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Research paper

The impact of family climate on problematic internet use: Findings from one nationwide study in China

Chenxi Liu [a], Xi Wang [a], Xinyi Zhang [a], Yushu Liu [a], Rujiao Lin [a], Yibo Wu [b,*], Dan Wang [c,d,e,**]

[a] School of Health Management and Medicine, Tongji Medical College, Huazhong University of Science and Technology, Hangkong Road No. 13, Qiaokou District, Wuhan 430030, China
[b] School of Public Health, Peking University, Beijing 100000, China
[c] School of Management, Hubei University of Chinese Medicine, Huangjiahu West Road No.16, Hongshan District, Wuhan, 430000, China
[d] Hubei Shizhen Laboratory, Hubei University of Chinese Medicine, Huangjiahu West Road No.16, Hongshan District, Wuhan, 430000, China
[e] Research Center for Traditional Chinese Medicine Development, Hubei University of Chinese Medicine, Huangjiahu West Road No.16, Hongshan District, Wuhan, 430000, China

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ABSTRACT

Background: With the growing attention paid to problematic internet use (PIU), this study aims to i) explore the prevalence of PIU based on a nationally representative sample and ii) propose and validate the theoretical model that correlates family climate with PIU.
Methods: One national cross-sectional study was conducted with probability sampling and stratified sampling. Overall, 21,854 sample were included and analyzed. Validated measures of family climate, loneliness, and PIU was distributed and collected from June 2022 to August 2022.
Results: The overall prevalence of PIU in the sample population is approximately 30.86 %. The model findings showed that family communication and family health had indirect effects of −0.12 and − 0.05 on PIU by the mediating effects of loneliness. The indirect effect explained 80.0 % of the total effect of family communication on PIU and 38.5 % of family health on PIU, highlighting the dominance effects of path family communication and PIU via loneliness. Extended family type (−0.047, $p = 0.050$), low family income (income≤3000 group, −0.127, $p < 0.001$) were identified as protective factors against PIU, while not living with family members (0.034, $p = 0.021$) was identified as risk factors of PIU.
Limitations: The nature of cross-sectional data have the limitation of preventing examining the casual relationships of PIU and the loneliness and family climate, in which future longitudinal study design is needed.
Conclusions: The high prevalence of PIU should be given adequate attention. Optimizing the family climate or family atmosphere by improving positive communication skills, providing family support and family health external resources can be served as effective strategies for controlling PIU.

1. Introduction

With the globalization of the Internet and advances in technology, the number of Internet users is increasing exponentially worldwide. By 2022, China will account for approximately one-fifth of the 5.3 billion Internet users, according to the annual statistical report released by the China Internet Network Information Center (China Internet Network Information Center, 2023). With the popularity of Internet use, problematic Internet use (PIU) draws widespread social attention. PIU refers to the generalized impulse control disorder of spending much of one's time on online activities to the point where other areas of life suffer (Cheng and Li, 2014; Reed et al., 2015). A high prevalence of PIU behaviors (20.0–44.6 %) has been reported across different settings, especially in some Asian countries (Chia et al., 2020; Endomba et al., 2022). Substantial evidence suggests that PIU could have harmful effects on psychological development and individual health, such as depression, anxiety, insomnia, and subjective well-being (Aboujaoude, 2010; Cai et al., 2023).

* Correspondence to: Y. Wu, School of Public Health, Peking University, 38 Xueyuan Road, Haidian District, Beijing 100000, China.
** Correspondence to: D. Wang, School of Management, Hubei University of Chinese Medicine, Huangjiahu West Road No.16, Hongshan District, Wuhan 430000, China.
E-mail addresses: bjmuwuyibo@outlook.com (Y. Wu), wangdan1992@hbucm.edu.cn (D. Wang).

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Epidemiological studies on PIU conducted so far have mainly been carried out with self-selected convenience samples or a small sample size, which resulted in unreliable prevalence rates among the Chinese population (Cao et al., 2011; Shek and Law, 2014; Yang and Zhu, 2023). The prevalence of PIU varies greatly depending on the investigation method used and the population under study. Previous studies results provided insights for characteristics associated with higher PIU prevalence, such as young age, male gender, social-economic level, and living alone (Kósa et al., 2022; Mei et al., 2016). Examining the prevalence of PIU among groups with specific socio-demographic characteristics will help identify high-risk target groups within the Chinese population.

The inherent family system and relevant factors play important roles in the development of additive Internet behavior (W. Wang et al., 2018). An affectionate, warm family atmosphere provides security and favors family members to express themselves and face the challenges that cyber behavior entails (Romera et al., 2020). Conversely, poor family cohesion, family relationships, and intensive family conflicts are likely associated with problematic Internet behavior, such as online gaming or gambling (Casalo and Escario, 2019; Sela et al., 2020).

