ORIGINAL RESEARCH

The Relationship Between Family Communication and Adolescent Problematic Internet Use: The Chain Mediation Effects of Loneliness and Depression

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Introduction: Problematic internet use (PIU) is a significant issue during adolescence. It is recognized as a condition for further study in the DSM-5 and may also be a consequence of underlying psychopathologies, as suggested by previous studies. Poor family communication is an important predictor of adolescent PIU. However, it remains unclear how family communication impacts adolescent PIU from the perspective of underlying psychopathologies. This study tested the chain mediating effect of loneliness and depression as well as the moderating effect of developmental stage in this chain mediation model to uncover the mechanisms underlying this association.

Methods: This cross-sectional study recruited a total of 1,377 participants (53% male) from 23 provinces across China, all aged 12 to 17. Family communication was assessed using the FCS-10, which measures aspects such as openness, emotional expression, and problem-solving abilities within family interactions. PIU was assessed using the PIUQ-SF-6, loneliness was measured by the T-ILS, and depression was assessed using the PHQ-9. The chain mediating effects were tested using bias-corrected percentile bootstrap (sample = 5000).

Results: The results indicated that (a) poor family communication was positively associated with adolescent PIU; (b) loneliness and depression mediated the link between family communication and adolescent PIU; (c) loneliness and depression sequentially mediated the link between family communication and adolescent PIU; (d) the developmental stage of adolescence (early vs late) moderated the relationship between depression and PIU in the chain mediation model.

Conclusion: This study reveals that depression, as a potential underlying psychopathology, may precede PIU. It also establishes a link between family communication and PIU, showing that loneliness resulting from poor family communication contributes to the development of depression in adolescents. The connection between depression and PIU is particularly pronounced in late adolescence. These findings highlight the importance of addressing underlying psychopathologies when screening and treating adolescent PIU.

Keywords: adolescent, family communication, problematic internet use, loneliness, depression

Introduction

In adolescence, problematic internet use (PIU) becomes a significant problem that is associated with negative consequences and functional impairment.[1] It has been reported that approximately 5% to 25% of teenagers have internet overuse and addiction

problems.[2–4] In the Diagnostic and Statistical Manual of Mental Disorders, version 5,[5] PIU is included as a condition for further study under the category of nonsubstance addictive disorders. In the International Classification of Diseases and Related Health Problems, version 11,[6] PIU is included in the section on mental, behavioral or neurodevelopmental disorders, signaling an impairment in the psychological, biological and developmental processes that underlie mental and behavioral functioning. Therefore, as suggested by some researchers, it could be the case that PIU is a consequence of other psychopathologies.[7,8]

As the primary and most directly influential environment on child development, the family environment has been shown to correlate with PIU in adolescents and to predict PIU over the long term.[9–11] A potential mechanism from the perspective of underlying psychopathologies for PIU is as follows: poor family communication, characterized by unsatisfactory cohesion and adaptability, is associated with adolescent loneliness.[12] The loneliness that adolescents experience due to family dysfunction is further associated with higher levels of depression,[13,14] which could subsequently be related to PIU.[7]

However, to date, no research has fully examined the psychopathological mechanisms linking family communication to PIU by considering PIU as a consequence of other psychopathologies. Additionally, the influence of differenlopmental stages on these mechanisms has not been explored from a developmental perspective. Therefore, the current study aims to investigate adolescent PIU from the perspective of underlying psychopathologies and to explore the chain mediating roles of loneliness and depression between family communication and adolescent PIU in China. The impact of adolescents' developmental stages on the chain mediation process was also considered.

Family Communication and Adolescent Development

Family communication is an important environmental factor in adolescent development, significantly influencing depression, anxiety, and life satisfaction in adolescents.[15–17] This impact can be systematically explained by Bronfenbrenner's ecological systems theory,[18,19] which posits that child and adolescent development is shaped by a nested model of environmental influences. The family environment is part of the microsystem, which is the most immediate and influential factor in this framework. It provides a space where children directly interact with others, forming their schemas of self, others, and interpersonal scripts within the family. These schemas are known as "relational schemas in interpersonal communication", and they influence how adolescents will interact in other relationships later in life. Building on this, recent researchers have introduced the neo-ecological theory,[20] which also considers the impact of modern digital technology on adolescents. In this updated model, the influence of the internet is included as part of the microsystem, alongside face-to-face interactions within the family environment. At the mesosystem level of the neo-ecological theory, the interrelation between various physical and virtual microsystems is reflected, such as the connection between home life and online engagement in adolescent development. Both the microsystem and mesosystem are nested within broader systems, such as the exosystem and macrosystem. This suggests that broader cultural contexts can directly influence adolescent development or do so indirectly through the family environment. For example, compared to Western families, communication in Chinese families tends to be more conservative and reserved, focusing on cultivating proper behavior and rarely expressing affection directly.[21,22]

Family functions, including family communication, through influence adolescents' cognitive schemas, affecting their mental health.[23] Specifically, regarding adolescents' PIU, Davis's cognitive-behavioral model of PIU suggests that PIU could result from underlying psychological distress and maladaptive schemas.[7] In this model, psychological distress does not always result in PIU; however, it is an important part of the etiology of PIU, and they can coexist.[24] This suggests other psychopathologies or environmental stressors could be the precursor for PIU. Specifically, Davis argues that the internet offers individuals a nonthreatening outlet to cope with maladaptive thoughts about themselves (such as self-doubt, low self-efficacy, and negative self-appraisal) and about the world (such as mistrust of others).[7] For adolescents in poor family communication environments, the negative perceptions they develop about themselves and the world, along with the psychological issues developed by the maladaptive schemas, are likely the direct and indirect mechanisms contributing to their PIU.

