family/peer relationship quality and STBs is not merely an epiphenomenon of affective symptom severity among youth with BD. Controlling for current depressive and/or manic symptom severity, Sewall and colleagues (2019) found that a one-unit difference in average relationship quality (e.g., those with “fair” versus “poor” relationship quality) increased the odds of having current SI by 45% for the family domain and 24% for the peer domain. However, given the cross-sectional nature of these studies, the longitudinal association between family/peer relationship quality and STBs remains unclear.

Longitudinal analyses employing a multilevel modeling framework are crucial as they allow for detailed insights into how different elements of relationship quality (i.e. within- and between-person differences) relate to STBs over time. That is, the between-person component captures the overall average quality of the relationship that is relatively stable over time, while the within-person component reflects time-varying fluctuations in relationship quality that may occur in response to situational dynamics (e.g. conflict or break-up). These stable and time-varying aspects of relationship quality align with distal and proximal categories of risk factors for STBs, respectively. Distal factors — such as sociodemographics, family history (i.e. genetic loading), and clinical history (e.g. previous suicide attempt)—predispose individuals to higher risk for STBs and are fixed or relatively stable over time. Proximal risks—such as current psychopathology and psychosocial complications—are factors that change over time and are influenced by situational dynamics (Hawton & van Heeringen, 2009; Malhi et al., 2018).

Importantly, proximal and distal risk factors may interact to confer increased risk of STBs. Consistent with the stress-diathesis model of suicidal behavior (Brent & Mann, 2006; Hawton & van Heeringen, 2009), distal factors, such as family history of suicide, create a predisposition to STBs (i.e. diathesis) such that when they are exposed to proximal stressors, like worsening depression or interpersonal conflict, their risk for STBs is elevated compared to those without the predisposition. Additionally, evidence suggests that, among people with BD, proximal and distal risk factors for STBs likely vary by age and/or sex (Schaffer et al., 2015). However, how certain proximal and distal risk factors may interact to confer risk for STBs, and how these factors may be moderated by age or sex, are rarely investigated in youth suicide research in general and, in particular, research among youth with BD.

In the current study, we analyzed longitudinal data from the Course and Outcome of Bipolar Youth (COBY) study—a longitudinal, multisite study of pediatric BD (Axelson et al., 2006; Birmaher et al., 2006)—which allowed us to examine how overall average relationship quality and recent fluctuations in relationship quality in family and peer domains are associated with STBs over time. In line with the ideation-to-action framework, which stipulates that SI and suicide attempts are unique phenomena with distinct correlates (Klonsky, May, & Saffer, 2016) we investigated the following research question: 1.) Does overall average relationship quality and recent fluctuations in relationship quality in family and peer domains act as distal and proximal risk factors, respectively, for SI and/or suicide attempt, beyond the effects of major clinical covariates? Also, consistent with the stress-diathesis model of suicidal behavior (Brent & Mann, 2006), and given the fact that risk factors for STBs among youth vary across sex and age (Schaffer et al., 2015), we investigated the following research question: 2.) How do distal factors (i.e. overall average relationship quality and sex) interact with proximal factors (i.e. recent relationship quality and age) to confer risk of SI and suicide attempt?

## Methods

Detailed descriptions of the methodology used in COBY are provided elsewhere (Axelson et al., 2006; Birmaher et al., 2006). Here we describe the specific methods employed for the present study.

## Sample

COBY participants were recruited primarily from outpatient clinics at three university centers: Brown University, the University of California, Los Angeles, and the University of Pittsburgh. The original study enrolled 446 youths 7-17 years of age with DSM-IV BD I or II or with BD not otherwise specified as operationalized by COBY (Axelson et al., 2006). Youth with schizophrenia, intellectual disabilities, autism, or mood disorder secondary to medical conditions or substance use were excluded. The analyses in this report are based on the prospective evaluation of N=386 participants who completed at least one follow-up assessment that included the measure of suicidality<sup>1</sup>. At baseline, participants were, on average, age 14.5 years, mostly white (82%), and slightly more than half (53%) were male. Participants in our sample had an average of 11.0 years (SD= 3.1; Range= 0.6-18.0) of data once the suicidality measure was incorporated into the COBY study. Attrition was low, as 90% of participants had at least 6.4 years of data and 50% had at least 12.1 years.

## Procedures

Each study site obtained institutional review board approval for all study procedures, and consent or assent was obtained from participating youth and their parents/primary caregivers prior to administration of study procedures. Trained study clinicians completed intake and follow-up interviews and child psychiatrists or psychologists confirmed all diagnoses. All scores appraised by study clinicians after interviewing participants and their parents/primary caregivers were confirmed in consensus meetings with study investigators. Interrater agreement for all baseline psychiatric disorders were at least 0.8 and intraclass correlation coefficients for follow-up assessments were at least 0.75.

## Lifetime History and Intake Assessments.

Youth were assessed for psychiatric disorders and treatment history with the Schedule for Affective Disorder and Schizophrenia for School-Age Children—Parent and Lifetime Version (K-SADS-PL; Kaufman et al., 1997). Parents were assessed for psychopathology with the Structured Clinical Interview for DSM-IV (Spitzer, Williams, Gibbon, & First, 1996) and first- and second-degree family psychiatric history was assessed with the Family History Screen (Weissman et al., 2000). Demographic data including sex, age, race, socioeconomic status (SES; using Hollingshead Scale; Hollingshead, 1975) and living situation were collected using a General Information Form at each site.