The mechanism between PIU and the family environment is complex and may be mediated by mental health, depression, and fear of missing out (Sela et al., 2020). To achieve a better understanding of PIU, previous research on family climate suggested some family-related characteristics associated with PIU, such as family functionality, parenting approaches, and parental online behaviors (Liu et al., 2013; Wu et al., 2016). However, most existing research relies on correlation or regression approaches to identify significant factors with small sample sizes from a certain grade or school (Nannatt et al., 2022). Nonetheless, little is known about the mediating and moderating mechanisms underlying this relationship.

Existing evidence has shown that family environment-related characteristics, such as family conflict and family cohesion, are predictors of PIU (Balázová et al., 2017). Loneliness has been identified as an important potential factor explaining the association between family climate and PIU, underlining the importance of loneliness in this association. Moreover, the association between PIU and loneliness has been explored and demonstrated by some research findings (Moretta and Buodo, 2020). Nevertheless, few studies have quantified the moderating effects of loneliness on the family climate and PIU.

Therefore, this study aimed to explore the prevalence of PIU based on a nationally representative sample and distinguish the target subgroups with a high prevalence of PIU among the Chinese population. Further, it explored the mechanism of family climate on PIU with the mediating effects of loneliness. The second aim was elaborated upon with a detailed theoretical model and hypotheses regarding family climate and PIU, as follows.

1.1. Theoretical model

1.1.1. Family climate and PIU

Some empirical evidence recognizes the importance of family climate and suggests that family climate characteristics such as family conflicts and cohesion are associated with PIU (Sela et al., 2020).

Family climate characterized by communication problems between family members is a negative factor developing PIU (Shek et al., 2019). Good family communication provides a safe climate for adolescents to disclose themselves comfortably (Shek and Law, 2014), while family communication problems would lead to increased involvement in risky online behavior (Wang et al., 2013). Evidence suggests that positive family communication provides support and demonstrates affection and coping with conflicts, which helps young adults face the challenges of online activities (Segrin, 2011).

However, family health is another crucial family climate characteristic. Family health is defined as "a resource at the level of the family unit that develops from the intersection of the health of each family member, their interactions and capacities, as well as the family's physical, social, emotional, economic, and medical resources"(Weiss-Laxer et al., 2020). Family health covers comprehensive aspects of social and emotional health processes, family health styles, external support, and health resources (Crandall et al., 2020). Healthy families promote a bond of belonging, build family members' ability to care for each other, and provide health resources and family support. Unhealthy families with emotional and resource-support challenges increase their involvement in risky online behaviors.

Hence, we hypothesize that aspects of family climate are correlated with PIU as follows:

H1. Family communication is negatively associated with PIU.

H2. Family health is negatively associated with PIU.

1.1.2. Family climate and loneliness

Generally, loneliness is defined as the unpleasant experience that occurs when a person's social relationship network is significantly deficient qualitatively or quantitatively" (Perlman and Letitia, 1984). Studies conducted across different regions and countries have shown that the prevalence of loneliness is U-shaped and common in adolescents and older adults (Anthony et al., 2016; Matthews et al., 2019).

Research on the relationship between family climate and loneliness has shown that participants with poor family climates are more likely to experience high levels of loneliness (Demirli and Demir, 2014; Johnson et al., 2001). Significant predictors of loneliness and social isolation come from the social environment in which disruptive family climate characteristics (such as emotional relationships and affective empathy problems) play an important role in the development of loneliness. A disruptive family climate would prevent young adults from diminishing feelings of empathy and the ability to establish interpersonal relationships and further turn them into risky online behaviors (Balázová et al., 2017).

Specifically, we hypothesized that the family climate was associated with loneliness.

H3. Family communication is negatively associated with loneliness.

H4. Family health is negatively associated with loneliness.

1.1.3. Loneliness and PIU

Empirical evidence suggests the crucial role of loneliness and interpersonal problems in developing PIU. Previous findings suggested that the relationship between loneliness and PIU is complex (Moretta and Buodo, 2020). It remains uncertain whether loneliness serve as a cause of PIU or a result of PIU. Loneliness can have either a direct or an indirect effect on PIU (Wongpakaran et al., 2021). Several cross-sectional studies have reported a positive association between loneliness and PIU by causing individuals to excessively engage in online activities as a means of seeking social connections and relief from their feelings of loneliness. (Wongpakaran et al., 2021). Researchers have also indicated loneliness could be mediated by family support, depression or social anxiety (Moretta and Buodo, 2020). Loneliness could serve as a potential cause of PIU, and a plausible explanation is that lonely individuals would engage excessively in online activities because of the increased potential for more interactions to relieve loneliness. In this model, we hypothesized that loneliness would be a predictor of PIU (Moretta and Buodo, 2020).

H5. Loneliness was positively associated with PIU.

Furthermore, some evidence suggests that demographics (e.g., age and sex) and intrafamilial characteristics (e.g., family type) affect the endogenous factors of PIU and loneliness; thus, the covariates of relevant intrafamilial and demographic factors are included in the theoretical model. The proposed theoretical model is illustrated in Fig. 1.