Therefore, combining the ecological theory, neo-ecological theory and cognitive-behavioral model of PIU, the family environment plays a crucial role in shaping adolescents' schemas about themselves and the world. Family interactions,

such as the quality of family communication, not only directly influence how adolescents engage in other relationships (both real and virtual), but also impact PIU through the potential underlying psychopathologies.

Family Communication, Loneliness and Depression in Adolescents

Poor family communication is associated with adolescent loneliness,[12,25] characterized by both emotional and physical isolation.[26,27] The association between family communication and loneliness is partly due to the fact that loneliness is characterized by dysfunction in communication, which is closely linked to family relationships.[28] Additionally, during adolescence, the focus of attachment shifts from family to peers,[29] and the attachment adolescents feel toward their parents is significantly correlated with their attachment to peers.[30] This suggests that the family environment plays a crucial role in shaping how adolescents engage with their peers, thereby jointly predicting adolescent loneliness alongside other social relationships.[25]

Family communication is also associated with adolescent depression,[31,32] an emotional disorder characterized by sadness and hopelessness.[33–35] One explanation for the association between family communication and adolescent depression is the role that emotional understanding and communication play in parent–child interactions. Specifically, acceptance from family members helps children recognize, discriminate, and understand their emotions,[36] which contributes to lower levels of depression.[37] In addition, the physiological mechanisms linking parent–adolescent communication and depression have also been revealed in previous studies. When observing discussions between parents and adolescents in the laboratory, researchers found that parents' communication skills impact children's salivary α-amylase, an index of the sympathetic nervous system (SNS),[38] and cortisol reactivity, an index of the hypothalamic–pituitary–adrenal (HPA) axis.[39] Both the SNS and HPA play important roles in emotion regulation and are correlated with depression.[40]

PIU as a Consequence of Adolescent Loneliness and Depression

Loneliness in adolescents, resulting from poor family communication, in turn leads to PIU.[41] Previous studies have shown that maladaptive schemas formed in families negatively impact other relationships as well.[42,43] Adolescents who lack social skills and experience loneliness in both family and peer contexts often seek social interactions online.[26] The correlation between loneliness and PIU can also be explained through the compensation hypothesis. This hypothesis posits that individuals with limited social interactions or increased loneliness are more likely to resort to the internet as a means of compensating for their social deprivation.[44] However, overusing media to compensate for the lack of offline social networking can further lead to PIU.[45]

Depressive adolescents in dysfunctional families have a higher risk of developing PIU as well.[10] Davis argues that the internet provides individuals with a nonthreatening way to compensate for maladaptive thoughts about themselves (such as self-doubt, low self-efficacy, and negative self-appraisal) and about the world (such as a lack of trust in others).[7] These negative schemas regarding the self and the world are often foundational thoughts in individuals with depression.[24,46] As a low-risk and easier way to connect with others,[47] online communication satisfies the needs of depressive individuals, who are characterized by reduced activity levels, rumination, negative self-concept, social withdrawal, and a bad mood,[48,49] which can further lead to PIU.[7] Therefore, we propose the following hypotheses:

Hypothesis 1: Loneliness mediates the relationship between poor family communication and PIU.

Hypothesis 2: Depression mediates the relationship between poor family communication and PIU.

The Chain Mediating Effect of Loneliness and Depression

Loneliness also serves as a link between family communication and depression, which is a potential precursor to PIU. Although some studies have shown that the connection between loneliness and depression is reciprocal,[8] additional evidence may help determine the direction of the relationship among family communication, loneliness, and depression. From a theoretical perspective, according to the interpersonal theory of depression, negative feedback and rejection in interpersonal conflicts reinforce individuals' negative self-concept, one of the key symptoms of depression, and

contribute to an increased risk of depression.[50,51] Therefore, as previously mentioned, family dysfunction, which could affect adolescents' beliefs about interpersonal relationships, may lead to greater peer problems and loneliness, ultimately resulting in higher levels of depression.[13,14,52] Additionally, previous longitudinal studies have also provided evidence for the direction of loneliness and depression when discussing the influence of family factors. A study tracked adolescents over three time points with six-month intervals and found that family dysfunction predicted later depression and anxiety through feelings of loneliness.[14] Another study, after a year-long follow-up, found that family identification predicted depression through feelings of loneliness.[52] Therefore, in the current study, loneliness is considered a precursor to depression due to deficits in family communication, and depression is viewed as a potential psychopathology that further contributes to PIU among adolescents. Based on these findings, we propose the following hypotheses:

Hypothesis 3: Loneliness and depression serve as a chain mediation in the relationship between poor family communication and PIU.