## Longitudinal Assessments.

Weekly course of psychiatric symptoms were ascertained using the Longitudinal Interval Follow-up Evaluation (LIFE) and quantified with the LIFE's Psychiatric Status Rating scale (PSR), which numerically operationalizes DSM-IV criteria (Keller et al., 1987). For mood disorders, PSR scores of 1 or 2 indicate euthymia, 3 or 4 indicates subsyndromal symptoms,

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<sup>1</sup>A total of 33 participants only attended the intake assessment and were therefore ineligible for this longitudinal analysis. Additionally, the COBY study did not begin prospectively tracking suicidality until approximately 3 years after the study commenced. Thus, given the aims of our analyses, the first follow-up assessment that included the suicidality measure was treated as the baseline for each participant. N=27 participants dropped out of COBY before the suicidality measure was incorporated and were therefore excluded from analyses. See Table S1 in the Supplement to see summary of differences between the analytic sample and excluded/ineligible participants.

and 5 or 6 indicates full threshold symptoms. At each interview, there was a retrospective recall of weekly symptomatology from the previous interview to the current interview, using a calendar and several memory aids via a procedure similar to the timeline follow-back (TLFB) method (Sobell & Sobell, 2008). Participants were assessed, on average, every 9.4 months (SD= 6.7; Range= 6.0-90.0).

Monthly changes in family and peer relationship quality were assessed using the interpersonal functioning domain of the Range of Impaired Functioning Tool of the LIFE instrument (Leon et al., 1999). Scores reflect the degree of emotional closeness, frequency of conflict and how it is resolved, level of active and passive avoidance, degree of satisfaction, and willingness to improve the relationship during the worst week of each month. Parent and peer relationship quality scores range from 1 (“very poor”) to 5 (“very good”).

Weekly SI and suicide attempt were ascertained using the LIFE Self-Injurious/Suicidal Behavior Scale (see Goldstein et al., 2012 for details). SI severity was scored according to the following scale: 0=Not at all, 1=Slight (passive thoughts of death), 2=Mild (occasional thoughts of suicide without specific method), 3=Moderate (often thinks of suicide and has thought of specific method), 4=Severe (often thinks of suicide and has thought of or mentally rehearsed a specific plan), 5=Extreme (has made preparations for potentially serious suicide attempt). All self-injurious behaviors were also prospectively assessed. The intent to die and medical threat for each self-injurious behavior were rated per the K-SADS-P Depression Scale (Chambers et al., 1985), ranging from 1 (none), to 6 (extreme, careful planning, every expectation of death) for intent and 1 (no danger) to 7 (death) for medical threat. In line with the guidelines provided by the Columbia-Suicide Severity Rating Scale (Posner et al., 2010), we defined suicide attempt as a self-injurious behavior for which there is evidence that the person intended at some level to kill him or herself, or any highly lethal self-injurious behavior that is clearly not an accident. Therefore, all self-injurious acts with intent rated as “only minimal intent” (scored at a 2) or greater, and all self-injurious acts with “severe” medical threat (scored at a 5) or greater, were considered a suicide attempt for the present analyses.

## Statistical Analysis

We estimated four separate models to address the research questions described above. First, to analyze the relationship quality variables as predictors of SI, we fit a mixed-effects ordinal regression model to the full sample (N=386). Then, to analyze the same set of variables as predictors of suicide attempt, we fit a mixed-effects logistic regression model on the subset of the sample who endorsed SI at some point during follow-up (N=265). In addition to the main effect models, we estimated interaction models to examine whether the effect of recent fluctuations in relationship quality varies across levels of overall average relationship quality, and whether the effects of either component of relationship quality varied by sex or age. Listwise deletion was used for missing data<sup>2</sup>.

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<sup>2</sup>In both the SI and attempts data sets, only the relationship quality variables had a small amount of missing values. Average parent relationship quality had n=67 (<0.4%) missing observations in the SI data and n=69 (<0.5%) in the attempts data; recent parent relationship quality had n=1,059 (6.1%) missing observations in the SI data and n=969 (7%) in the attempts data; and recent friend

In both models, each data point represented a three-month period<sup>3</sup> from a single participant. In the ideation model, we took the maximum SI score over each interval. In the attempts model, the presence or absence of an attempt during each interval was dichotomized. Models were estimated within a Bayesian multilevel modeling framework (Gelman et al., 2013) using the brms software package (P. C. Bürkner, 2017). Complete model details, including syntax and output, are available as part of the supplemental materials (available online at <https://osf.io/rtz7g/>).

Central to our research hypotheses were four predictors describing different aspects of the quality of participants' relationships. Two variables described participants' relationships with their parents and the other two described participants' relationships with their friends. Each of these relationship types was decomposed into a stable, between-person component—which represents each participants' average relationship quality across time--and a varying, within-person component—which represents how much participants deviate from their overall average relationship quality during a three-month interval. We created the average relationship quality variables by averaging each participants' parent and friend relationship quality ratings over all time points. For the recent relationship quality variables, since each data point represents three months and the relationship quality variables were rated on a monthly basis, we first computed the average relationship quality for each three-month interval and then computed the difference between the three-month average and the participants' overall average. Thus, the recent relationship quality variables capture deviations from participant-specific averages. To ease model convergence and interpretation, all relationship quality variables were z-scored.

Our models also included numerous time-variant and time-invariant covariates. Time-invariant covariates were participant sex, race, family psychiatry history, family SES, and parental relationship status (together or separated). Time-varying covariates were participant age and psychopathology.

Psychopathology was coded in two steps. First, we grouped the psychiatric disorders into categories of psychopathology consistent with previous research (Krueger et al., 2018): internalizing disorders (any Anxiety Disorder, Major Depressive Episode, or Post-Traumatic Stress Disorder [PTSD]), externalizing disorders (any Substance Use Disorder [SUD], Attention-Deficit Hyperactivity Disorder [ADHD], Conduct Disorder [CD], or Oppositional Defiant Disorder [ODD]), and any thought disorder (psychosis). Then, for each category, we used dummy codes to indicate the presence of full threshold symptoms, where 1=full threshold symptoms for at least one of the disorders in the category (scoring a 5 or 6 on the PSR, as noted above) and 0 if otherwise. We used an ordinal rating to capture both hypomanic and manic mood states (where 0=euthymic, 1=hypomanic symptoms, and 2=manic symptoms).