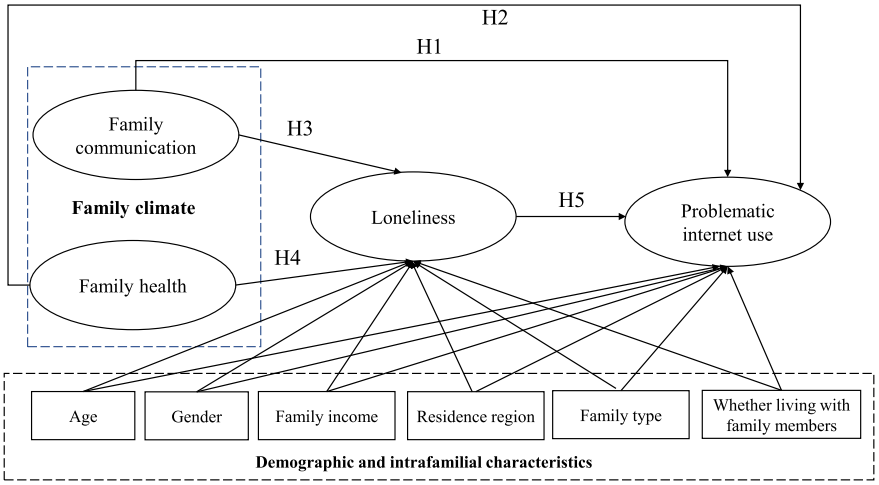

Fig. 1. The study hypotheses of the proposed model of family climate and Problematic Internet Use.

2. Methods

2.1. Study design and sample

A nationwide, representative population-based survey was conducted between June and August 2022 (Wu et al., 2024). The survey was held in 148 cities, 202 districts and counties, 390 townships, towns, or streets, and 780 communities or villages (excluding Hong Kong, Macao, and Taiwan) in 23 provinces, five autonomous regions, and four municipalities directly under the central government in China. Probability and equal probability sampling (stratified sampling) were applied to ensure that the samples were representative (Wang et al., 2022a). Overall, of 31, 449 collected questionnaires, 30,505 met the qualification criteria after performing logical checks, and 21,916 valid response remained using quota sampling. Finally, 21,854 response were included and analyzed as 62 cases were deleted due to missing values, or location outside mainland China. Among the 21,854 respondents, most were from nuclear families (52.89 %), while 17.49 % and 17.59 % were from extended and childless families, respectively. Most of the respondents had a monthly family income of <5000 yuan, and approximately 80 % of the respondents were living with family members. The detailed characteristics of the study sample were presented in Supplementary File 1. The study design and sampling process are described in detail in our previously published study protocol (Wang et al., 2022a).

To execute the research, investigator group, consisting of provincial heads, survey teams, and investigators, was assembled. The provincial head, responsible for the recruitment, training, organization and coordination of investigators/team in the province. Within each designated sample cities, a survey team of up to 10 members were openly recruited and rigorously trained. The survey was conducted anonymously, with investigators distributing electronic questionnaires to respondents in person. The questionnaire was designed using the Wenjuanxing platform (Wenjuanxing, 2023). Participants could complete the online questionnaire survey themselves or with the help of an investigator.

Inclusion criteria of the participants: age ≥ 12 years old; a Chinese permanent population with Chinese nationality; adequate ability to read and understand the questionnaire. This study was approved by the Ethics Review Committee of the Shaanxi Institute of International Trade and Commerce (JKWH-2022-02). All interviewees provided written informed consent to participate in the study upon recruitment. A flowchart of the study is presented in Supplementary File 2.

2.2. Study measures

2.2.1. Family health

The 10-item Family Health Scale (short form) was used to measure family health (Crandall et al., 2020). The instrument captures the comprehensive measurement of family health, covering the following: family social and emotional health processes (e.g., “I feel safe in my family relationships”); family healthy style (e.g., “We help each other in seeking health care services when needed, such as making doctor’s appointments”); family external support (e.g., “We have people outside of our family we can turn to when we have problems at school or work”); health resources (e.g., “A lack of health insurance would prevent us from asking for medical help” (R). The participants were asked to rate items based on a 5-Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”), with higher scores indicating higher levels of family health. The instrument has been previously validated with good reliability in a Chinese setting (Wang et al., 2022b).

2.2.2. Family communication

The 10-item Family Communication Scale was used to measure the degree of positive communication among family members (Olson and Barnes, 2004). Examples of family communication items are “Family members are very good listeners,” “Family members are satisfied with how they communicate with each other,” and “Family members express affection to each other.” Responses were scored on a 5-Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The higher the total score on the Family communication Scale, the higher the level of positive communication between family members are. The Family Health Scale has previously been validated in the Chinese population and shown to be a reliable and valid measure of positive family communication (Guo et al., 2021).

