

Original Research

Loneliness and Problematic Social Network Use Among Rural Left-Behind Children: A Three-Wave Moderated Mediation Study of Fear of Missing Out and Self-Control

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Abstract

Background: Problematic social network use (PSNU) has become an increasingly relevant concern for child well-being because it is characterized by excessive, intrusive, and poorly regulated engagement with social networking platforms. Rural left-behind children may be particularly vulnerable due to prolonged parent-child separation and alternative caregiving arrangements can weaken daily emotional support and increase reliance on digitally mediated social interactions. This study examined whether fear of missing out (FoMO) mediates the association between loneliness and PSNU and whether self-control moderates this pathway. **Methods:** A three-wave questionnaire survey was conducted among 620 rural left-behind children in China, with two-month intervals between consecutive waves. The time-lagged design was adopted to align measurement with the hypothesized sequence linking loneliness, FoMO, and PSNU and to reduce same-occasion response bias. Loneliness and self-control were measured at Time 1, FoMO at Time 2, and PSNU at Time 3. Reliability analysis, confirmatory factor analysis, descriptive statistics, correlation analysis, subgroup descriptive comparisons, and time-lagged moderated mediation analyses were conducted. Gender and age were included as covariates. **Results:** Loneliness was positively associated with subsequent FoMO and subsequent PSNU. FoMO was positively associated with later PSNU and significantly mediated the time-lagged association between loneliness and PSNU. Self-control negatively predicted PSNU and significantly moderated the FoMO-PSNU association, such that the association was stronger among children with lower levels of self-control. In addition, the conditional indirect association between loneliness and PSNU through FoMO was also stronger at lower levels of self-control. The measurement model showed acceptable fit, and all four constructs demonstrated satisfactory internal consistency. **Conclusions:** For rural left-behind children, problematic social network use appears to be closely associated with loneliness, FoMO, and self-control. Prevention efforts may be more effective when they integrate emotional support, consistent parent-child communication, school connectedness, digital literacy education, and self-control training, rather than focusing solely on screen-time restriction. Given the time-lagged observational design, the findings should be interpreted as temporally ordered associations and not as evidence of definitive causal effects.

Keywords: rural left-behind children; problematic social network use; loneliness; fear of missing out; self-control; digital well-being

1. Introduction

Digital media have become deeply embedded in children's everyday lives. Social networking platforms provide opportunities for communication, self-expression, peer interaction, information acquisition, and emotional connection. For children living in geographically or emotionally constrained environments, online social networking may also function as an important channel for maintaining relationships and compensating for limited offline social resources. At the same time, platform affordances such as constant accessibility, real-time feedback, visible social comparison, and continuous updates may increase the likelihood of excessive checking, difficulty disengaging, and intrusive patterns of use. Problematic social network use (PSNU) generally refers to excessive and poorly controlled engagement with social networking platforms

that interferes with daily functioning, psychological adjustment, study, rest, or offline relationships (Andreassen and Pallesen, 2014). In child populations, PSNU is therefore more informative than screen time alone because it captures whether online engagement has begun to intrude into everyday functioning and relationships.

This issue is particularly salient for rural left-behind children in China. Due to long-term labor migration by one or both parents, many rural children grow up separated from their parents and are cared for primarily by grandparents, one remaining parent, relatives, or other guardians. Although parental migration may improve family economic resources, prolonged parent-child separation can reduce daily companionship, emotional responsiveness, parental supervision, and perceived relational security. Recent Chinese evidence suggests that left-behind children remain vul-



nerable to loneliness, psychological symptoms, social anxiety, and relational difficulties, and that parent-child communication and online social capital are relevant to their socio-emotional adjustment (Liu et al., 2024; Qi and Wu, 2024; Xiong et al., 2024; Zhang et al., 2024). In this context, social networking platforms may serve a dual function. They can provide opportunities to maintain contact with migrant parents and peers, but they may also increase vulnerability to problematic use when offline belongingness needs remain unmet.

The present study is grounded primarily in Compensatory Internet Use Theory (CIUT), which proposes that individuals may turn to online activities to alleviate negative emotions, cope with offline difficulties, or compensate for unmet psychological needs (Kardefelt-Winther, 2014). From this perspective, problematic online behavior can arise when digital interaction becomes a convenient way to manage distress rooted in real-life relational or emotional deprivation. For rural left-behind children, prolonged parental absence and limited emotional support may increase loneliness. Loneliness is a subjective and distressing experience arising from the perceived discrepancy between desired and actual social relationships (Qualter et al., 2015). During childhood, loneliness is consequential because the needs for belonging, acceptance, peer affiliation, and relational affirmation are developmentally salient (Laursen and Hartl, 2013). When offline relationships do not provide sufficient emotional security, children may be more likely to seek connection, recognition, and reassurance through online social networks.

Social Capital Theory and Uses and Gratifications Theory further clarify why online social networking may be psychologically meaningful for left-behind children. Social Capital Theory emphasizes that interpersonal networks provide access to emotional support, information, trust, and a sense of belonging (Lin, 2001). Online interaction can sometimes help individuals maintain weak ties, receive social feedback, and cultivate perceived belonging in networked communities (Ellison et al., 2007; Zhao et al., 2012). Uses and Gratifications Theory emphasizes that media use is motivated by needs such as information seeking, entertainment, identity expression, social interaction, and emotional support (Katz et al., 1973; Nadkarni and Hofmann, 2012). From this perspective, social networking platforms may be attractive to left-behind children not only because they are entertaining, but also because they help satisfy relational and emotional needs that are difficult to meet in everyday offline contexts. However, when these gratifications become the primary means of compensating for loneliness or relational uncertainty, ordinary use may become difficult to regulate.

Loneliness is therefore expected to be an important antecedent of later PSNU among rural left-behind children. Existing studies have linked loneliness to problematic internet use, problematic smartphone use, and other maladaptive

patterns of digital media engagement (Caplan, 2007; Li et al., 2021). In the left-behind context, this association may be especially meaningful because loneliness can reflect disrupted parent-child contact, limited emotional responsiveness, and weak everyday support rather than simply a lack of companions. Social networking platforms may become places where lonely children try to maintain relational continuity, monitor social cues, and reduce emotional deprivation. Accordingly, this study expected loneliness to be positively associated with PSNU among rural left-behind children.