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relationship quality had n=104 (0.6%) missing observations in the SI data and n=68 (<0.5%) in the attempts data. All missing data patterns were MAR.

<sup>3</sup>Since our primary dependent and independent variables were assessed on different time frames (weeks vs. months, respectively), the shortest time interval that we could cleanly merge these variables was three months.

Family psychiatric history was similarly grouped into dummy codes based on availability: internalizing disorder (Major Depressive Disorder or any Anxiety Disorder), externalizing disorder (any SUD, ADHD, or CD), any bipolar disorder, and any thought disorder (schizophrenia or psychosis). We also included a dummy code for any family history of suicide. The age and SES variables were grand-mean centered; the dummy codes were left uncentered.

In both models, we included random slopes for all time-varying predictors (Barr, Levy, Scheepers, & Tily, 2013). We accounted for the categorical nature of the SI outcome variable using the adjacent-category ordered categorical distributional family and a logit link function (P.-C. Bürkner & Vuorre, 2019), and accounted for the binary nature of the attempts outcome variable using the Bernoulli distributional family and a logit link function (Bergtold, Spanos, & Onukwugha, 2010). We selected weakly informative priors for all model parameters; given that all variables were either z-scores or dummy codes, we could safely assume that most model parameters would take on values between  $-5$  and  $5$ . Thus, we used normal priors ( $\mu=0, \sigma=1$ ) for all regression coefficients to apply light regularization, Student\_t priors ( $\nu=3, \mu=0, \sigma=2$ ) for all intercepts, positive-half Student\_t priors ( $\nu=3, \mu=0, \sigma=1$ ) for all standard deviations (since these parameters cannot be negative), and lkj priors ( $\eta=1$ ) for the random effects correlation matrix.

The models were estimated using Markov Chain Monte Carlo (MCMC) via the No-U-Turn Sampler algorithm (Hoffman & Gelman, 2014); this algorithm converges quickly, even for high-dimensional models, and eliminates the need for any hand-tuning. For each model, eight Markov chains were used, each with 1250 burn-in iterations and 1250 inference iterations; this setup yielded a total of 10,000 posterior samples. To interpret the results, we summarized the posterior distributions using medians and 95% highest density intervals (HDIs; Kruschke & Liddell, 2018). HDIs represent the 95% most plausible values for a parameter, given the data and model. Finally, we calculated directional probability (pd) values for each parameter, which can be interpreted as the probability that the parameter value is strictly positive or negative (Makowski, Ben-Shachar, & Lüdtke, 2019). Although we emphasize direct interpretation of the HDIs, we describe parameters with pd values greater than or equal to 95% as “significant” and those with pd values greater than or equal to 90% as “suggestive.”

## Results

### Descriptive results

Summary statistics for all time-variant and time-invariant variables are provided in Table 1. For the ideation models, there were a total of 17,224 observations nested within 386 participants. Over two-thirds (68.7%) of participants endorsed “slight” SI (akin to passive death wish) or worse at least once during follow-up. This subsample of ideators ( $N=265$ ) constituted our sample for the attempts analyses. There were a total of 220 observations that included at least one suicide attempt, and 41.5% of those who endorsed SI made at least one suicide attempt during follow-up. Across all participants, overall average relationship quality was between “fair” and “good” for parent and friend domains.



### Model convergence and fit

All models converged without issues as evidenced by visual inspection of the trace plots, high effective sample sizes (values for the ideation models ranged from 3,069 to 18,759 and attempt models ranged from 1,130 to 15,516), and  $\hat{R}$  values close to 1.000 (values for the fixed effects ranged from 0.999 to 1.003 across all models). Posterior predictive checks showed good fit to the data for all models. To view the posterior predictive checks and for additional details about model comparison for the main effects and interaction models see the online supplement.

### Suicidal Ideation results

Results for main and interaction effects of the SI models are provided in Table 2. Effect sizes for overall average relationship quality with parents (median  $\beta = -0.33$ , 95% HDI  $[-0.54, -0.11]$ ) and with friends (median  $\beta = -0.33$ , 95% HDI  $[-0.55, -0.11]$ ) were more than three times larger than those of recent relationship quality with parents (median  $\beta = -0.10$ , 95% HDI  $[-0.19, -0.03]$ ) and with friends (median  $\beta = -0.06$ , 95% HDI  $[-0.15, 0.03]$ ). Further inspection of the posterior distributions revealed that these effects were dependably negative. That is, within the confines of our data and models, there was a >99% probability that overall parent relationship quality, overall friend relationship quality, and recent parent relationship quality were negatively associated with SI severity, and a >92% probability that recent friend relationship quality was negatively associated with SI severity.

Three interaction effects reached levels that can be described as “significant,” with greater than 95% probability of their posterior distributions being strictly negative or positive. Two of the three interactions included friend relationship quality and sex. As can be seen in Figure 1, the association between average friend relationship quality and SI was stronger in males (panel A), but the association between recent friend relationship quality and SI was stronger in females (panel B). Additionally, the effect of worsening recent friend relationship quality varied across levels of average parent relationship quality (median  $\beta = -0.09$ , 95% HDI  $[-0.18, 0.01]$ ; see Figure 2, panel A).