2.2.3. Demographic and intrafamilial characteristics

Intrafamilial demographic variables, including family type, whether living with family members, and family income, were collected. Family structure was classified into nuclear family, extended family, single-parent family, reconstituted family, grandparents raising the family, or other. The nuclear or extended family was coded as a traditional family structure, whereas other family types were coded as nontraditional family structures. Demographic characteristics (e.g., age, sex, and education) were also collected.

2.2.4. Loneliness

Individual loneliness was measured using a self-reported Three-Item Loneliness Scale (Hughes et al., 2004). This short scale measures three

aspects: relational connectedness, social connectedness, and self-perceived isolation. Each question was rated on a 3-point scale: 1 = Hardly ever; 2 = Some of the time; 3 = Often. Higher scores indicated higher levels of loneliness.

2.2.5. PIU

We used the Problematic Internet Use Questionnaire-Short Form-6 (PIUQ-SF-6) to measure the respondents' PIU (Demetrovics et al., 2016). The scale contains six items assessing three basic aspects of PIU: obsession (e.g., How often do you feel tense, irritated, or stressed if you cannot use the Internet as long as you want to?); neglect (e.g., How often do you spend time online when you would rather sleep); control disorder (e.g., How often does it happen to you that you wish to decrease the amount of time spent online but you do not succeed?). The respondents were asked to rate the item from "1 = never" to "5 = always." This short-form scale has been validated across different settings, and its high reliability has been reported in previous studies (Opakunle et al., 2020).

2.3. Data analysis

Descriptive analyses were conducted using means and standard deviations. Applying a cut-off score of 15 points on the PIUQ measurement, the distribution of PIU among different subgroups was analyzed (Demetrovics et al., 2016). Before testing the hypothesized theoretical model, the reliability and validity of the measures were tested. Skewness/Kurtosis tests were applied for normality test. The Kruskal–Wallis test was used to compare the means of the study measures across different groups (such as age and family type groups) as a nonparametric method, while ANOVA test was applied for normally distributed data. Post-hoc analysis was conducted for multiple comparisons test. A structural equation model was used to test the direct and indirect paths of family climate constructs, loneliness, and PIU. The Tucker–Lewis index (TLI; >0.90 acceptable, >0.95 excellent), comparative fit index (CFI; >0.90 acceptable, >0.95 excellent), and root mean square error of approximation (RMSEA; <0.08 acceptable, <0.05 excellent) were used to evaluate the model fitness (Bentler, 1990; Hu and Bentler, 1999). All data analyses were conducted using Stata (version 13.0; Stata Corp LLC, Texas, USA) and Mplus (version 8.0; Los Angeles, CA, USA).

3. Results

3.1. Reliability and validity results of the study instruments

The reliability results showed that Cronbach's α for all the constructs was >0.80 (Family Communication Scale α = 0.96; Family Health Scale α = 0.86; Loneliness Scale α = 0.86; PIU scale α = 0.93). The validity results for the four study instruments were analyzed with confirmatory factor analysis and demonstrated a high level of mono-factorial validity: family communication scale(RMSEA = 0.074, CFI = 0.998, and TLI = 0.996), family health scale(RMSEA = 0.070, CFI = 0.999, and TLI = 0.995), loneliness scale(RMSEA = 0.002, CFI = 0.999, and TLI = 0.999), and PIU instrument (RMSEA = 0.055, CFI = 0.999, and TLI = 0.998).

3.2. The PIU distribution

The overall prevalence of PIU among the study participants was found to be was 30.86 %. The PIU prevalence was highest among the youngest age group (12–19 years) at 48.18 %, and progressively decreased with age, reaching the lowest prevalence in the ≥60 years age group (14.88 %). The Northeast region exhibited the highest PIU prevalence at 40.20 %, followed by the Middle region at 34.10 %. Among family types, extended families showed the lowest PIU prevalence at 17.55 %, while prevalence increased with higher family income. Additionally, individuals not living with family members had a significantly higher PIU prevalence compared to those living with family members (28.44 %). The prevalence of PIU among different subgroups was presented in Supplementary File 3.

3.3. Preliminary tests

The distribution of family communication scores was inverted and U-shaped. The youngest (12–19 years group) and most elderly age group (≥ 60 years) had the lowest level of family communication (36.93 ± 8.88 for 12–19 years group; and 36.88 ± 7.67 for ≥ 60 years group). The 12–19 years age group had the highest PIU scores of 13.99 ± 5.61, while the >60 years group had the lowest level of PIU of 9.08 ± 4.68. The age groups of 12–19, 20–29, 30–39, and > 60 years had relatively higher levels of loneliness. As for the variable of the region of residence, the north and northwest regions had the highest level of family communication (38.65 ± 8.07 and 38.11 ± 7.49, respectively), while the northeast (12.86 ± 5.79) and middle regions (12.03 ± 5.62) had the highest level of PIU (Table 1).