Fear of missing out (FoMO) may represent a key psychological mechanism linking loneliness to PSNU. FoMO refers to a pervasive apprehension that others may be having rewarding experiences from which one is absent, accompanied by a persistent desire to remain connected and monitor social information (Przybylski et al., 2013). In social networking contexts, FoMO is reflected in repeated checking, concern about missing messages or updates, and difficulty disengaging from online interactions. Prior research has consistently shown that FoMO is associated with problematic social media use, problematic smartphone use, and excessive online checking behavior (Beyens et al., 2016; Elhai et al., 2016; Fang et al., 2026; Fioravanti et al., 2021; Servidio et al., 2024). For rural left-behind children, FoMO may be especially relevant because online interaction often carries relational significance. Missing a message from a parent, a peer response, or a social update may be experienced not merely as missing information but as missing an opportunity for connection, inclusion, or emotional confirmation.

Theoretically, FoMO can be understood as a digital manifestation of thwarted belongingness and relational insecurity. Children who experience loneliness may become more vigilant toward signs of social inclusion and exclusion. This vigilance may be amplified in online environments, where social feedback is immediate, visible, and continuously updated. For rural left-behind children, loneliness arising from reduced parental companionship and limited offline support may increase sensitivity to whether they are noticed, replied to, or included by significant others. As a result, lonely children may develop stronger FoMO, which may then encourage frequent monitoring of social networking platforms, repeated checking of notifications, and difficulty disengaging from online communication. Thus, FoMO may statistically account for part of the association between loneliness and PSNU.

However, not all children who experience FoMO necessarily develop problematic social network use. Self-control may differentiate children at higher and lower levels of risk. Self-control refers to the capacity to regulate impulses, resist immediate temptations, delay gratification, and align behavior with longer-term goals (Tangney et al., 2004). In digital contexts, self-control is particularly important because social networking platforms provide im-

mediate rewards, social feedback, and continuous opportunities for engagement. Children with lower self-control may find it more difficult to resist the urge to check messages, stop scrolling, or disengage from online interaction once FoMO has been activated. By contrast, those with higher self-control may better regulate FoMO-related impulses and prevent temporary concern about missing out from developing into persistent and intrusive patterns of use.

Although prior work has examined loneliness, FoMO, self-control, and problematic digital media use (Beyens et al., 2016; Caplan, 2007; Li et al., 2021; Servidio, 2021), several gaps remain. First, many studies have focused on general adolescent or college student samples, whereas rural left-behind children have received less attention despite their distinctive family contexts (Beyens et al., 2016; Li et al., 2021; Servidio, 2021). Second, prior research has often examined emotional vulnerability and digital behavior at a single time point, limiting the ability to clarify temporal ordering (Cole and Maxwell, 2003; Liu et al., 2024; Maxwell and Cole, 2007). Third, relatively few studies have tested whether self-control buffers the pathway from FoMO to later PSNU in vulnerable child populations (Li et al., 2021; Servidio, 2021; Wang et al., 2019). Fourth, local Chinese evidence on media use among left-behind children remains insufficiently integrated into theoretical discussions of problematic digital media use (Liu et al., 2024; Xiong et al., 2024; Zhang et al., 2024). Addressing these gaps can clarify how family separation, online relational concerns, and regulatory capacity jointly shape children's problematic social networking.

Given the hypothesized mediation process, the time-lagged design was necessary for both methodological and practical reasons. Methodologically, mediation is inherently temporal: the antecedent should be measured before the mediator and outcome, because cross-sectional mediation may conflate concurrent covariation with a process that unfolds over time and can produce biased estimates of longitudinal mediation parameters (Cole and Maxwell, 2003; Maxwell and Cole, 2007). In the present model, loneliness was conceptualized as a relatively enduring relational-emotional condition that could heighten later FoMO, which could then be associated with subsequent PSNU. Measuring loneliness and self-control at T1, FoMO at T2, and PSNU at T3 therefore allowed the analysis to examine whether the observed associations followed the theoretically proposed order rather than reflecting only same-occasion associations. The temporal separation also reduced the likelihood that the mediation pattern was driven mainly by response consistency within a single survey session. Practically, the two-month interval balanced theoretical sensitivity and school-based feasibility. It was long enough to separate emotional vulnerability, online relational concern, and problematic behavior across the school term, but short enough to limit attrition among young rural left-behind chil-

dren and to reduce the likelihood that major changes in schooling, guardianship, or parental migration status would occur between waves. Thus, the design was intended to strengthen temporal ordering without claiming definitive causality.

Building on this time-lag rationale, the present study therefore examined a three-wave time-lagged moderated mediation model among rural left-behind children in China. Loneliness and self-control were measured at Time 1, FoMO at Time 2, and PSNU at Time 3. The model tested whether FoMO mediated the time-lagged association between loneliness and PSNU and whether self-control moderated the FoMO-PSNU association. The study contributes to the literature in four ways. Theoretically, it integrates CIUT with Social Capital Theory and Uses and Gratifications Theory to explain why online social networking may become compensatory for left-behind children. Contextually, it focuses on a vulnerable rural child population whose digital behavior is embedded in parent-child separation and alternative caregiving. Methodologically, it uses a three-wave design that matches the proposed temporal sequence and controls for gender and age. Practically, it identifies emotional, digital, and regulatory indicators that can inform school-based and clinical support.

Based on the above framework, the following hypotheses were proposed:

H1. Time 1 loneliness is positively associated with Time 3 problematic social network use among rural left-behind children.

H2. Time 2 fear of missing out mediates the time-lagged association between Time 1 loneliness and Time 3 problematic social network use.

H3. Time 1 self-control moderates the association between Time 2 fear of missing out and Time 3 problematic social network use, such that this association is stronger among children with lower self-control.

H4. The indirect association between Time 1 loneliness and Time 3 problematic social network use through Time 2 fear of missing out is conditional on Time 1 self-control, such that the indirect association is stronger at lower levels of self-control.