### Suicide attempts results

Results for main and interaction effects of the attempts models are provided in Table 3. Main effects for overall average relationship quality with parents (median  $\beta = -0.15$ , 95% HDI  $[-0.42, 0.12]$ ) and with friends (median  $\beta = -0.16$ , 95% HDI  $[-0.42, 0.10]$ ) were appreciably smaller than in the SI main effects model, and their posterior distributions were not consistently concentrated over negative values. The main effect for recent friend relationship quality was small (median  $\beta = -0.09$ ) and, like the overall average relationship quality variables, the posterior distribution was not consistently negative (95% HDI  $[-0.27, 0.10]$ ). Only the main effect of worsening recent relationship quality with parents can be described as “significant.” That is, having a three-month period of better (or poorer) relationship quality with one’s parents, relative to one’s own baseline level of relationship quality, was associated with lower (or higher) probability of a suicide attempt during that period (median  $\beta = -0.15$ , 95% HDI  $[-0.31, 0.01]$ ).

Two interaction effects reached levels which can be described as constituting “suggestive” or “significant” evidence. First, the effect of worsening recent relationship quality with friends varied across levels of overall average relationship quality with friends (median  $\beta = -0.17$ , 95% HDI [-0.36, 0.02]; Figure 2, panel B). Second, overall average relationship quality with friends had a stronger association with suicide attempt for males than females (median  $\beta = 0.38$ , 95% HDI [-0.14, 0.91]; Figure 1, panel C). However, the wide 95% HDI interval indicates a large degree of uncertainty around this parameter estimate.

## Discussion

To our knowledge, this is the first study to longitudinally examine how relationship quality in parent and friend domains are longitudinally associated with SI and suicide attempt among a sample of youth with BD. Importantly, we investigated relationship quality as a distal and proximal risk factor by decomposing the relationship quality variables into stable (i.e. overall average) and varying components (i.e. recent). And, in line with recent directions in the field of suicidology (Klonsky & May, 2014), we examined whether these different aspects of relationship quality differentiate ideators from non-ideators and attempters from ideators, while controlling for clinically significant time-varying and time-invariant covariates. Finally, we examined these questions using a Bayesian multilevel modeling approach, which allowed us to fit models that would likely have had difficulty if we used a traditional frequentist approach (Wagenmakers et al., 2018).

While cross-sectional studies of youth with BD have established that poorer relationship quality is associated with increased risk of STBs (Algorta et al., 2011; Goldstein et al., 2009; Sewall et al., 2020; Weinstein et al., 2015), our study extends these findings substantially by elucidating how different aspects of relationship quality may act as a distal and/or proximal risk factor for SI and/or attempts among youth with BD. Specifically, we found that those with poorer overall average relationship quality in either parent or peer domains were generally at higher risk of SI over time, and that recent periods of worse-than-average relationship quality, particularly with parents, may be a time-sensitive indicator of increased SI risk. Importantly, these associations were robust to key distal (i.e. family psychiatric history) and proximal (i.e. current psychopathology) covariates, suggesting that recent and overall relationship quality with parents/friends may be longitudinally associated with SI regardless of current psychopathology or family psychiatric history.

Aside from recent relationship quality with parents, we found that relationship quality played less of a role in differentiating attempters from ideators (i.e. the attempts main effects model) than they did in differentiating ideators from non-ideators (i.e. the SI main effects model). The medians of the posterior distributions for the relationship quality variables were consistently negative, providing some evidence that poorer overall average or worse-than-average relationship quality with parents/friends are associated with slightly increased risk of suicide attempt. However, only the posterior distribution for recent relationship quality with parents was overwhelmingly negative (as indicated by a pd value >95%) and, thus, was the only relationship quality main effect to surpass our a priori threshold for (un)certainty. These results suggest that worsening recent relationship quality with parents may be a proximal indicator of increased risk for a suicide attempt among youth with BD.

Experiencing recent decrements in parental and/or peer relationship quality may increase risk of STBs in direct and indirect ways for youth with BD. Directly, the distress associated with increased interpersonal discord may itself trigger increased STBs. This aligns with prior work which found that proximal aspects of interpersonal conflict, such as an argument or fight, are associated with suicidal behavior among youth (Bridge et al., 2006). At the same time, worsening relationship quality with parents and/or peers may increase risk of STBs indirectly, as potentially crucial sources of emotional and social support are undermined and, therefore, impede positive coping.

In line with the stress-diathesis model of suicidal behavior (Hawton & van Heeringen, 2009) and the evidence that interpersonal risk factors for suicide have important developmental moderators (King & Merchant, 2008), we examined whether the effects of recent and average relationship quality vary by sex and age. In both the SI and attempts models, we found that the effects of recent and average relationship quality did not depend on age. However, we did find evidence suggesting that sex may play an important role in the association between friend relationship quality and STBs. Specifically, the distal association between average friend relationship quality and SI severity and attempts was stronger for males, but the proximal association between recent friend relationship quality and SI severity was stronger for females.

In addition to developmental moderators, we examined whether the proximal associations of recent relationship quality with STBs are buffered or amplified by the distal effect of overall average relationship quality. For attempts, we found that the effect of worsening recent relationship quality with friends was strongest for those who had better overall average *friend* relationship quality. Similarly, for SI, we found that the effect of worsening recent relationship quality with friends was associated with increased SI severity for youth who had better overall average *parent* relationship quality. However, there were some counter-intuitive findings in these interaction effects. Specifically, for those with poorer average parent relationship quality, the effect of improving recent friend relationship quality was associated with slightly increased risk of SI. Given the limited range of the relationship quality measures (five categories ranging from “very poor” to “very good”) it is likely that these counter-intuitive findings can be explained by floor effects (see limitations below).

Although the effects discussed above surpassed our a priori thresholds for “suggestive” or “significant” evidence, it is important to also consider the magnitudes of the effects for the relationship quality variables and how they compare with the other distal and proximal covariates included in the models. Notably, the presence of full-threshold internalizing psychopathology during a three-month interval was, by far, the strongest proximal predictor of SI severity (median  $\beta = 1.51$ , 95% HDI [1.24, 1.78]) and attempts (median  $\beta = 1.63$ , 95% HDI [1.07, 2.18])—roughly 10 to 15 times the size of the proximal effect of having a three-month interval of worse-than-average (1 standard deviation below the person-mean) parent relationship quality. While the potency of current psychopathology, particularly depression, as a risk factor for STBs among youth with BD is well-established (Schaffer et al., 2015), this comparison helps to understand the relationship quality effect sizes in their proper context.