The Role of Developmental Stage

When examining the relationship between psychopathologies and PIU, developmental stage emerges as an important factor during adolescence. The developmental stages of adolescence are often divided at the age of 15, distinguishing between early-to-middle adolescence and late adolescence.[53–55] Research indicates that late adolescents are more vulnerable to mental disorders compared to their early adolescent counterparts.[56] As adolescents grow older, they gradually engage more in social activities outside the family.[57] Additionally, they have greater flexibility and autonomy in their schedules to use the internet and are more likely to use online interactions as virtual social tools.[58] Consequently, using the internet as a means of coping with emotional problems is more likely to occur during late adolescence.[59]

This reliance on the internet by late adolescents with depression is also supported by a network analysis study,[54] which highlights changes in the psychopathological mechanisms of PIU across different developmental stages. The study found that the core symptoms of PIU shift from "increasing time for satisfaction" and "feeling of an empty life" in early adolescence to "depression" becoming the most prominent symptom in mid-to-late adolescence, suggesting that the psychopathological model of PIU is influenced by the adolescent's age.

Given the important role of developmental stages in the underlying psychopathological mechanisms of adolescent PIU, and considering that the association between depression and PIU strengthens as adolescents grow older, the following hypothesis is proposed:

Hypothesis 4: The developmental stage of adolescence moderates the association between depression and PIU in the chain mediating effect of poor family communication on PIU through loneliness and depression. While this chain mediating effect is significant in both early and late adolescence, it is more pronounced in late adolescence.

The Current Study

If we consider PIU as a consequence of underlying psychopathologies stemming from poor family communication, there are two pathways that need to be explained: the mechanism linking family communication to psychiatric problems, and the mechanism linking psychiatric problems to PIU.

The second part of these pathways has been explored. For instance, one study viewed PIU as a consequence of depression. It found that depression mediates the relationship between family communication and fear of missing out (FoMO), with FoMO subsequently increasing the risk for PIU.[10]

Therefore, the current study, using a chain mediating approach, especially focuses on the earlier part of the pathway—the mechanism linking family communication to depression, which is one of the potential underlying psychopathologies behind adolescent PIU. Loneliness is expected to serve as a mediator in this relationship. In addition, we also take into account the developmental stage of adolescents and explore how it may influence the psychopathological mechanisms underlying PIU at different phases of adolescence in China (see Figure 1).
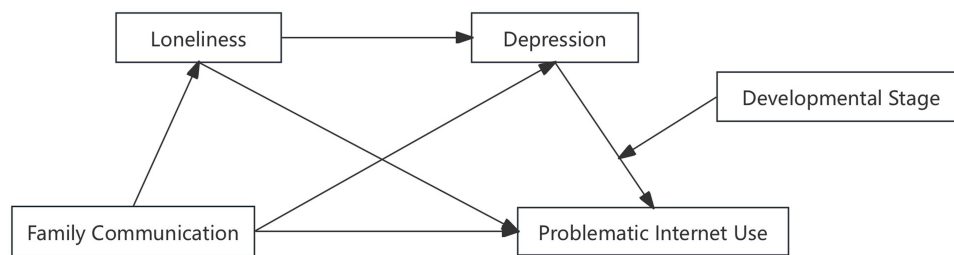
Figure 1 The Theoretical Model of this Study.

Method

Participants

The survey was conducted from June 20, 2022, to August 31, 2022. The data were collected across 23 provinces, 5 autonomous regions, and 4 municipalities in China. A total of 1377 questionnaires were collected, with a valid response rate of 96% (53% males, 47% females). All the participants were aged 12 to 17, including 89 primary school students (6.4%), 562 middle school students (40.7%), 634 high school students (46%), 42 vocational school students (3%), 42 undergraduate students (3%), and 11 college students (0.7%). Based on the classification used in previous studies,[53–55] we categorized adolescents aged 12 to 15 years as early adolescents (corresponding to middle school and lower educational levels), totaling 651 participants (47%). Adolescents aged 16 to 17 years were classified as late adolescents (corresponding to high school and higher educational levels), totaling 726 participants (53%).

967 participants were from urban areas (70%), while the other 411 participants lived in rural areas (30%). The monthly family income of most participants was less than 6000 yuan (72.8%). Informed consent from a parent or legal guardian, along with the participants' assent, was obtained during the survey process. The study adheres to the ethical principles outlined in the Declaration of Helsinki and has received approval from the Institutional Review Board (IRB) of the corresponding author's institution.

Measures

This study used well-established scales to measure the variables, and the Chinese versions of the scales were obtained through the "translation-back translation" method. Previous studies have confirmed the reliability and validity of the scales utilized in this paper within the context of Chinese culture.[60–62] In the current study, we also conducted Confirmatory Factor Analysis (CFA) to validate the scales (see Table 1). Several indices were used to evaluate the model fit of all the models in this study: Comparative Fit Index (CFI), Tucker Lewis Index (TLI), SRMR (standardized root mean squared residual) and Root Mean Square Error of Approximation (RMSEA). A model is considered good fit when the CFI $\geq$ 0.95, TLI $\geq$ 0.95, SRMR $\leq$0.08, and RMSEA $\leq$ 0.06.[63] Table 2 presents the standardized factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR) for each variable. In addition, Table 3 presents the discriminant validity of the four scales.