2. Materials and Methods

2.1 Participants and Sampling Procedure

This study employed a three-wave time-lagged questionnaire design for both methodological and practical reasons. Methodologically, the hypothesized model presupposed a temporal order in which loneliness and self-control preceded FoMO and later PSNU; therefore, measuring all variables at one time point would have been less consistent with the logic of mediation and more vulnerable to same-occasion response bias (Cole and Maxwell, 2003; Maxwell and Cole, 2007). Separating the measurements also allowed FoMO to function as a temporally intermediate variable rather than only as a concurrent correlate. Practically, the

two-month intervals were selected after consultation with participating schools because they fit the semester schedule, reduced disruption to teaching, and helped maintain participant retention. In longitudinal school-based research, the length of the lag should be aligned with the theoretical process and the field context (Ployhart and Vandenberg, 2010). For rural primary-school left-behind children, a substantially longer interval could have increased attrition caused by school transfer, guardian availability, or family migration changes, whereas a much shorter interval would have provided weaker temporal separation. Thus, the design was intended to strengthen temporal ordering and feasibility while acknowledging that causal inference remains limited. Data were collected from rural schools serving Grades 3 to 6 in Jiangsu and Anhui Provinces, China, with a two-month interval between adjacent waves. At Time 1 (T1), participants completed measures of loneliness and self-control and reported demographic and family-background information. At Time 2 (T2), participants completed the FoMO measure. At Time 3 (T3), participants completed the PSNU measure. Purposive sampling was used because the study targeted rural schools in communities where parental labor migration was common. Within participating schools, eligible students were identified according to the operational definition of left-behind status and invited to participate after school permission, guardian consent, and child assent had been obtained.

Rural left-behind children were operationally defined as students whose one or both parents had migrated to other regions for work for at least six months and who were unable to live with the migrating parent(s) on a daily basis. Their daily care was mainly provided by grandparents, one remaining parent, other relatives, or other guardians. This definition allowed the study to distinguish different left-behind characteristics, including one-sided versus two-sided parental migration, primary caregiver type, duration of being left behind, and frequency of contact with migrant parent(s).

A total of 669 students participated in the first wave. After excluding questionnaires with substantial missing data, patterned responding, uniform responses across scales, implausibly short completion time, or invalid matching information across the three waves, 620 valid matched cases were retained for analysis, yielding an effective response rate of 92.7%. Among the final sample, 265 participants were boys (42.74%) and 355 were girls (57.26%). Participants ranged from 8 to 12 years old ($M = 9.35$, $SD = 1.35$). Detailed demographic and family-background characteristics are presented in Table 1.

2.2 Measures

All scales were administered in Chinese. Because participants were rural primary-school children aged 8 to 12 years, two researchers with backgrounds in educational psychology and child development reviewed the items for

developmental appropriateness, reading difficulty, and contextual relevance before formal administration. Minor wording adjustments were made only to clarify sentence structure or platform-related expressions and did not alter the substantive meaning of the items. A pilot comprehension check with comparable rural students who were not included in the final sample was conducted to ensure that children could understand the response options and item wording independently.

2.2.1 T1 Loneliness

Loneliness was measured at T1 using the UCLA Loneliness Scale developed by Russell et al. (1978). The scale assesses subjective feelings of loneliness, perceived social isolation, and dissatisfaction with social relationships. It contains 20 items rated on a 4-point Likert scale ranging from 1 (never) to 4 (often). Higher scores indicate higher levels of loneliness. In the present study, Cronbach's alpha was 0.836.

2.2.2 T2 Fear of Missing Out

Fear of missing out was assessed at T2 using the Fear of Missing Out Scale in the Mobile Social Media Environment developed by Song et al. (2017). The instrument measures concerns about missing important information, social interactions, updates, or experiences involving others in mobile social media environments. It consists of 12 items rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate higher levels of FoMO. In the present study, Cronbach's alpha was 0.791.

2.2.3 T3 Problematic Social Network Use

Problematic social network use was measured at T3 using the revised Social Network Site Intrusion Scale developed by Hou et al. (2017). The scale assesses excessive involvement in social networking, loss of control over use, and the extent to which social network use intrudes into daily life and psychological functioning. It includes 9 items rated on a 5-point Likert scale ranging from 1 (strongly inconsistent) to 5 (strongly consistent). Higher scores indicate higher levels of PSNU. In the present study, Cronbach's alpha was 0.907.

2.2.4 T1 Self-Control

Self-control was assessed at T1 using the revised 12-item Brief Self-Control Scale derived from Tangney et al. (2004). The scale measures trait self-control, including the ability to regulate impulses, resist temptations, inhibit maladaptive tendencies, and pursue longer-term goals. Participants responded on a 5-point Likert scale ranging from 1 (very unlike me) to 5 (very like me). Higher scores indicate higher levels of self-control. In the present study, Cronbach's alpha was 0.903.

Table 1. Demographic and family characteristics of participants (N = 620).

Characteristic	Category	n	%
Gender	Boys	265	42.74
	Girls	355	57.26
Age group	8–9 years	405	65.32
	10–12 years	215	34.68
Grade level	Grade 3	142	22.90
	Grade 4	165	26.61
	Grade 5	176	28.39
	Grade 6	137	22.10
Parental migration status	Father migrated for work	256	41.29
	Mother migrated for work	82	13.23
	Both parents migrated for work	282	45.48
Primary caregiver	Grandparents	431	69.52
	One parent remaining at home	96	15.48
	Other relatives	74	11.94
	Other guardians	19	3.06
Duration of being left behind	6 months–1 year	74	11.94
	1–3 years	186	30.00
	3–5 years	204	32.90
	More than 5 years	156	25.16
Frequency of contact with migrant parent(s)	Daily or almost daily	126	20.32
	Several times per month	238	38.39
	About once per month	167	26.94
	Less than once per month	89	14.35
Frequency of social networking use	Rarely	94	15.16
	Occasionally	213	34.35
	Often	221	35.65
	Very often	92	14.84

Table 2. Comparison of fit indices for competing measurement models.