The results of this study need to be taken in the context of the following limitations. First, the findings related to recent relationship quality may be hindered by floor effects. That is, among those with “poor” or “very poor” overall average relationship quality, their monthly relationship quality scores are already anchored toward the floor of the measure, so there is limited opportunity to report worsening relationship quality. Second, our three-month time interval may not be ideal when attempting to identify proximal risk factors. Third, despite the prospective cohort, the data collected through the LIFE (via a method similar to TLFB) were based on retrospectively recalled intervals averaging 9 months in duration and, therefore, are subject to recall bias. Finally, the majority of participants were self-reported White (reflecting the race distribution of the general population in the metropolitan areas surrounding each study site at the time of original enrollment), and were recruited from clinical settings, which may limit the generalizability of the results to other race/ethnicity groups and non-clinical settings.

## Conclusion

In conclusion, these findings offer important clinical insight into the importance of peer and family relationship quality as risk factors for STBs among youth with BD. Poorer average relationship quality with peers and/or parents represents a distal risk factor for SI but not suicide attempts. Additionally, recent periods of worsening relationship quality with parents may be a time-sensitive indicator of increased risk for SI or suicide attempt. In addition to assessing for and treating other potent risk factors for STBs, such as current psychopathology, clinicians treating youth with BD should attend to the quality of youths’ relationships with parents and friends, both overall and recently. Risk assessment and treatment targeting these interpersonal factors may help to identify and mitigate risk of STBs.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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## CONFLICT OF INTERESTS STATEMENT

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## Abbreviations:

|             |                                 |
|-------------|---------------------------------|
| <b>BD</b>   | Bipolar disorder                |
| <b>STBs</b> | suicidal thoughts and behaviors |
| <b>SI</b>   | suicidal ideation               |

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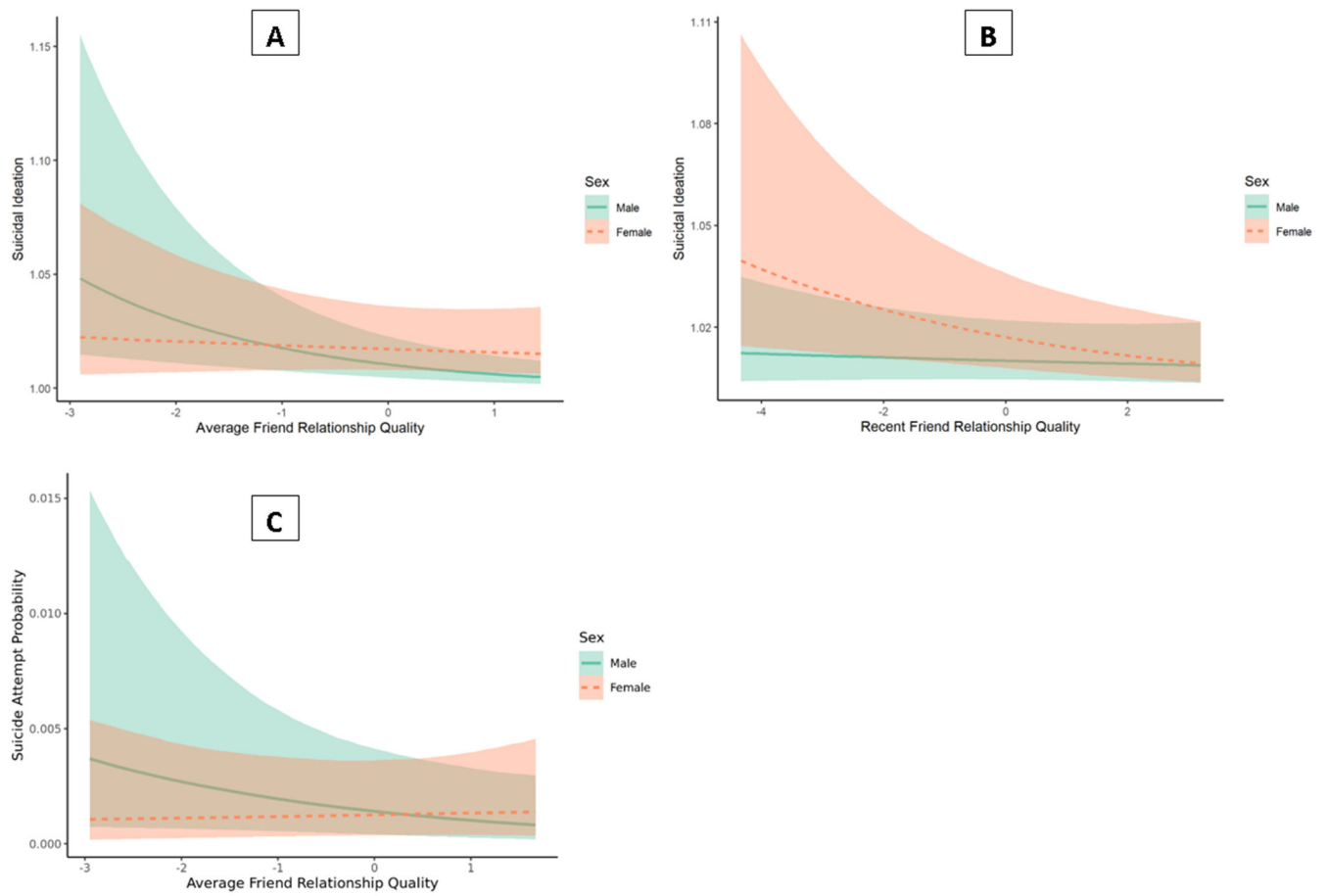
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**KEY POINTS**