The Skewness and Kurtosis tests revealed that the Family Health Score, Family Communication Score, Loneliness Score, and PIU Score deviated significantly from normal distribution ($p < 0.0001$). The Kruskal–Wallis test results showed that family climate, loneliness, and PIU scores differed significantly across different intrafamilial characteristic groups. As shown in Table 1, traditional family types had significantly higher scores of family communication (nuclear family = 38.07 ± 7.96, extended family = 37.56 ± 7.24) and family health (nuclear family = 39.53 ± 6.62, extended family = 38.43 ± 6.36) than nontraditional family types (35.56 ± 9.16 for family communication; 37.01 ± 7.13 for family health); traditional family types were also associated with lower levels of individual loneliness and PIU. Families with higher monthly incomes also indicated a higher level of family climate (39.08 ± 8.92&39.99 ± 7.27 for income>12,001; 36.48 ± 7.88& 37.62 ± 6.37 for income⟨3000). However, a higher level of family income was associated with higher PIU scores, with 12.82 ± 6.19 and 11.28 ± 5.48, respectively, for the highest and lowest income groups. Compared with not living with family members, participants living with family members rated higher levels of family health and lower prevalence of PIU (12.94 ± 5.81 vs. 11.36 ± 5.34) and loneliness (4.96 ± 1.75 vs. 4.45 ± 1.56). Comparisons of family climate, loneliness, and PIU across the different groups are presented in Table 1. Additionally, the results of the post-hoc analysis for multiple comparisons were presented in Supplementary File 4.

The means, standard deviations, and zero-order correlations for each study variable are presented in Table 2. As shown in Table 2, the constructs of family climate are positively correlated. Family health was significantly associated with family communication. High loneliness positively correlated with high PIU levels. Nevertheless, loneliness was negatively associated with family climate, as indicated by family communication and health. As expected, PIU negatively correlated with family climate. The zero-order correlations of PIU and family climate are presented in Table 2.

3.4. Theoretical model results

Structural equation modeling (SEM) was performed to validate the hypothesized model. Our sample showed a good model fit, with RMSE = 0.032, CFI = 0.99, and TLI-0.99. All hypotheses (H1 ~ H5) were validated at a significance level of $p < 0.05$. Specifically, the model findings showed that family communication and family health had −0.03 and − 0.08 direct effects on PIU, respectively. Loneliness was strongly and positively associated with PIU ($p = 0.455$, $p < 0.001$). Family communication and health had indirect effects of −0.12 and − 0.05, respectively, on PIU by the mediator of loneliness. Overall, family communication and health had total effects of −0.15 and 0.13 on PIU, respectively. Thus, the indirect effect explained 80.0 % of the total effect of family communication and 38.5 % of the total effect of family health on PIU. The detailed path coefficients and model results are shown in Fig. 2.

Table 1
Comparisons of family climate, loneliness, and PIU across different groups.

Characteristics	Family communication	p⁎	Family health	p⁎	Loneliness	p⁎	PIU	p⁎
Response Range	**10–50**		**10–50**		3–9		6–30	
Age groups		<0.001		<0.001		<0.001		<0.001
12–19 years	36.93 ± 8.88		38.81 ± 6.79		4.83 ± 1.76		13.99 ± 5.61	
20–29 years	37.37 ± 8.62		38.96 ± 7.00		4.74 ± 1.67		13.47 ± 5.42	
30–39 years	38.30 ± 8.28		38.05 ± 7.00		4.61 ± 1.60		12.00 ± 5.39	
40–49 years	38.38 ± 7.63		39.20 ± 6.70		4.37 ± 1.49		10.88 ± 4.91	
50–59 years	38.34 ± 7.25		39.35 ± 6.41		4.19 ± 1.44		10.02 ± 4.75	
≥ 60 years	36.88 ± 7.67		37.71 ± 6.48		4.44 ± 1.54		9.08 ± 4.68	
Sex		<0.001		<0.001		<0.001		0.270
Female	37.42 ± 8.04		39.09 ± 6.64		4.61 ± 1.61		11.60 ± 5.31	
Male	37.78 ± 8.28		38.23 ± 6.87		4.50 ± 1.61		11.79 ± 5.64	
Residence Region		<0.001		<0.001		<0.001		<0.001
North region	38.65 ± 8.07		38.94 ± 6.83		4.45 ± 1.65		11.84 ± 5.73	
Northeast region	37.30 ± 8.90		37.78 ± 7.35		4.81 ± 1.62		12.86 ± 5.79	
East region	36.70 ± 8.73		39.07 ± 7.06		4.54 ± 1.58		11.56 ± 5.26	
Middle region	37.45 ± 8.10		39.00 ± 6.81		4.76 ± 1.66		12.03 ± 5.62	
South region	37.06 ± 7.94		38.40 ± 6.52		4.49 ± 1.60		11.11 ± 5.29	
Southwest region	37.41 ± 7.98		38.33 ± 6.56		4.74 ± 1.64		11.74 ± 5.43	
Northwest region	38.11 ± 7.49		38.45 ± 6.40		4.39 ± 1.53		11.46 ± 5.32	
Family type		<0.001		<0.001		<0.001		<0.001
Nuclear family	38.07 ± 7.96		39.53 ± 6.62		4.53 ± 1.59		12.31 ± 5.32	
Extended family	37.56 ± 7.24		38.43 ± 6.36		4.30 ± 1.50		9.76 ± 4.87	
Childless family	37.64 ± 8.68		37.421 ± 6.93		4.56 ± 1.62		11.24 ± 5.62	
Other types of family†	35.56 ± 9.16		37.01 ± 7.13		5.02 ± 1.74		12.49 ± 6.03	
Family income monthly (yuan)		<0.001		<0.001		<0.001		<0.001
≤3000	36.48 ± 7.88		37.62 ± 6.37		4.61 ± 1.63		11.28 ± 5.48	
3001–5000	38.00 ± 8.05		38.89 ± 6.70		4.48 ± 1.57		11.45 ± 5.32	
5000–12,000	38.08 ± 8.24		39.27 ± 6.98		4.56 ± 1.60		12.21 ± 5.42	
≥ 12,001	39.08 ± 8.92		39.99 ± 7.27		4.62 ± 1.74		12.82 ± 6.19	
Whether living with family members		<0.001		<0.001		<0.001		<0.001
No	36.29 ± 8.84		37.34 ± 7.11		4.96 ± 1.75		12.94 ± 5.81	
Yes	37.95 ± 7.94		39.01 ± 6.63		4.45 ± 1.56		11.36 ± 5.34	