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	SRMR	AIC
One-factor model	8022.88	1325	6.05	0.886	0.881	0.090	0.086	8234.88
Two-factor model	7251.52	1324	5.48	0.901	0.896	0.085	0.079	7465.52
Three-factor model	5949.00	1322	4.50	0.923	0.918	0.075	0.066	6167.00
Four-factor model	4570.74	1319	3.47	0.946	0.942	0.063	0.049	4794.74

Note. In the four-factor model, T1 loneliness, T2 FoMO, T1 self-control, and T3 PSNU were specified as four correlated but distinct latent constructs. FoMO, fear of missing out; PSNU, problematic social network use; CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; AIC, Akaike information criterion; df, degrees of freedom.

Table 3. Reliability and convergent validity of the main constructs.

Construct	Cronbach's α	CR	AVE	Standardized loading range
T1 Loneliness	0.836	0.903	0.756	0.868–0.871
T2 FoMO	0.791	0.874	0.697	0.826–0.842
T1 Self-control	0.903	0.945	0.850	0.917–0.928
T3 PSNU	0.907	0.942	0.844	0.918–0.919

Note. CR and AVE were calculated from parcel-based standardized loadings as a supplementary convergent validity check. All Cronbach's alpha and CR values exceeded 0.70, and all AVE values exceeded 0.50. CR, composite reliability; AVE, average variance extracted.

2.3 Data Collection Procedure and Ethical Considerations

Data were collected through group-administered paper-and-pencil questionnaires in classroom settings. The questionnaires were distributed and collected by trained researchers or research assistants. Before each survey, participants received standardized instructions explaining the research purpose, response format, anonymity procedures, confidentiality protections, and voluntary nature of participation. Students were informed that there were no right or wrong answers and that they could withdraw at any time without penalty. Teachers and research assistants remained present only to maintain order and provide procedural clarification; they did not guide or influence responses.

2.4 Control of Common Method Bias

Because all core variables were measured using self-report questionnaires, common method bias remained a potential concern. Several procedural remedies were used. First, the three-wave design temporally separated measurement of loneliness/self-control, FoMO, and PSNU. Second, anonymity and confidentiality were emphasized to reduce social desirability and evaluation apprehension. Third, participants were told that there were no right or wrong answers. At the statistical level, Harman's single-factor test was used as a preliminary diagnostic test. The first unrotated factor accounted for 15.94% of the total variance, which was below the commonly used 40% threshold. This suggests that common method variance was unlikely to dominate the observed associations, although it cannot be fully excluded.

2.5 Data Analysis

Data analyses were conducted using IBM SPSS Statistics 26.0 and IBM SPSS Amos 26.0 (IBM Corp., Armonk, NY, USA), and Hayes' PROCESS macro. Descriptive statistics, Pearson correlation analyses, and internal consistency reliability analyses were first performed. Confirmatory factor analysis (CFA) was used to examine the empirical distinctiveness of T1 loneliness, T2 FoMO, T1 self-control, and T3 PSNU. Model fit was evaluated using chi-square/df, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and Akaike information criterion (AIC). Composite reliability (CR) and average variance extracted (AVE) were also examined using parcel-based standardized loadings because the scales contained multiple items and parceling provided a parsimonious supplementary evaluation of convergent validity. Parcel-based CR and AVE were reported only as supplementary evidence of convergent validity, whereas the primary measurement evaluation relied on the competing CFA models and reliability estimates.

The hypothesized time-lagged moderated mediation model was tested using Hayes' PROCESS Model 14. The model was estimated as a temporally ordered conditional

indirect-association model rather than as definitive causal proof. T1 loneliness was entered as the independent variable, T2 FoMO as the mediator, T3 PSNU as the dependent variable, and T1 self-control as the moderator of the association between T2 FoMO and T3 PSNU. Gender and age were included as covariates in all regression equations. T2 FoMO and T1 self-control were mean-centered before the interaction term was computed. Conditional indirect associations were estimated at one standard deviation below the mean, the mean, and one standard deviation above the mean of T1 self-control. Bootstrap confidence intervals were based on 5000 resamples. An indirect association or index of moderated mediation was considered significant when the 95% bootstrap confidence interval did not include zero.

To address the reviewer's concern regarding left-behind heterogeneity, descriptive subgroup comparisons were conducted by parental migration status, primary caregiver type, and duration of being left behind. Because several subgroups were relatively small, these analyses were treated as contextual descriptive checks rather than as replacements for the primary moderated mediation model.

3. Results

3.1 Measurement Model, Reliability, and Common Method Bias

The four-factor measurement model showed the best fit to the data, indicating that T1 loneliness, T2 FoMO, T1 self-control, and T3 PSNU were empirically distinguishable constructs. As shown in Table 2, the hypothesized four-factor model fit the data better than the more constrained one-factor, two-factor, and three-factor alternatives. This supported the use of the four constructs in the subsequent time-lagged moderated mediation analysis. The reliability and convergent validity results for the four constructs are presented in Table 3.

Item-level descriptive checks indicated that FoMO item means ranged from 3.12 to 3.42 and corrected item-total correlations ranged from 0.39 to 0.50. PSNU item means ranged from 3.48 to 3.78 and corrected item-total correlations ranged from 0.65 to 0.70. These results suggested that no single FoMO or PSNU item dominated the scale scores and that the item-level pattern was broadly consistent with the composite-level analyses.

3.2 Descriptive Statistics and Correlations

Descriptive statistics and Pearson correlations are presented in Table 4. T1 loneliness was positively correlated with T2 FoMO and T3 PSNU. T2 FoMO was positively correlated with T3 PSNU. T1 self-control was negatively correlated with T1 loneliness, T2 FoMO, and T3 PSNU. These bivariate results provided preliminary support for the proposed time-lagged association pattern.

Table 4. Descriptive statistics and correlations among the study variables.

Variable	M	SD	1	2	3	4
1. T1 Loneliness	2.72	0.33	-			
2. T2 FoMO	3.31	0.46	0.332**	-		
3. T3 PSNU	3.67	0.80	0.228**	0.354**	-	
4. T1 Self-control	3.14	0.58	-0.199**	-0.221**	-0.322**	-

Note. ** $p < 0.01$. M, mean; SD, standard deviation.