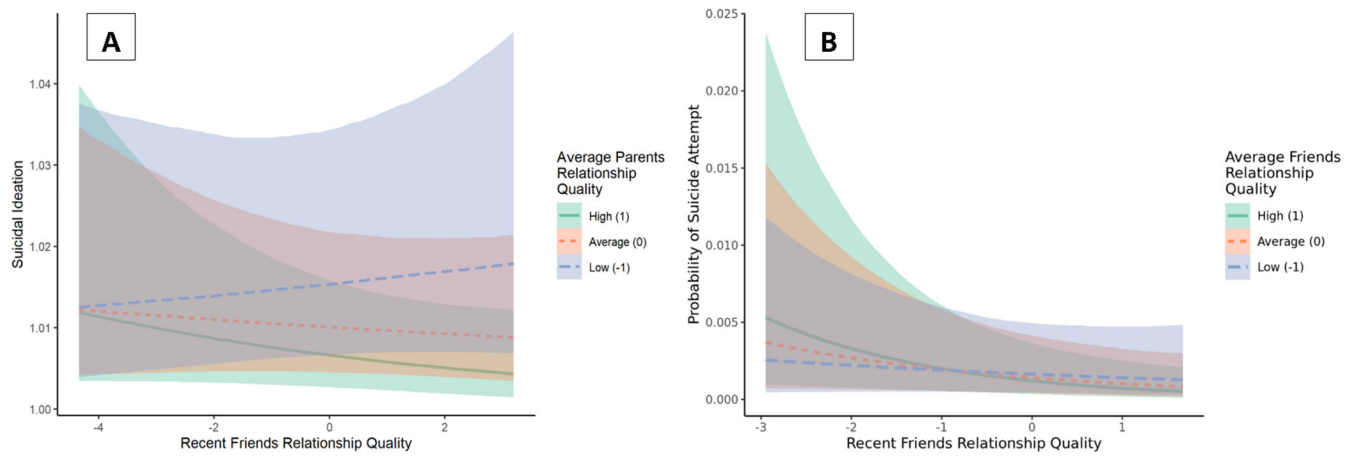
- Youth with bipolar disorder are at high risk for suicidal ideation (SI) and attempts (SA) and frequently experience interpersonal impairment, which is a risk factor for suicide.
- This is the first study to examine the longitudinal associations between relationship quality in family/peer domains and SI and SA among youth with bipolar disorder.
- Worse overall average relationship quality with peers and/or parents may act as a distal risk factor for SI but not SA. Additionally, recent periods of worsening relationship quality with parents may be a time-sensitive indicator of increased risk for SI or SA.
- Clinicians treating youth with bipolar disorder should carefully attend to the quality of youths' relationships with parents and friends, both overall and recently. Assessment and treatment targeting these interpersonal factors may help to identify and mitigate risk of suicide.





**Figure 1.**

Interaction plots displaying the association between friend relationship quality and suicidal ideation (panels A and B) or attempt (panel C) moderated by sex. For the average relationship quality variable, higher scores reflect better overall relationship quality. For the recent relationship quality variable, positive scores reflect recent relationship quality that is better than average, while negative scores reflect the opposite. Shaded ribbons represent 95% credibility intervals. *Note:* y-axis for panels A and B is the predicted level of suicidal ideation using the scale (0-5) of the raw suicidal ideation variable.



**Figure 2.**

Interaction plots displaying the association between recent relationship quality with friends and suicidal ideation (panel A) or attempt (panel B) moderated by different levels of average relationship quality with parents or friends. For the recent friends relationship quality variable, positive scores reflect recent relationship quality that is better than average, while negative scores reflect the opposite. For the average relationship quality variables, higher scores reflect better overall relationship quality. Shaded ribbons represent 95% credibility intervals. *Note:* y-axis for panel A is the predicted level of suicidal ideation using the scale (0-5) of the raw suicidal ideation variable.

**Table 1.**

Descriptive statistics for time-varying and time-invariant variables

| Variable                                 | Participants (N=386) |               | Observations (n=17,224) |               |
|--|----------------------|---------------|-------------------------|---------------|
|  | Freq. or Mean        | Percent or SD | Freq.                   | Percent or SD |
| <b><i>Time-Variant</i></b>               |                      |               |                         |               |
| Suicidal Ideation                        |                      |               |                         |               |
| None                                     | 384                  | 99.48%        | 14,328                  | 83.19%        |
| Slight                                   | 236                  | 61.14%        | 1,774                   | 10.30%        |
| Mild                                     | 154                  | 39.90%        | 555                     | 3.22%         |
| Moderate                                 | 99                   | 25.65%        | 322                     | 1.87%         |
| Severe                                   | 85                   | 22.02%        | 179                     | 1.04%         |
| Extreme                                  | 43                   | 11.14%        | 66                      | 0.38%         |
| Suicide Attempt <sup>a</sup>             | 110                  | 41.51%        | 220                     | 1.59%         |
| Internalizing Disorder                   | 320                  | 82.90%        | 7,066                   | 41.02%        |
| Externalizing Disorder                   | 324                  | 83.94%        | 10,088                  | 58.57%        |
| Thought Disorder                         | 83                   | 21.50%        | 812                     | 4.71%         |
| Hypomania                                | 169                  | 43.78%        | 795                     | 4.62%         |
| Mania                                    | 130                  | 33.68%        | 463                     | 2.69%         |
| Parent Relationship Quality <sup>b</sup> | 3.67                 | 0.79          | --                      | 0.69          |
| Friend Relationship Quality <sup>b</sup> | 3.80                 | 0.90          | --                      | 0.78          |
| <b><i>Time-Invariant</i></b>             |                      |               |                         |               |
| Age at baseline                          | 14.49                | 3.66          | --                      | --            |
| Sex (Female)                             | 181                  | 46.89%        | --                      | --            |
| Race (White)                             | 317                  | 82.12%        | --                      | --            |
| Family SES                               | 3.46                 | 1.21          | --                      | --            |
| Parents Living Together                  | 164                  | 42.49%        | --                      | --            |
| Family History: Internalizing Disorder   | 327                  | 84.72%        | --                      | --            |
| Family History: Externalizing Disorder   | 265                  | 68.65%        | --                      | --            |
| Family History: Bipolar Disorder         | 162                  | 41.97%        | --                      | --            |
| Family History: Thought Disorder         | 51                   | 13.21%        | --                      | --            |
| Family History: Suicide                  | 191                  | 49.48%        | --                      | --            |

Note.