† Other types of family included single-parent families, stepfamilies, and grandparent families.
⁎ Kruskal–Wallis test, $p < 0.05$ significance level.

Table 2
Mean, standard deviations, and zero-order correlations between PIU and study variables.

Variables	Mean	SD	1	2	3	4
1. Family communication	37.60	8.16	–			
2. Family health	38.66	6.77	0.574***	–		
3. Loneliness	4.56	1.61	−0.281***	−0.271***	–	
4. PIU	11.70	5.48	−0.199***	−0.227***	0.402***	–

*** < 0.001.

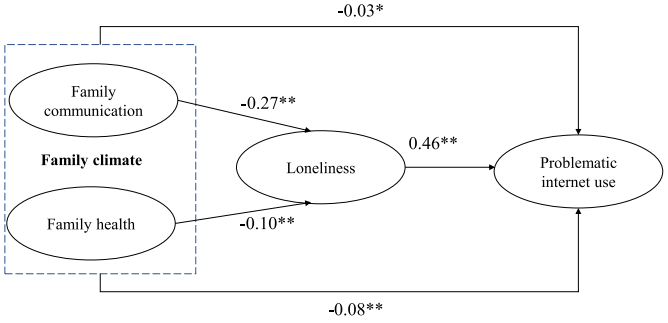

Fig. 2. The study hypothesized model results of family climate and PIU.

After controlling for covariates, the model results showed a good fit, with RMSE = 0.025, CFI = 0.99, and TLI = 0.99. Compared with a higher family monthly income, a lower family income of ≤3000 and 3000–5000 had negative effects on PIU of −0.088 and − 0.015, respectively. The effects of the intrafamilial characteristics (family type, income, and living with family members) on the PIU is presented in

Table 3
Effects of intrafamilial covariates on the SEM model.

Factors	Intrafamilial covariates	Coef	S.E.	p
Factor (PIU)	**Family type (Reference: Other nontraditional types)**			
	Nuclear family	−0.009	0.022	0.616
	Extended family*	−0.047	0.024	0.050
	Childless family	−0.016	0.021	0.455
	Family income monthly (Reference group: ≥ 12,001)			
	≤3000***	−0.127	0.022	<0.001
	3001–5000***	−0.088	0.022	<0.001
	5000–12,000	−0.015	0.021	0.488
	Living with family members (Reference group: Yes)			
	No	0.034	0.015	0.021
Factor (Loneliness)	**Family type (Reference: Other nontraditional types)**			
	Nuclear family***	−0.250	0.024	<0.001
	Extended family***	−0.288	0.029	<0.001
	Childless family***	−0.158	0.027	<0.001
	Family income monthly (Reference group: ≥ 12,001)			
	≤3000	0.005	0.029	0.855
	3001–5000**	−0.067	0.030	0.022
	5000–12,000	−0.031	0.029	0.284
	Living with family members (Reference group: Yes)			
	No	0.233	0.018	<0.001

* < 0.10.
** < 0.05.
*** < 0.001.