Table 5. Regression results for the time-lagged moderated mediation model.

Outcome	Model	Predictor	β	t	p	R^2
T2 FoMO	Model 1	T1 Loneliness	0.332	8.732	<0.001	0.111
T3 PSNU	Model 2	T1 Loneliness	0.227	5.801	<0.001	0.054
T3 PSNU	Model 3	T1 Loneliness	0.092	2.375	0.018	0.203
T3 PSNU	Model 3	T2 FoMO	0.268	6.906	<0.001	0.203
T3 PSNU	Model 3	T1 Self-control	-0.240	-6.415	<0.001	0.203
T3 PSNU	Model 3	T2 FoMO $\times$ T1 Self-control	-0.079	-2.273	0.023	0.203

Note. β , standardized regression coefficient. Gender and age were included as covariates in all regression equations. T2 FoMO and T1 self-control were mean-centered before computing the interaction term. Coefficients for gender and age are not displayed for brevity but were included in all equations.

3.3 Moderated Mediation Analysis

The time-lagged moderated mediation model was tested using PROCESS Model 14. Gender and age were included as covariates. As shown in Table 5, T1 loneliness was positively associated with T2 FoMO, $\beta = 0.332$, $t = 8.732$, $p < 0.001$. T1 loneliness was also positively associated with T3 PSNU at the total-association level, $\beta = 0.227$, $t = 5.801$, $p < 0.001$.

In the final equation predicting T3 PSNU, T2 FoMO was positively associated with T3 PSNU, $\beta = 0.268$, $t = 6.906$, $p < 0.001$, whereas T1 self-control was negatively associated with T3 PSNU, $\beta = -0.240$, $t = -6.415$, $p < 0.001$. After T2 FoMO, T1 self-control, and the interaction term were included, T1 loneliness remained positively associated with T3 PSNU, $\beta = 0.092$, $t = 2.375$, $p = 0.018$. The interaction between T2 FoMO and T1 self-control was significant, $\beta = -0.079$, $t = -2.273$, $p = 0.023$, indicating that self-control moderated the time-lagged association between FoMO and PSNU. The standardized path coefficients for the hypothesized moderated mediation model are presented in Fig. 1.

Simple slope analyses further indicated that T2 FoMO was positively associated with T3 PSNU at low, mean, and high levels of T1 self-control, but the association weakened as self-control increased. The standardized simple slopes were $\beta = 0.347$ at low self-control, $\beta = 0.268$ at mean self-control, and $\beta = 0.189$ at high self-control. Thus, higher self-control buffered, but did not eliminate, the association between FoMO and later PSNU.

3.4 Conditional Indirect Associations

Bootstrap analyses with 5000 resamples were used to test the conditional indirect association between T1 loneliness and T3 PSNU through T2 FoMO at different levels of T1 self-control. As shown in Table 6, the indirect association was significant at low, mean, and high levels of self-control. However, the magnitude of the indirect association decreased as self-control increased. The index of moderated mediation was also significant, indicating that the loneliness-FoMO-PSNU pathway was conditional on self-control.

3.5 Subgroup Descriptive Comparisons by Left-Behind Characteristics

To address the heterogeneity of left-behind status, descriptive subgroup comparisons were conducted by parental migration status, primary caregiver type, and duration of being left behind. As shown in Table 7, mean PSNU scores were descriptively similar across subgroups. One-way analysis of variance (ANOVA) results showed no statistically significant subgroup differences in T3 PSNU by parental migration status, primary caregiver type, or duration of being left behind. These results suggest that the primary time-lagged model was not driven by large mean differences across these observed left-behind categories. Nevertheless, the subgroup findings should be interpreted cautiously because some categories were relatively small.

4. Discussion

4.1 Principal Findings

This study examined a three-wave time-lagged model linking loneliness, FoMO, self-control, and PSNU among

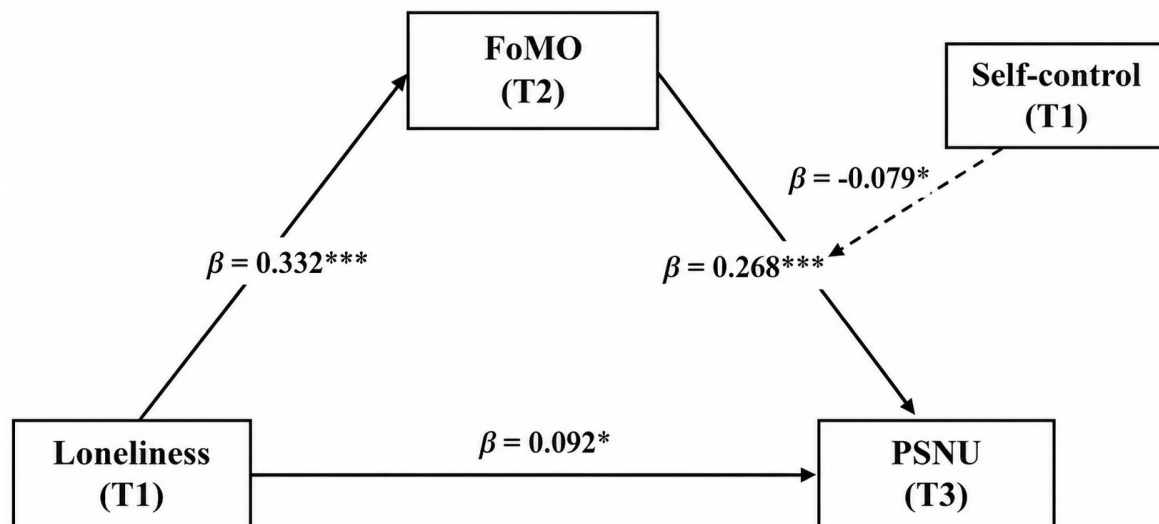


Fig. 1. Three-wave time-lagged moderated mediation model with standardized path coefficients. Note. Values are standardized regression coefficients. Gender and age were included as covariates. The dashed arrow indicates the moderation of the T2 FoMO-T3 PSNU path by T1 self-control; the main effect of T1 self-control on T3 PSNU was included in the model ($\beta = -0.240, p < 0.001$) but is not displayed to maintain visual clarity. * $p < 0.05$, *** $p < 0.001$.