<sup>a</sup>These figures were computed on subset of full sample who endorsed suicidal ideation during follow-up (N=265 participants and n=13,838 overall observations).

<sup>b</sup>Raw relationship quality variables before decomposition into state/trait components; the between-person mean and SD reflect the overall average trait relationship quality across all participants; the overall SD reflects participants' average within-person deviation (state) from their trait relationship quality.

**Table 2.**

Fixed effects from the mixed-effects ordinal regression model predicting suicidal ideation (N=386)

| Variable                                      | Model 1: Main Effects |                | Model 2: Interaction Effects |                |
|---|-----------------------|----------------|------------------------------|----------------|
|   | Median                | 95% HDI        | Median                       | 95% HDI        |
| (Intercept 1)                                 | 4.29 *                | [3.53, 5.00]   | 4.50 *                       | [3.70, 5.28]   |
| (Intercept 2)                                 | 4.82 *                | [4.10, 5.60]   | 5.11 *                       | [4.32, 5.94]   |
| (Intercept 3)                                 | 4.76 *                | [4.02, 5.54]   | 5.08 *                       | [4.30, 5.93]   |
| (Intercept 4)                                 | 5.21 *                | [4.46, 6.02]   | 5.56 *                       | [4.74, 6.40]   |
| (Intercept 5)                                 | 5.87 *                | [5.06, 6.67]   | 6.26 *                       | [5.40, 7.13]   |
| <i>Relationship Quality Variables</i>         |                       |                |                              |                |
| Recent Parent RQ                              | -0.10 *               | [-0.19, -0.03] | -0.08                        | [-0.21, 0.05]  |
| Recent Friend RQ                              | -0.06 †               | [-0.15, 0.03]  | -0.04                        | [-0.19, 0.10]  |
| Average Parent RQ                             | -0.33 *               | [-0.54, -0.11] | -0.41 *                      | [-0.74, -0.07] |
| Average Friend RQ                             | -0.33 *               | [-0.55, -0.11] | -0.52 *                      | [-0.83, -0.22] |
| <i>Current Full Threshold Psychopathology</i> |                       |                |                              |                |
| Internalizing Disorder                        | 1.51 *                | [1.24, 1.78]   | 1.57 *                       | [1.29, 1.84]   |
| Externalizing Disorder                        | 0.47 *                | [0.23, 0.70]   | 0.49 *                       | [0.26, 0.73]   |
| Hypomania/Mania                               | 0.03                  | [-0.22, 0.27]  | 0.49 *                       | [0.09, 0.92]   |
| Thought Disorder                              | 0.55 *                | [0.13, 0.96]   | 0.09                         | [-0.15, 0.33]  |
| <i>Family History of Psychopathology</i>      |                       |                |                              |                |
| Family History: Internalizing Disorder        | 0.47 †                | [-0.15, 1.05]  | 0.46 †                       | [-0.16, 1.12]  |
| Family History: Externalizing Disorder        | -0.01                 | [-0.43, 0.44]  | 0.00                         | [-0.47, 0.48]  |
| Family History: Bipolar Disorder              | 0.03                  | [-0.38, 0.42]  | 0.05                         | [-0.37, 0.49]  |
| Family History: Thought Disorder              | -0.34                 | [-0.90, 0.18]  | -0.38 †                      | [-0.93, 0.17]  |
| Family History: Suicide                       | 0.32 †                | [-0.06, 0.72]  | 0.35 †                       | [-0.08, 0.75]  |
| <i>Sociodemographics</i>                      |                       |                |                              |                |
| Age   | -0.06 *               | [-0.09, -0.03] | -0.07 *                      | [-0.11, -0.04] |
| Sex (Female)                                  | 0.45 *                | [0.08, 0.82]   | 0.50 *                       | [0.09, 0.89]   |
| Race (White)                                  | -0.49 *               | [-0.95, 0.00]  | -0.49 *                      | [-0.99, 0.02]  |
| Family SES                                    | 0.22 *                | [0.06, 0.40]   | 0.23 *                       | [0.05, 0.42]   |
| Parents Living Together                       | 0.04                  | [-0.36, 0.42]  | 0.10                         | [-0.32, 0.52]  |
| <i>Interactions</i>                           |                       |                |                              |                |
| Average Parent RQ *Recent Parent RQ           |                       |                | -0.02                        | [-0.10, 0.07]  |
| Average Parent RQ *Recent Friend RQ           |                       |                | -0.09 *                      | [-0.18, 0.01]  |
| Average Friend RQ *Recent Parent RQ           |                       |                | 0.04                         | [-0.04, 0.13]  |
| Average Friend RQ *Recent Friend RQ           |                       |                | -0.05                        | [-0.15, 0.04]  |
| Average Parent RQ *Age                        |                       |                | -0.01                        | [-0.04, 0.02]  |
| Average Friend RQ *Age                        |                       |                | -0.01                        | [-0.04, 0.03]  |
| Recent Parent RQ *Age                         |                       |                | 0.01                         | [-0.01, 0.02]  |
| Recent Friend RQ *Age                         |                       |                | 0.00                         | [-0.02, 0.03]  |
| Average Parent RQ *Sex (Female)               |                       |                | -0.01                        | [-0.43, 0.43]  |

| Variable                        | Model 1: Main Effects |         | Model 2: Interaction Effects |               |
|---------------------------------|-----------------------|---------|------------------------------|---------------|
|                                 | Median                | 95% HDI | Median                       | 95% HDI       |
| Average Friend RQ *Sex (Female) |                       |         | 0.43 *                       | [0.00, 0.88]  |
| Recent Parent RQ *Sex (Female)  |                       |         | -0.02                        | [-0.17, 0.12] |
| Recent Friend RQ *Sex (Female)  |                       |         | -0.15 *                      | [-0.32, 0.01] |