Table 3. Compared to nontraditional family types, the extended family type (−0.047, $p = 0.050$) was a protective covariate of PIU, while nuclear families (−0.250, $p < 0.001$), extended families (−0.288, $p < 0.001$), and childless families (−0.158, $p < 0.001$) were protective factors for individual loneliness. Additionally, not living with family members was found as a risk predictor of PIU (0.034, $p = 0.021$) and loneliness (0.233, $p < 0.001$). The covariate analyses of demographic characteristics (such as age and sex) were also conducted, and the results are presented in Supplementary File 5.

4. Discussion

4.1. Main findings

4.1.1. The PIU distribution

Our study had a high detection rate of PIU of approximately 30.86 %, with the proportion of PIU among 12–19 years age group being the highest, exceeding 40 %. This figure was consistent with the figure of 20.0–44.6 % based on meta-analysis results (Cai et al., 2023). However, it was considerably higher than the figure reported 10 years ago in a cross-sectional study, which was conducted in a large representative sample of 17, 599 students with a prevalence rate of 8.1 % among Chinese adolescents, especially high school students (Cao et al., 2011). Although the results should be interpreted with caution due to the different PIU measurements and study settings, the rapid increase in the rate of PIU should be given adequate attention.

Consistent with previous findings, the PIU distribution results showed that the younger population was the target population with the highest PIU levels among all age groups. Nevertheless, most existing research has focused on the PIU of youths and young adults. Little attention has been paid to PIU in older adults (Rochat et al., 2021). Although older adults constitute a part of the population with the lowest level of Internet use, with the rapid advancement of the Internet and an aging population, the potential benefits and problems raised by PIU among older adults deserve worldwide attention (d'Orsi et al., 2018; Kraut et al., 1998).

Our study also revealed that the respondents from different regions had different PIU levels. Respondents from the northeast and middle regions had the highest PIU levels. The aforementioned cross-sectional study also reported that respondents from the eastern and western regions had a higher prevalence of PIU (Cao et al., 2011). Nonetheless, the classification of the eastern, western, and middle regions is relatively crude and based on overall economic development. Several independent studies have been conducted in Guangzhou City, Wuhan City, Liaoning Province, Jilin Province, and Hong Kong with different study settings and instruments (Mei et al., 2016; Shek et al., 2019; Wu et al., 2013; Yang and Zhu, 2023); thus, the comparison data of PIU across different regions are limited. Therefore, the variation in PIU across different regions is likely explained by economic, cultural, or other factors that require further exploration. For example, one researcher presumed that residents in non-coastal regions (such as the middle and southwest regions) had more leisure time to spend online, as the life pace was considerably slower in non-coastal regions (Chi, 2009).

4.1.2. The direct relationship between family climate and PIU

This study proposed a theoretical model to examine the relationship between family climate and PIU. Based on a national survey sample, our study validated the proposed model with good fit indices.

The SEM model results confirmed the direct relationship between family climate and PIU and confirmed the direct effects of family climate on PIU with the mediating effects of loneliness.

Consistent with previous findings, a poor family climate is a crucial factor leading to PIU (Rega et al., 2023; Sela et al., 2020; Shi et al., 2023). Some evidence has shown that adolescents' positive communication with their parents is a major contributor to preventing engagement in problematic Internet behavior (Alt and Boniel-Nissim, 2018), whereas family conflicts were identified as contributors to PIU. For example, Dorit Alt et al. showed that poor parent-child communication negatively affected PIU (Alt and Boniel-Nissim, 2018). Additionally, a high level of family health, indicated by safe family relationships, a healthy family style, and external resources and support, was negatively associated with PIU. Although limited research has directly explored the relationship between family health and PIU, several studies have suggested that family health-related characteristics, such as intensive family conflicts, low cohesion, poor family support, and limited resources, are significant risk factors influencing PIU (Sela et al., 2020; Zhu et al., 2022).

4.1.3. The mediating effects of loneliness on the relationship between family climate and PIU

Furthermore, the mediating effects of loneliness due to the family climate on PIU were explored.

Consistent with previous research and meta-analysis, PIU was related to feelings of loneliness. Notably, participants with a sense of loneliness are likely to have PIU when they have negative thoughts (Wongpakaran et al., 2021). Positive communication activities, such as being good listeners, calmly discussing problems, and understanding how family members feel, can help create a positive and supportive atmosphere for family members, which can help reduce feelings of loneliness and isolation (Guo et al., 2021). Respondents with PIU usually report less communication and conflicting family communication (Nannatt et al., 2022). Poor communication, in turn, makes it difficult for family members to provide the personal and social support and resources necessary to deal with problematic Internet behavior, such as cyberbullying (Cañas et al., 2020; Ortega-Barón and Cava, 2016). Family is an important source of social support. Family communication, support, positive relationships, and resources provide material security and help eliminate emotional and social loneliness.