Table 6. Conditional indirect associations and bootstrap test.

Path/Association	Estimate	Boot SE	95% bootstrap CI
Indirect association via T2 FoMO at low T1 self-control (−1 SD)	0.279	0.049	[0.190, 0.383]
Indirect association via T2 FoMO at mean T1 self-control	0.216	0.040	[0.142, 0.298]
Indirect association via T2 FoMO at high T1 self-control (+1 SD)	0.152	0.051	[0.054, 0.255]
Index of moderated mediation	−0.109	0.052	[−0.216, −0.012]

Note. Values are unstandardized bootstrap estimates based on 5000 bootstrap samples. Bootstrap confidence intervals that do not include zero indicate statistical significance. Boot SE, bootstrap standard error; CI, confidence interval.

Table 7. Descriptive PSNU comparisons by left-behind characteristics.

Grouping variable	Category	n	M	SD	ANOVA
Parental migration status	Father migrated for work	256	3.62	0.79	$F = 0.91, p = 0.404$
	Mother migrated for work	82	3.68	0.84	
	Both parents migrated for work	282	3.71	0.80	
Primary caregiver	Grandparents	431	3.66	0.79	$F = 0.13, p = 0.943$
	One parent remaining at home	96	3.67	0.84	
	Other relatives	74	3.71	0.79	
	Other guardians	19	3.60	0.95	
Duration of being left behind	6 months–1 year	74	3.64	0.76	$F = 0.48, p = 0.697$
	1–3 years	186	3.70	0.82	
	3–5 years	204	3.69	0.79	
	More than 5 years	156	3.61	0.82	

Note. These subgroup analyses were included as contextual checks and should not be interpreted as tests of causal subgroup differences. ANOVA, analysis of variance.

rural left-behind children in China. The findings supported all four hypotheses. T1 loneliness was positively associated with T3 PSNU and was also indirectly associated with T3 PSNU through T2 FoMO. T1 self-control moderated the association between T2 FoMO and T3 PSNU, such that the

association was stronger among children with lower self-control. The conditional indirect association from loneliness to PSNU through FoMO was also strongest at lower levels of self-control.

Taken together, the findings place PSNU within the everyday relational context of rural left-behind children. The issue is not simply that some children use social networking too much or lack discipline. Rather, children who felt lonely appeared more attentive to online relational cues and more concerned about missing opportunities for connection. When this concern was accompanied by lower self-control, FoMO was more strongly associated with intrusive or poorly regulated social networking over time. This interpretation is consistent with CIUT, which suggests that problematic online engagement may emerge when digital activities are used to cope with unmet offline needs, negative emotions, or relational deprivation (Kardefelt-Winther, 2014).

4.2 Loneliness and PSNU in the Left-Behind Context

The positive association between loneliness and later PSNU indicates that problematic digital behavior may carry emotional meaning in the left-behind context. This finding is consistent with previous work linking loneliness to problematic internet or smartphone use (Caplan, 2007; Li et al., 2021). In the present sample, many participants experienced prolonged parent-child separation and were cared for by grandparents or other guardians. For these children, loneliness may involve not only reduced companionship but also less consistent emotional responsiveness and relational security.

At the same time, the direct association between loneliness and PSNU became modest after FoMO and self-control were included. This suggests that loneliness alone is unlikely to explain why children develop problematic social networking. Other factors, such as parent-child communication quality, caregiver monitoring, peer support, school connectedness, platform affordances, and access to digital devices, probably also matter. Thus, the observed association is theoretically meaningful but should not be overstated in practical terms. Interventions should address loneliness together with more immediate digital anxieties and self-regulatory skills.

4.3 FoMO as a Digital Manifestation of Belongingness Insecurity

The mediating role of FoMO suggests that loneliness may be linked to later PSNU through children's concern about online connection and exclusion. In the left-behind context, FoMO is unlikely to be only a worry about missing information. It may also involve concern about missing emotionally meaningful interaction, such as messages from migrant parents, peer responses, or visible signs of social inclusion. This interpretation aligns with prior research showing that FoMO is consistently associated with problematic social media use and related maladaptive digital behaviors (Fioravanti et al., 2021; Servidio et al., 2024).

The mediation finding also supports the integration of CIUT, Social Capital Theory, and Uses and Gratifica-

tions Theory. Left-behind children may use social networking platforms to maintain relationships, gain social feedback, and meet needs for belonging and emotional support. These functions can be adaptive when online contact supplements stable offline support. The risk increases when loneliness makes children rely heavily on online cues to confirm whether they are noticed, included, or valued. In that case, FoMO can help explain why relational difficulty in everyday life is associated with persistent checking and difficulty disengaging from social networking.

4.4 Self-Control as a Protective Regulatory Resource

Self-control weakened the association between FoMO and later PSNU. This finding is consistent with prior evidence that self-control is negatively related to problematic smartphone use and other maladaptive online behaviors (Li et al., 2021; Servidio, 2021; Wang et al., 2019). Children with higher self-control may be better able to resist notification-checking impulses, stop scrolling, delay immediate online gratification, and disengage from social networking when it interferes with daily functioning.

Self-control should therefore be understood as a useful but incomplete protective resource. The indirect association from loneliness to PSNU through FoMO remained significant even at higher levels of self-control, although it became weaker. This finding cautions against attributing rural left-behind children's problematic social networking simply to poor discipline or weak willpower. Even children with relatively stronger self-control may remain vulnerable when loneliness and FoMO are present. A more balanced interpretation is that loneliness increases sensitivity to online connection, FoMO channels this sensitivity into repeated monitoring, and self-control influences whether such monitoring becomes difficult to regulate.