*Note.* Effect estimates (Medians and 95% HDIs) are presented as log-odds;

\* = Significant,

† = Suggestive

HDI=Highest Density Interval, RQ=Relationship Quality.

**Table 3.**

Fixed effects from the mixed-effects logistic regression model predicting suicide attempt (N=265)

| Variable                                      | Model 1: Main Effects |                  | Model 2: Interaction Effects |                  |
|---|-----------------------|------------------|------------------------------|------------------|
|   | Median                | 95% HDI          | Median                       | 95% HDI          |
| (Intercept)                                   | -6.41                 | * [-7.52, -5.27] | -6.55                        | * [-7.77, -5.45] |
| <i>Relationship Quality Variables</i>         |                       |                  |                              |                  |
| Recent Parent RQ                              | -0.15                 | * [-0.31, 0.01]  | -0.19                        | † [-0.42, 0.05]  |
| Recent Friend RQ                              | -0.09                 | [-0.27, 0.10]    | -0.15                        | [-0.40, 0.10]    |
| Average Parent RQ                             | -0.15                 | [-0.42, 0.12]    | -0.02                        | [-0.41, 0.38]    |
| Average Friend RQ                             | -0.16                 | [-0.42, 0.10]    | -0.33                        | * [-0.69, 0.04]  |
| <i>Current Full Threshold Psychopathology</i> |                       |                  |                              |                  |
| Internalizing Disorder                        | 1.63                  | * [1.07, 2.18]   | 1.63                         | * [1.06, 2.20]   |
| Externalizing Disorder                        | 0.42                  | * [-0.06, 0.92]  | 0.47                         | * [-0.02, 0.95]  |
| Hypomania/Mania                               | -0.06                 | [-0.52, 0.32]    | -0.06                        | [-0.52, 0.32]    |
| Thought Disorder                              | 0.55                  | * [-0.07, 1.17]  | 0.58                         | † [-0.10, 1.20]  |
| <i>Family History of Psychopathology</i>      |                       |                  |                              |                  |
| Family History: Internalizing Disorder        | 0.26                  | [-0.60, 1.30]    | 0.24                         | [-0.59, 1.11]    |
| Family History: Externalizing Disorder        | 0.21                  | [-0.39, 0.82]    | 0.21                         | [-0.41, 0.85]    |
| Family History: Bipolar Disorder              | 0.14                  | [-0.37, 0.64]    | 0.14                         | [-0.38, 0.67]    |
| Family History: Thought Disorder              | -0.61                 | * [-1.29, 0.06]  | -0.65                        | * [-1.34, 0.05]  |
| Family History: Suicide                       | 0.54                  | * [0.06, 1.05]   | 0.53                         | * [0.02, 1.06]   |
| <i>Sociodemographics</i>                      |                       |                  |                              |                  |
| Age   | -0.02                 | [-0.06, 0.03]    | -0.02                        | [-0.07, 0.02]    |
| Sex (Female)                                  | -0.12                 | [-0.59, 0.36]    | -0.11                        | [-0.60, 0.38]    |
| Race (White)                                  | -0.67                 | * [-1.23, -0.13] | -0.72                        | * [-1.30, -0.14] |
| Family SES                                    | 0.17                  | † [-0.04, 0.38]  | 0.19                         | * [-0.02, 0.41]  |
| Parents Living Together                       | -0.19                 | [-0.70, 0.33]    | -0.15                        | [-0.68, 0.39]    |
| <i>Interactions</i>                           |                       |                  |                              |                  |
| Average Parent RQ * Recent Parent RQ          |                       |                  | 0.00                         | [-0.18, 0.19]    |
| Average Parent RQ * Recent Friend RQ          |                       |                  | 0.03                         | [-0.15, 0.20]    |
| Average Friend RQ * Recent Parent RQ          |                       |                  | 0.03                         | [-0.14, 0.21]    |
| Average Friend RQ * Recent Friend RQ          |                       |                  | -0.17                        | * [-0.36, 0.02]  |
| Average Parent RQ * Age                       |                       |                  | -0.02                        | [-0.06, 0.02]    |
| Average Friend RQ * Age                       |                       |                  | 0.00                         | [-0.04, 0.05]    |
| Recent Parent RQ * Age                        |                       |                  | 0.00                         | [-0.03, 0.03]    |
| Recent Friend RQ * Age                        |                       |                  | -0.01                        | [-0.04, 0.02]    |
| Average Parent RQ * Sex (Female)              |                       |                  | -0.31                        | [-0.84, 0.20]    |
| Average Friend RQ * Sex (Female)              |                       |                  | 0.38                         | † [-0.14, 0.91]  |
| Recent Parent RQ * Sex (Female)               |                       |                  | 0.14                         | [-0.16, 0.46]    |
| Recent Friend RQ * Sex (Female)               |                       |                  | 0.01                         | [-0.29, 0.34]    |

*Note.* Effect estimates (Medians and 95% HDIs) are presented as log-odds;

\* = Significant,

<sup>†</sup> = Suggestive;

HDI=Highest Density Interval, RQ=Relationship Quality.

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