As indicated by the direct path effects of SEM, the important role of family climate in controlling PIU should receive full attention. Simultaneously, the mediating effects of loneliness on the path between family communication and PIU were much higher than the path between family health and PIU (−0.12 vs. -0.05). The dominance-mediating path of family communication and PIU highlights the importance of eliminating loneliness in controlling PIU. Effective strategies targeting the reduction of loneliness (such as increasing social support from peers and communities or increasing social contact) may serve as supplementary measures to reduce the negative effects of a poor family climate on PIU (Masi et al., 2011).

4.1.4. The covariates effects on the theoretical model

The covariate analyses further confirmed the protective effects of the extended family type on PIU. Specifically, this study indicated that the level of PIU was higher among individuals from nuclear family types than among individuals from an extended family, similar to findings in previous studies. Individuals from nuclear families are likely lonelier than those living in extended families (Antognoli-Toland, 2001) and turn to the Internet to meet interpersonal needs and increase their Internet use (Islam et al., 2020). Moreover, not living with family members was a risk predictor for individual loneliness and PIU. The explanation for individuals from nuclear family type also seems plausible for the variable "whether living with family members." Staying alone without family members leads individuals to turn to the Internet for interaction and increases their Internet use time. Additionally, a lower family income was found to be a protective factor against PIU and loneliness. Lai and Kwan (2017) explored socioeconomic background effects on PIU in Hong Kong and confirmed that higher family income was a risk factor.

4.2. Practice implications

The Chinese government recognizes PIU as a serious threat to public

health. A high level of PIU was identified based on this nationally representative sample, especially among young adolescents and the regions of middle and northwest China. The 12–19 age group and regions with a high prevalence of PIU should be prioritized. Policymakers implemented several measures to control PIU. For example, The Chinese government is currently working on the Regulation on the Network Protection of Minors (draft for comment) (Department of Public Security's Cybersecurity and Internet Protection, 2022). The Regulation requires that comprehensive and effective measures be taken to control PIU among minors by multiple departments and agencies (such as the state, local governments, press and publication industry, and the Internet industry). Recently, the State Press and Publication Administration released a notice on the strict management of Internet games to control PIU among teenagers (Administration of The State Press and Publication, 2021). Internet enterprises are required to provide Internet games for only one hour on a specific day.

However, the balance and management of Internet use among older adults—a controversial topic (Hunsaker and Hargittai, 2018) —should be given adequate attention. We hope elders can actively increase Internet use to enjoy the resultant convivence and benefits, including making friends and reducing isolation, especially under the rapid development of the Internet age. Nevertheless, addictive Internet use and potential risks, such as Internet fraud among the elderly population, are critical concerns.

This study may also imply that a positive family climate indicated by positive communication and a healthy family may be effective in preventing engagement in PIU directly or indirectly by mediating the feeling of loneliness. Thus, it is critical to develop strategies for building a positive family climate among family members. For example, in the dimension of family communication, being good listeners, expressing affection, and understanding how family members feel are useful communication skills for improving communication and establishing positive relationships. Families also play a critical role in providing resources to maintain health and prevent diseases. Strategies for acquiring family resources and support must be undertaken to ensure a healthy family climate. In summary, optimizing the family climate or atmosphere through positive communication skills and improving the level of family health can help control problematic PIU and relieve the sense of loneliness.

4.3. Study limitation

This study has several limitations. First, the nature of cross-sectional data can prevent definitive statements about the causality between PIU and family climate factors. Future research with a longitudinal study design should be conducted to examine the causal relationships between PIU, loneliness, and family climate to complement the current findings. Second, this study relied on a self-report survey that reflected only respondents' perspectives. Future reports from multiple informants (such as parents or peers) and data (such as qualitative and quantitative data) should be included to enrich the research data and further explore the potential mechanisms and relationships between family climate, PIU, and other important mediators.

5. Conclusions

Our study findings confirmed the high level of PIU based on a nationally representative sample and identified the key age group of 12–19 years and geographical locations of the middle and northeast regions with high PIU levels. However, as expected, our study validated the proposed theoretical model of family climate and PIU with good fit indices.

A good family climate, as indicated by positive communication and a healthy family, had direct protective effects on preventing loneliness and PIU. Loneliness mediated the indirect effects of family climate on PIU. The covariate analyses also identified extended family type and low family income as protective factors, and not living with family members as a risk factor for engaging in PIU. Strategies to promote and improve the family climate, such as improving family communication, acquiring family resources, and family support, must be undertaken to prevent the occurrence of PIU.

Ethics

This study has been approved by the Shaanxi Institute of International Trade and Commerce (JKWH-2022-02).

CRediT authorship contribution statement

Chenxi Liu: Writing – original draft, Formal analysis, Software. **Xi Wang:** Conceptualization, Writing – original draft. **Xinyi Zhang:** Formal analysis, Investigation. **Yushu Liu:** Formal analysis. **Rujiao Lin:** Formal analysis, Software. **Yibo Wu:** Conceptualization, Writing – review & editing. **Dan Wang:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that this study was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

Data availability

The datasets used and analyzed in this study will be made available by the corresponding author upon reasonable request.

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