4.5 Educational Administration Implications

The findings have direct implications for educational administration. First, schools serving rural left-behind children should treat elevated PSNU as a possible signal that a student may need closer emotional and behavioral support. Screening should not focus only on frequency of internet use; it should also consider loneliness, FoMO, self-control, school belonging, and family communication. Second, digital literacy education should be integrated with social-emotional learning. Students need support in recognizing FoMO, managing notification-checking impulses, and distinguishing necessary communication from compulsive monitoring. Third, teacher training is important. Homeroom teachers and school counselors should be trained to identify signs of loneliness, peer exclusion, excessive checking, sleep disruption, and functional interference related to social networking. Fourth, schools should strengthen peer-support programs, group activities, classroom integration, and campus support systems so that left-behind children can obtain belonging and recognition

through offline relationships rather than relying mainly on online feedback.

4.6 Clinical and Mental Health Implications

The results also have clinical and counseling implications. Mental health screening for rural left-behind children should include brief assessment of loneliness, FoMO, self-control, and problematic digital behavior. Students with high loneliness, strong FoMO, low self-control, and elevated PSNU may require early identification and targeted counseling. Counseling protocols may combine emotion regulation training, cognitive restructuring of FoMO-related beliefs, behavioral self-control strategies, and family communication support. For high-risk children, family interventions should encourage migrant parents and caregivers to provide predictable, emotionally meaningful contact rather than irregular or purely supervisory communication. Community mental health services and school counselors should also develop referral mechanisms for children whose PSNU is accompanied by anxiety, depression, sleep problems, academic interference, or relational withdrawal.

4.7 Limitations and Future Directions

Several limitations should be acknowledged. First, although the three-wave time-lagged design provides clearer temporal ordering than cross-sectional measurement, it still cannot establish definitive causality. The findings should therefore be interpreted as time-lagged associations rather than conclusive causal effects. The selected two-month interval was justified by the proposed loneliness-FoMO-PSNU sequence and by the practical requirements of school-based follow-up, but it may not capture slower or reciprocal changes that unfold over longer periods. Reciprocal associations remain plausible; for example, PSNU may increase loneliness or FoMO over time. Future studies should use longer-term longitudinal designs, cross-lagged panel models, random-intercept cross-lagged panel models, intensive repeated-measures designs, or intervention designs to examine dynamic and bidirectional relationships. Because the primary purpose was to estimate conditional indirect associations with an interaction term using observed composite scores, PROCESS Model 14 was used after CFA; future studies may further test latent moderated mediation within a full structural equation modeling (SEM) framework.

Second, all variables were measured using self-report questionnaires. Although self-report is appropriate for subjective experiences such as loneliness and FoMO, shared method variance and response bias cannot be fully excluded. Future research could combine self-report data with teacher reports, caregiver reports, peer nominations, and objective behavioral indicators of social networking use. Third, the sample was limited to rural schools in Jiangsu and Anhui Provinces, which may restrict generalizability to left-behind children in other regions. Fourth, although

subgroup descriptive analyses were conducted, some categories such as other guardians were relatively small; future studies should recruit larger and more balanced subgroup samples.

Fifth, the analytic dataset did not retain school- or classroom-level identifiers, preventing adjustment for clustering. Future studies should preserve cluster information and use multilevel modeling or cluster-robust standard errors when appropriate. Finally, the present model did not include several contextual variables that may be highly relevant to left-behind children's digital well-being, such as parent-child communication quality, caregiver monitoring, peer support, school belonging, family functioning, parental mediation, and access to digital devices. Incorporating these variables would allow future research to build a more comprehensive model of PSNU risk and protection.

5. Conclusions

This study provides three-wave time-lagged evidence that loneliness, FoMO, self-control, and PSNU are interrelated among rural left-behind children. T1 loneliness was positively associated with T3 PSNU both directly and indirectly through T2 FoMO, while T1 self-control weakened the association between T2 FoMO and T3 PSNU. These findings suggest that problematic social networking in this population is closely linked to children's emotional experiences and ability to regulate online impulses. Interventions aimed at reducing PSNU among rural left-behind children should combine emotional support, parent-child communication, school belonging, digital literacy education, and self-control training. Because the study used a time-lagged observational design, the findings should be understood as temporally ordered associations rather than definitive causal pathways.

Availability of Data and Materials

The datasets generated and analyzed during the current study are not publicly available because the participants were minors and the data contain sensitive information related to family migration and children's psychological experiences. De-identified data may be made available from the corresponding author upon reasonable request and subject to ethical approval and data protection requirements.

Author Contributions

ML participated in questionnaire preparation, data collection, and data screening. XJ conducted the statistical analyses and contributed to the interpretation of the results. WZ conducted the statistical analyses and contributed to the interpretation of the results. WZ drafted the initial manuscript, and ML and XJ contributed to critical revision and editorial improvements. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated

sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Biomedical Ethics Committee of the School of Education, Huaibei Normal University (Approval No. CHNU-202602). Written informed consent was obtained from participants' guardians, and assent was obtained from all participating children before data collection.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (GPT-5.6 Sol, OpenAI) only to check grammar, clarity, and academic expression. After using this tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