Table 1 Confirmatory Factor Analysis (CFA) Fit Indices

Variable	χ^2/df	CFI	TFI	SRMR	RMSEA
Family Communication	7.335	0.964	0.954	0.021	0.068
Depression	6.033	0.968	0.958	0.026	0.060
PIU	7.126	0.978	0.964	0.020	0.067

Table 2 Standardized Factor Loadings, AVE and CR of Each Scale

Variable	Factor	Estimate	AVE	CR
Family Communication	Factor 1	0.834	0.758	0.969
	Factor 2	0.873		
	Factor 3	0.861		
	Factor 4	0.857		
	Factor 5	0.889		
	Factor 6	0.897		
	Factor 7	0.875		
	Factor 8	0.895		
	Factor 9	0.838		
	Factor 10	0.883		
Loneliness	Factor 1	0.860	0.721	0.886
	Factor 2	0.879		
	Factor 3	0.807		
Depression	Factor 1	0.777	0.598	0.930
	Factor 2	0.808		
	Factor 3	0.777		
	Factor 4	0.821		
	Factor 5	0.740		
	Factor 6	0.788		
	Factor 7	0.762		
	Factor 8	0.784		
	Factor 9	0.698		
Problematic internet use	Factor 1	0.782	0.652	0.918
	Factor 2	0.835		
	Factor 3	0.837		
	Factor 4	0.777		
	Factor 5	0.782		
	Factor 6	0.829		

Table 3 Analysis of the Validity of Variables

	F1	F2	F3	F4
F1 Family communication	0.871			
F2 Loneliness	−0.326	0.849		

(*Continued*)

Table 3 (Continued).

	F1	F2	F3	F4
F3 Depression	−0.291	0.727	0.773	
F4 PIU	−0.288	0.474	0.495	0.807

Notes: The values on the diagonal are the square roots of the AVEs for each scale, while the other values are Pearson correlation estimates between the individual constructs.

Family Communication

The Family Communication Scale (FCS-10) was developed by Olson and measures the quality of family communication among adolescents over 12 years old.[64] Ten items are included in this self-report scale, covering various aspects: degree of openness in family communication, emotional expression, and problem-solving ability. The items include (1) family members can calmly discuss problems with each other. (2) Family members express their true feelings with each other. (3) Family members express affection for each other. The respondents were asked to rate their tendency to agree with the description of the items on a 5-point Likert scale ranging from "1 = strongly disagree" to "5 = strongly agree". The Cronbach's alpha coefficient of the Family Communication Scale is 0.968. The model fit indices from the CFA indicated good structural validity for this scale (see Table 1). The specific fit indices were as follows: χ^2/df = 7.335, CFI = 0.964, TLI = 0.954, SRMR = 0.021, and RMSEA = 0.068, suggesting an overall good model fit. All standardized factor loadings were above 0.650, with an AVE value of 0.758 and a CR value of 0.969 (see Table 2), confirming the convergent validity of this scale.

Loneliness

The Three-Item Loneliness Scale (T-ILS) was developed by Hughes et al.[65] It is a revision of UCLA Loneliness Scale.[66] It has been used in Chinese adolescents with good reliability and validity.[61,67] The items include three self-report questions: (1) How often do you feel left out? (2) How often do you feel isolated from others? (3) How often do you feel that you lack companionship? Respondents rate the tendency on a 3-point Likert scale. It measures the degree of loneliness as "1=almost never", "2=sometimes", and "3=frequently." The Cronbach's coefficient of this questionnaire is 0.885. CFA indicated that all standardized factor loadings were above 0.650, with an AVE value of 0.721 and a CR value of 0.886 (see Table 2), confirming the convergent validity of this scale.

Depression

Patient health questionnaire-9 (PHQ-9) was developed by Kroenke et al and consists of 9 self-report questions.[68] The specific questions include (1) Little interest or pleasure in doing things. (2) Felling tired or having little energy. (3) Feeling down, depressed, or hopeless. (4) Feeling bad about yourself — or that you are a failure or have let yourself or your family down. All questions are based on a 4-point Likert scale, ranging from "1=never" to "4=close to daily". The Cronbach's coefficient of this questionnaire is 0.930. The model fit indices from the CFA indicated that the scale has good structural validity (see Table 1). The specific fit indices were as follows: χ^2/df = 6.033, CFI = 0.968, TLI = 0.958, SRMR = 0.026, and RMSEA = 0.060. All standardized factor loadings were above 0.650, with an AVE value of 0.598 and a CR value of 0.930 (see Table 2), confirming the convergent validity of this scale.

Problematic Internet Use

The Problem Network Usage Scale (PIUQ-SF-6) was developed by Demetrovics et al and has three dimensions: obsession, neglect, and control.[69] Six items are included in this scale, with two questions for each dimension. For example, (1) How often do you feel tense, irritated, or stressed if you cannot use the internet for as long as you want to? (2) How often do people in your life complain about spending too much time online? (3) How often does it happen to you that you wish to decrease the amount of time spent online but you do not succeed? Each question

item was reported by a 5-point Likert scale, with a score from "1 = never" to "5 = always". The Cronbach's coefficient of this questionnaire is 0.917. The model fit indices from the CFA indicated that the scale has good structural validity (see Table 1). The specific fit indices were as follows: χ^2/df = 7.126, CFI = 0.978, TLI = 0.964, SRMR = 0.020, and RMSEA = 0.067, suggesting a good model fit. All standardized factor loadings were greater than 0.650, and the AVE value was 0.652, with a CR of 0.918 (see Table 2), confirming the convergent validity of this scale.

The Discriminant Validity Between Variables

The Fornell-Larcker criterion was used to examine the discriminant validity between variables.[70] According to this criterion, if the square root of a latent variable's AVE is greater than its correlation with other latent variables, it indicates good discriminant validity. In this study, the square roots of the AVEs for all four variables were greater than the correlations between them, confirming good discriminant validity among the variables (see Table 3).