- Andreassen CS, Pallesen S. Social network site addiction - an overview. *Current Pharmaceutical Design*. 2014; 20: 4053–4061. <https://doi.org/10.2174/13816128113199990616>
- Beyens I, Frison E, Eggermont S. "I don't want to miss a thing": Adolescents' fear of missing out and its relationship to adolescents' social needs, Facebook use, and Facebook related stress. *Computers in Human Behavior*. 2016; 64: 1–8. <https://doi.org/10.1016/j.chb.2016.05.083>
- Caplan SE. Relations among loneliness, social anxiety, and problematic Internet use. *Cyberpsychology & Behavior: the Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society*. 2007; 10: 234–242. <https://doi.org/10.1089/cpb.2006.9963>
- Cole DA, Maxwell SE. Testing mediational models with longitudinal data: questions and tips in the use of structural equation modeling. *Journal of Abnormal Psychology*. 2003; 112: 558–577. <https://doi.org/10.1037/0021-843X.112.4.558>
- Elhai JD, Levine JC, Dvorak RD, Hall BJ. Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. *Computers in Human Behavior*. 2016; 63: 509–516. <https://doi.org/10.1016/j.chb.2016.05.079>
- Ellison NB, Steinfield C, Lampe C. The Benefits of Facebook "Friends:" Social Capital and College Students' Use of On-line Social Network Sites. *Journal of Computer-Mediated Communication*. 2007; 12: 1143–1168. <https://doi.org/10.1111/j.1083-6101.2007.00367.x>
- Fang X, Yang J, Liu B, Wang Y, Liao J, Lei L. Exploring fear of missing out and problematic social media use among Generation Alpha: a random intercept cross-lagged panel model and cross-lagged panel network analysis. *Addictive Behaviors*. 2026; 172: 108489. <https://doi.org/10.1016/j.addbeh.2025.108489>
- Fioravanti G, Casale S, Benucci SB, Probstamo A, Falone A, Ricca V, et al. Fear of missing out and social networking sites use and abuse: A meta-analysis. *Computers in Human Behavior*. 2021; 122: 106839. <https://doi.org/10.1016/j.chb.2021.106839>
- Hou J, Ndasauka Y, Jiang Y, Ye Z, Wang Y, Yang L, et al. Excessive use of WeChat, social interaction and locus of control among college students in China. *PloS One*. 2017; 12: e0183633. <https://doi.org/10.1371/journal.pone.0183633>
- Kardefelt-Winther D. A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior*. 2014; 31: 351–354. <https://doi.org/10.1016/j.chb.2013.10.059>
- Katz E, Blumler JG, Gurevitch M. Uses and Gratifications Research. *Public Opinion Quarterly*. 1973; 37: 509. <https://doi.org/10.1086/268109>
- Laursen B, Hartl AC. Understanding loneliness during adolescence: developmental changes that increase the risk of perceived social isolation. *Journal of Adolescence*. 2013; 36: 1261–1268. <https://doi.org/10.1016/j.adolescence.2013.06.003>
- Li J, Zhan D, Zhou Y, Gao X. Loneliness and problematic mobile phone use among adolescents during the COVID-19 pandemic: The roles of escape motivation and self-control. *Addictive Behaviors*. 2021; 118: 106857. <https://doi.org/10.1016/j.addbeh.2021.106857>
- Lin N. Social capital: A theory of social structure and action. Cambridge University Press: Cambridge, UK. 2001.
- Liu C, Xu Y, Sun H, Yuan Y, Lu J, Jiang J, et al. Associations between left-behind children's characteristics and psychological symptoms: a cross-sectional study from China. *BMC Psychiatry*. 2024; 24: 510. <https://doi.org/10.1186/s12888-024-05932-8>
- Maxwell SE, Cole DA. Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*. 2007; 12: 23–44. <https://doi.org/10.1037/1082-989X.12.1.23>
- Nadkarni A, Hofmann SG. Why Do People Use Facebook? Personality and Individual Differences. 2012; 52: 243–249. <https://doi.org/10.1016/j.paid.2011.11.007>
- Ployhart RE, Vandenberg RJ. Longitudinal Research: The Theory, Design, and Analysis of Change. *Journal of*

- Management. 2010; 36: 94–120. <https://doi.org/10.1177/0149206309352110>
- Przybylski AK, Murayama K, DeHaan CR, Gladwell V. Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior*. 2013; 29: 1841–1848. <https://doi.org/10.1016/j.chb.2013.02.014>
- Qi D, Wu L. Different parenting styles and rural Children's mental Health: The mediational role of mental resilience. *Children and Youth Services Review*. 2024; 163: 107802. <https://doi.org/10.1016/j.childyouth.2024.107802>
- Qualter P, Vanhalst J, Harris R, Van Roekel E, Lodder G, Bangee M, et al. Loneliness across the life span. *Perspectives on Psychological Science: a Journal of the Association for Psychological Science*. 2015; 10: 250–264. <https://doi.org/10.1177/1745691615568999>
- Russell D, Peplau LA, Ferguson ML. Developing a measure of loneliness. *Journal of Personality Assessment*. 1978; 42: 290–294. https://doi.org/10.1207/s15327752jpa4203_11
- Servidio R. Self-control and problematic smartphone use among Italian University students: The mediating role of the fear of missing out and of smartphone use patterns. *Current Psychology*. 2021; 40: 4101–4111. <https://doi.org/10.1007/s12144-019-00373-z>
- Servidio R, Soraci P, Griffiths MD, Boca S, Demetrovics Z. Fear of missing out and problematic social media use: A serial mediation model of social comparison and self-esteem. *Addictive Behaviors Reports*. 2024; 19: 100536. <https://doi.org/10.1016/j.abrep.2024.100536>
- Song XK, Zhao YX, Zhang XH. Developing a fear of missing out (FoMO) measurement scale in the mobile social media environment. *Library and Information Service*. 2017; 61: 96–105. <https://doi.org/10.13266/j.issn.0252-3116.2017.11.012> (In Chinese)
- Tangney JP, Baumeister RF, Boone AL. High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*. 2004; 72: 271–324. <https://doi.org/10.1111/j.0022-3506.2004.00263.x>
- Wang P, Wang X, Nie J, Zeng P, Liu K, Wang J, et al. Envy and problematic smartphone use: The mediating role of FOMO and the moderating role of student-student relationship. *Personality and Individual Differences*. 2019; 146: 136–142. <https://doi.org/10.1016/j.paid.2019.04.013>
- Xiong Y, Li X, Li H, Qu C, Liu M, Lu C, et al. A meta-analysis of loneliness among left-behind children in China. *Current Psychology*. 2024; 43: 10660–10668. <https://doi.org/10.1007/s12144-023-04882-w>
- Zhang M, Zhang C, Jiang Z, Liu Y. A latent profile analysis of social anxiety among Chinese left-behind children and adolescents: Associations with online parent-child communication and online social capital. *Child Abuse & Neglect*. 2024; 158: 107102. <https://doi.org/10.1016/j.chiabu.2024.107102>
- Zhao L, Lu Y, Wang B, Chau PY, Zhang L. Cultivating the sense of belonging and motivating user participation in virtual communities: A social capital perspective. *International Journal of Information Management*. 2012; 32: 574–588. <https://doi.org/10.1016/j.ijinfomgt.2012.02.006>