Common Method Bias

Common method bias (CMB, such as anonymous reporting, reverse score items) was tested by the Harman single-factor test.[71] Specifically, the detailed steps referred to the "potential factor method".[72] Two models were conducted in this method: a confirmatory factor analysis model (M1) and a model including method factors (M2). Through a comparison of the main fit indices between the confirmatory factor analysis model M1 and M2 that included method factors, the following changes were observed: ΔCFI=0.011, ΔTLI=0.010, ΔIFI=0.011, ΔNFI=0.012, ΔSRMR=0.003 and ΔRMSEA=0.011. All of these changes were less than 0.03, indicating that the addition of common method factors did not lead to a significant improvement in the model fit. Thus, it can be concluded that there was no significant presence of common method bias in the measurement.[73]

Data Analysis

There were no missing values observed. Therefore, all analyses were conducted on a complete dataset without any missing data. SPSS 23.0 and Mplus 8.3 were used for data analysis.

The bias-corrected percentile bootstrap (sample = 5000) was used to test the mediating effects of loneliness and depression. This method has proven to be effective for small and medium samples.[74] By using it, bias-corrected percentile bootstrap confidence intervals (CIs) and standard errors are generated. When the confidence interval does not include 0, it indicates that the indirect effect is significant.[75] The moderating effect of adolescent developmental stages on the chain mediation model was examined using the index of moderated mediation.[74] If the index of moderated mediation is significant, it suggests that the moderator affects the mediation process.

To verify the robustness of the results across different demographic groups, the moderated chain mediation model was also conducted separately for male and female adolescents.

Results

Description and Correlations

The mean, standard deviation, and Pearson correlation of the main variables are shown in Table 4. The results show that family communication was negatively correlated with loneliness ($r = -0.309$, $p < 0.001$), depression ($r = -0.278$, $p < 0.001$), and PIU ($r = -0.274$, $p < 0.001$). Loneliness was positively correlated with depression ($r = 0.663$, $p < 0.001$) and PIU ($r = 0.429$, $p < 0.001$). PIU was positively correlated with depression ($r = 0.456$, $p < 0.001$), gender ($r = 0.071$, $p < 0.01$) and grade ($r = 0.151$, $p < 0.001$).

**Table 4** Descriptive Statistics and Inter-Correlations of the Main Variables

Variables	1	2	3	4	5	6	7	8
1. Gender[a]	1							
2. Grade[a]	0.030	1						
3. Family income	−0.096***	−0.031	1					
4. Residence[a]	−0.068*	−0.002	0.284**	1				
5. Family communication	−0.147***	−0.178***	0.132**	0.092***	1			
6. Loneliness	0.111***	0.144***	−0.017	−0.040	−0.309***	1		
7. Depression	0.066*	0.131***	−0.023	−0.020	−0.278***	0.663***	1	
8. Problematic Internet use	0.071**	0.151***	−0.035	−0.047	−0.274***	0.429***	0.456***	1
M (SD)	—	—	—	—	3.804 (0.828)	1.470 (0.560)	1.655 (0.657)	2.191 (0.932)

Notes: N = 1377; [a] Categorical variables: gender: 1 = male, 2 = female; grade: 1 = primary school, 2 = junior high school, 3 = high school, 4 = undergraduate; residence: 1 = rural, 2 = urban . *p <0.05, **p <0.01, ***p <0.001.
Abbreviations: M, mean; SD, standard deviation.

Bootstrap Method Verification

In this study, the bias-adjusted bootstrap method was used to perform the mediation analysis.[76] The current study was based on 5000 bootstrap samples to test the indirect effects. After controlling for relevant covariates, including gender, grade, income, and residence, the hypothetical model provided a good fit to the data: χ^2/df (N=1377) = 6.857, CFI = 0.962, TLI = 0.910, RMSEA = 0.065 (see Figure 2).
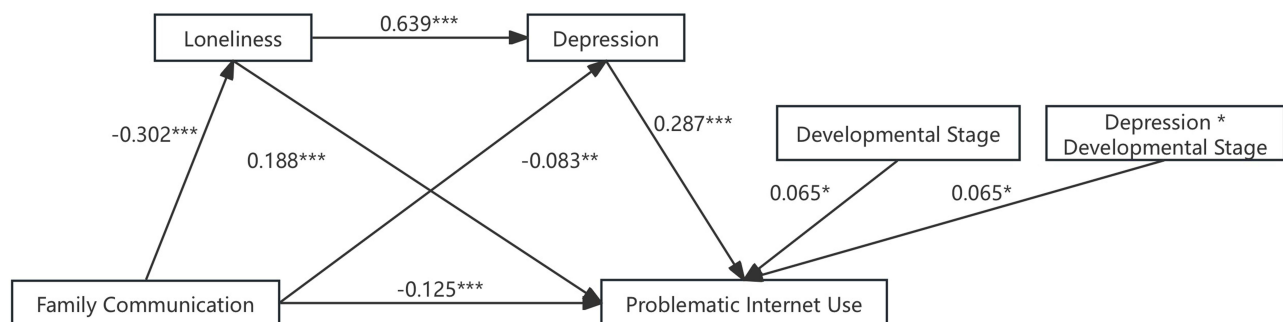
Figure 2 Structural Equation Modeling Examination of the Mechanism of Family Communication on Adolescent PIU. *p < 0.05, **p < 0.01, ***p < 0.001.

As shown in Table 5, family communication has a direct effect on both loneliness and depression in adolescents. Specifically, the effect of family communication on loneliness is −0.302 (p < 0.001), with 95% bias-corrected confidence intervals (CIs) of [−0.360, −0.247], excluding 0. Similarly, the effect of family communication on depression is −0.083 (p < 0.01), with 95% bias-corrected CIs of [−0.135, −0.031].

Table 5 The Moderated Chain Mediation Model

Path	β	95% CI		SE
		Lower	Upper	
Direct effects				
Family communication → PIU	−0.125***	−0.182	−0.068	0.029
Family communication → Loneliness	−0.302***	−0.360	−0.247	0.029

(*Continued*)

Table 5 (Continued).

Path	β	95% CI		SE
		Lower	Upper	
Loneliness→ PIU	0.188***	0.116	0.255	0.035
Family communication → Depression	−0.083**	−0.135	−0.031	0.027
Depression → PIU	0.287***	0.214	0.361	0.038
Loneliness → Depression	0.639***	0.582	0.695	0.029
Developmental stage → PIU	0.065*	0.018	0.115	0.024
Indirect effects				
Family communication → Loneliness → PIU	−0.057***	−0.081	−0.035	0.012
Family communication → Depression → PIU (early adolescence)	−0.018*	−0.037	−0.006	0.008
Family communication → Depression → PIU (late adolescence)	−0.029**	−0.048	−0.011	0.009
Family communication → Loneliness → Depression → PIU (early adolescence)	−0.042***	−0.066	−0.023	0.011
Family communication → Loneliness → Depression → PIU (late adolescence)	−0.067***	−0.090	−0.049	0.010
Moderating effects				
Depression*Developmental stage → PIU	0.065*	0.008	0.120	0.029
Index of moderated mediation	−0.013*	−0.024	−0.002	0.006

Notes: N = 1377; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Abbreviations: CI, confidence interval. *SE*, Standard Error.

The mediating effect of loneliness is −0.057 ($p < 0.001$), with 95% bias-corrected Cis of [−0.081, −0.035] excluding 0, supporting the mediating effect of loneliness on the relationship between family communication and PIU (Hypothesis 1). In early adolescence, the mediating effect via depression is −0.018 ($p < 0.05$), with 95% bias-corrected CIs of [−0.037, −0.006], excluding 0. In late adolescence, the mediating effect via depression is −0.029 ($p < 0.01$), with 95% bias-corrected CIs of [−0.048, −0.011], excluding 0. Thus, Hypothesis 2 is supported in both early and late adolescence, indicating the mediating role of depression in the relationship between family communication and PIU.

In early adolescence, loneliness and depression's chain mediating effect is −0.042 ($p < 0.001$), with 95% bias-corrected CIs of [−0.066, −0.023], excluding 0. In late adolescence, the chain mediating effect is −0.067 ($p < 0.001$), with 95% bias-corrected CIs [−0.090, −0.049], confirming the chain mediating effect of loneliness and depression (Hypothesis 3).

Additionally, the index of moderated mediation is −0.013 ($p < 0.05$), with 95% biased corrected CIs of [−0.024, −0.002]. Therefore, developmental stage moderates the chain mediating effect of family communication, loneliness, depression, and PIU. Hypothesis 4 is supported.

Sample Slope Test

Post hoc simple slope tests were conducted to examine the moderating effect of developmental stage in the association between depression and PIU. The results indicated that the predictive effect of depression on PIU is stronger in late adolescence compared to early adolescence. The simple slopes were 0.219 ($p < 0.001$) for early adolescents and 0.348 ($p < 0.001$) for late adolescents, respectively (see Figure 3).
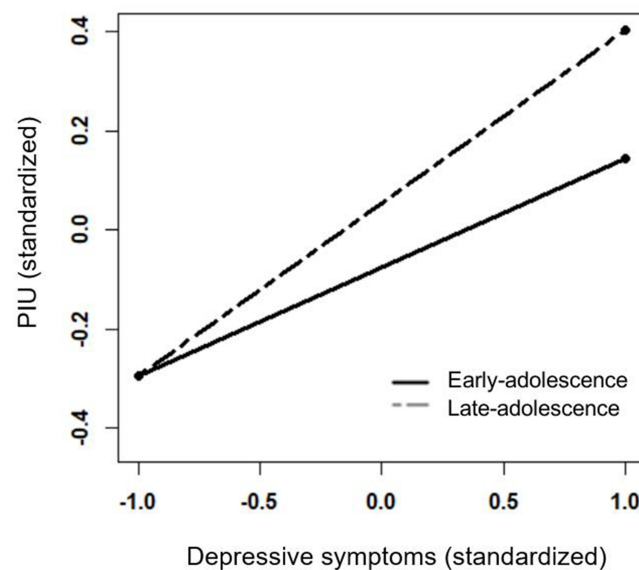
Figure 3 The Moderating Effect of Developmental Stage on the Relationship Between Depression and PIU.

Robustness Test

To examine the stability of the findings across different demographic groups, robustness tests were conducted. The moderated chain mediation models were tested separately in male and female adolescents (see Supplementary Tables 1 and 2). The results showed that the chain mediating effects were replicated in both sex groups. Specifically, for male adolescents, the chain mediating effect in early adolescence was −0.026 ($p < 0.05$), with 95% bias-corrected CIs of [−0.056, −0.004]. In late adolescence, the effect was −0.059 ($p < 0.001$), with 95% bias-corrected CIs of [−0.088, −0.037]. For female adolescents, the chain mediating effect in early adolescence was −0.063 ($p < 0.001$), with 95% bias-corrected CIs of [−0.099, −0.034]; in late adolescence, the effect was −0.072, with 95% CIs of [−0.106, −0.046]. However, the moderating effect of developmental stage was found only in male adolescents. The index of moderated mediation model was −0.016 ($p < 0.05$), with 95% bias-corrected CIs of [−0.031, −0.004]. For female adolescents, the developmental stage did not moderate the chain mediating effect.

Discussion

This study included participants spanning the entire adolescent age range, revealing how family communication affects adolescent PIU in China. It also uncovered the mechanisms by which adolescent loneliness and depression served as underlying psychopathologies linking family communication and PIU, and considered the impact of these mechanisms across different developmental stages. Overall, it was found that family communication had both direct and indirect effects on PIU through loneliness and depression, with the mediating effect being stronger in individuals in late adolescence compared to those in early adolescence. The study provides a novel perspective on the developmental psychopathological mechanisms underlying adolescent PIU.

Family Communication, Loneliness, Depression and PIU in Adolescents

The study found that family communication has a significant direct effect on loneliness, depression, and PIU in adolescents. This conclusion aligns with existing research.[12,31,77,78] Several explanations could account for this. Firstly, according to ecological systems theory/neo-ecological theory,[20,79] the development of adolescents is influenced by their surroundings. For this reason, their behavior should be studied in the context of their relationships. Adolescence is a crucial period characterized by vulnerability to psychopathology and during which conflicts and controversies between parents and adolescents may increase.[56,80] In instances where parents fail to provide adequate attention and support, adolescents are more likely to experience emotional problems, including loneliness and depression.[17,81] Therefore, adolescents may resort to the internet as a means to escape familial distress,[7] which can lead to PIU issues

over time. Moreover, Chinese participants, coming from a collectivist culture,[82] tend to have a stronger sense of connection with their family and society. Compared to their Western counterparts, Chinese individuals' self-concept is more closely tied to their immediate family members and intimate friends.[83,84] This may lead Chinese adolescents to place greater importance on relationships and seek virtual interactions to compensate for the absence of face-to-face family communication and psychological support. Additionally, Chinese parents generally adopt a more authoritarian parenting style compared to those in Western countries,[85] offering less verbal and non-verbal emotional support in communication.[86] This further increases the likelihood of adolescents turning to the internet as a compensatory mechanism. Therefore, while previous studies have shown that Chinese participants report lower overall levels of PIU,[87] research on parent-child dynamics and PIU has found that this relationship is stronger among Chinese participants compared to their Italian counterparts.[88]

Mediating Effects of Loneliness and Depression

Loneliness mediates the association between family communication and PIU. Many studies have examined the role of loneliness as a strong predictor of PIU,[89,90] which is consistent with the results of this study. Social psychologists emphasize that humans inherently need positive interpersonal relationships.[91] In dysfunctional family settings, adolescents may exhibit poor communication skills and often experience a sense of being misunderstood.[41] Media enable users to overcome limitations such as time, space, personal traits, and behavioral preferences, compensating for demands that are challenging to fulfill offline.[44] Therefore, when adolescents experience loneliness due to a lack of family communication, they may seek comfort through digital communication,[92,93] thereby enhancing their interpersonal connections through digital platforms and fulfilling their emotional needs.[94]

Depression also mediates the relationship between family communication and adolescent PIU. In the cognitive-behavioral model of PIU, false beliefs are important factors contributing to PIU behavior.[7] Several maladaptive cognitions collectively explain the mediating effect of depression: negative self-evaluation, such as believing that one is incompetent or unpopular;[95] distortion of reality, characterized by excessive attention to the online world while neglecting the real world;[96] false beliefs about the internet, such as the notion that it can alleviate real-life stress or tension;[97] and the desire to attract parents' attention through PIU behavior.[98] These maladaptive cognitions and coping strategies lead adolescents to choose the internet as a means of compensating for deficits in family communication. Teenagers mistakenly believe that virtual online environments can help them overcome negative emotions such as depression.[99]

Chain Mediating Effect of Loneliness and Depression

Depression and loneliness not only act as parallel mediators in the pathway from family communication to PIU, but they also function as chain mediators, collectively explaining this pathway. The influence of loneliness on depression aligns with previous studies, which have shown that loneliness resulting from the family environment can significantly impact the development and maintenance of depression.[14,52] One possible explanation is that teenagers may feel lonely and lack social support due to poor family communication. As a result, they have fewer resources to cope with the pressures and challenges of life, which, in turn, leads to increased negativity, sadness, loneliness, and anxiety, ultimately raising the risk of developing depression.[100] Additionally, loneliness may also affect emotional regulation abilities, making individuals more prone to negative emotions and emotional disorders, thereby exacerbating depression.[101,102]

In total, in dysfunctional family settings, adolescents often experience a sense of being misunderstood and feelings of loneliness.[41] These feelings of loneliness subsequently intensify social exclusion, leading to heightened levels of anxiety and depression in adolescents.[103] Furthermore, depression in adolescents exacerbate their PIU.[104]

The Moderating Effect of Developmental Stages

Depression has a more significant impact on PIU during late adolescence, suggesting that depression are more likely to serve as precursors to PIU at this stage. Several factors may contribute to this phenomenon. Firstly, during late adolescence, adolescents undergo a notable shift toward forming social relationships outside the family[105] and gain greater freedom to access the internet.[58] This provide more opportunities for them to use the internet as a coping

mechanism for their depression as they grow older. Furthermore, individuals with mental health issues and those seeking help for such issues continue to face stigma in China.[106] Compared to early adolescents, late adolescents are increasingly sensitive to social evaluation,[107] and the stigma related mental health issues could make it even more challenging for late adolescents with depressive symptoms to seek and receive adequate support. In this context, social networks that encourage the sharing of privacy-sensitive information may serve as an outlet for them to express their feelings and alleviate stress.[108] This strengthens the connection between PIU and its underlying psychopathology—such as depression—during late adolescence.

Robustness Test

Overall, the chain mediation results of this study remained stable across gender groups, suggesting that poor family communication consistently impacts both male and female adolescents through loneliness and depression. However, the moderating effect of developmental stage was observed only in male adolescents, not in female adolescents. This may be because female adolescents tend to enter puberty earlier than males,[109,110] and the hormonal changes associated with puberty contribute to an increase in depression in female adolescents,[111] requiring them to face the task of managing emotional challenges at an earlier age. Additionally, compared to their male counterparts, female adolescents are more sensitive to social evaluation,[112] and the stigma prevents them from seeking psychological support.[113] Altogether, adolescent girls may begin using the internet to cope with their depressive symptoms earlier than boys, which could explain why the moderating effect of developmental stage is less significant in female adolescents. Therefore, the gender differences in the psychopathological mechanisms of PIU require further research.

Practical Implications

Based on the above analysis, this paper argues that family communication is a significant factor influencing adolescents' PIU. Therefore, improving the quality of family communication is an effective way to reduce the likelihood of adolescents developing PIU. This includes fostering openness, emotional expression, active listening, and conflict resolution skills.[64] Additionally, for adolescents struggling with PIU and experiencing a lack of family communication, family-based intervention programs[114] or family therapy[115] could be considered.

Furthermore, this paper primarily focuses on the psychopathological mechanisms underlying adolescents' PIU, confirming that depression may serve as a precursor to PIU. It also identifies loneliness as a potential mediator linking poor family communication and depression. Therefore, from the perspective of adolescent psychiatrists, addressing PIU should not only target internet use behavior but also involve identifying and treating the underlying psychopathologies. Additionally, according to ecological systems theory, environments beyond the family, such as schools and peer relationships, also play an important role in adolescent development.[18,19] Peer relationships may moderate the mediating pathway between family functioning and adolescent depression.[116] Therefore, schools and teachers could support adolescents in building healthy peer relationships to alleviate PIU. Furthermore, as online environment is also a key part of the Neo-ecosystem,[20] internet providers and media regulators can contribute positively by offering mental health resources for adolescents within the online environment and guiding them toward healthy internet usage, helping to decrease adolescent PIU and related psychopathologies.

Limitations and Future Directions

Despite its contributions, this study has some limitations. First, the data rely primarily on self-report measures, which may introduce self-report bias.[117] In particular, Chinese adolescents might experience stigma and shame when disclosing PIU, potentially leading to underreporting.[118] Future research could incorporate meta-information alongside self-reports to mitigate bias.

Furthermore, the overall mediating effect (β) in this study was relatively low, which may be attributed to several factors. First, since the study includes two mediators, the indirect effects are distributed across three mediation pathways, reducing the effect size of each individual pathway. Additionally, the effect of family communication on depression, or the indirect pathway from family communication through depression to PIU, had a particularly lower β compared to other pathways. This may be due to the fact that part of the relationship between family communication and depression is

explained by the mediating role of loneliness. Moreover, as mentioned earlier, Chinese participants may underreport PIU due to social expectations, which could also lead to a lower statistical effect size.

Finally, in the current study, we used a cross-sectional study design instead of exploring the longitudinal relationship between adolescent family communication and PIU. Longitudinal studies can track changes and developmental trends over time within the same sample. Therefore, longitudinal studies can be used to reveal how the relationship between family communication and PIU changes over time and to evaluate how family factors and the emotional state of adolescents affect PIU in the long term.

Conclusion

This study explores the relationships between family communication, loneliness, depression, and PIU in Chinese adolescents. Positive family communication is associated with reduced loneliness, lower levels of depression, and a decreased likelihood of PIU. By integrating these factors into a developmental psychopathology framework, we also observe that family communication indirectly influences PIU through loneliness and depression, with developmental stages moderating the mechanism between depression and PIU. Overall, this study provides an insightful developmental psychopathological perspective on the occurrence and development of adolescent PIU, offering useful guidance for PIU prevention and intervention. Future research could further explore these relationships using longitudinal data to examine the long-term connections between underlying psychopathologies and adolescent PIU.

Data Sharing Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Ethics Approval Statement

This study complies with the ethical principles outlined in the Declaration of Helsinki. This study was approved by the Ethics Research Committee of the Health Culture Research Center of Shaanxi (No. JKWH-2022-02), as the corresponding author, Wu Yibo, conducted the research while working at this institution. The cover page of the questionnaire explained the study's purpose and assured participants of their anonymity, confidentiality, and right to refuse participation. Furthermore, informed consent from a parent or legal guardian, along with the participants' assent, was obtained during the survey process.

Disclosure

This paper was accepted for the Association for Education in Journalism and Mass Communication (AEJMC) Conference as a conference talk with interim findings, however, it was not presented. The authors report no conflicts of interest in this work.

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