# Problematic use of the internet among adolescents: A four-wave longitudinal study of trajectories, predictors and outcomes

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## ABSTRACT

*Background and aims:* Problematic use of the internet (PUI) among adolescents has become one of the public problems around the world. Understanding the developmental trajectory of PUI may be beneficial to develop prevention and intervention. The current study aimed to identify the developmental trajectories of PUI among adolescents, considering individual differences over time. And also explored how familial factors contributed to the identified trajectories, and the relationship between PUI changes over time and social, mental health, and academic functioning. *Methods:* A total of 1,149 adolescents ($M_{age}$ = 15.82, $SD$ = 0.61; 55.27% girls at Wave 1) participated in assessments at four time points, using 6-month assessment intervals. *Results:* Based on a latent class growth model, three trajectories of PUI were identified: Low Decreasing, Moderate Increasing, and High Increasing groups. Multivariate logistic regression analyses suggested that inter-parental conflicts and childhood maltreatment served as negative familial predictors for the risk trajectories of PUI (i.e., Moderate Increasing and High Increasing groups). Additionally, adolescents in these two groups displayed more estranged interpersonal relationships, more mental health difficulties, and poorer academic functioning. *Discussion and conclusions:* It is important to consider individual differences in understanding the developmental patterns of PUI among adolescents. Identifying family predictors and the behavioral outcome associated with groups with different developmental trajectories of PUI, which may help to understand better risk factors related to specific developmental patterns of PUI and its adverse correlates. The findings highlight a need to develop more specific effective intervention programs for individuals displaying different problematic developmental trajectories with PUI.

## KEYWORDS

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## INTRODUCTION

The internet is being used increasingly widely among adolescents (Gunuc & Dogan, 2013). When not used appropriately, the internet may constrain individuals' development and lead to

problematic use of the internet (PUI). PUI, also known as "internet addiction" (Ioannidis et al., 2021), refers to excessive and compulsive use of the internet despite negative consequences (Lai, Wang, Guo, & Lu, 2022; Vondráčková & Gabrhelík, 2016). PUI is considered a major public health issue around the world, especially in East Asian countries like China (Kuss, Kristensen, & Lopez-Fernandez, 2021). According to a national study of China, the prevalence of PUI among adolescents was 11.90% (Li, Zhang, Lu, Zhang, & Wang, 2014). Excessive use of the internet has been associated with a wide range of developmental problems among adolescents, including interpersonal conflicts, mental health concerns, and academic difficulties (Özaslan, Yıldırım, Güney, Güzel, & İşeri, 2022; Thomas et al., 2022; Zhang, Qin, & Ren, 2018). Given the high prevalence of PUI and its negative correlates, there is a significant need to investigate PUI among adolescents.

PUI may be a long-lasting issue, and individual differences exist (e.g., Coyne et al., 2020; Zhou, Zhen, & Wu, 2018). Based on the theoretical and empirical studies (e.g., Mascolo, van Geert, Steenbeek, & Fischer, 2016; Tóth-Király, Morin, Hietajärvi, & Salmela-Aro, 2021), this study investigated the latent distinct trajectories of PUI of youth in an effort to understand further the heterogeneity of PUI developmental patterns. In addition, familial predictors and adjustment outcomes associated with distinct PUI trajectories were also examined. Such information may provide a better foundation for the development of improved prevention and intervention efforts.

## Developmental trajectories of PUI

Drawing upon the dynamic systems model of developmental psychopathology and empirical studies (e.g., Jia, Tong, Zhang, Liu, & Fang, 2021; Mascolo, et al., 2016), understanding PUI from longitudinal perspectives could provide a meaningful lens for understanding the development process of it. Of note, studies have suggested that trajectories of PUI exist reflecting inter-individual variations (e.g., Tóth-Király et al., 2021), with not all adolescents experiencing a similar trajectory. Therefore, an important question is what are the developmental patterns of adolescent PUI.

To address this issue, a few of studies have examined distinct trajectories of PUI (Coyne et al., 2020; Li, Hou, Yang, Jian, & Wang, 2019; Yu & Park, 2017; Zhou et al., 2018). In these studies, two to four groups with distinct trajectories were identified, reflecting stability, improvement, and deterioration in PUI, respectively. Different studies have failed to reach consensus on the subgroups of PUI trajectories, and only two characteristics seemed consistent: most adolescents exhibited low levels of PUI over time (i.e., non-problematic group), and a smaller group demonstrated a higher level of PUI over time. While some previous studies have provided information about heterogenous PUI trajectories, more studies are needed to understand key issues, including identification of subgroups of PUI trajectories. Additionally, high attrition (from 25.10% to 36.05%) or relatively small samples (e.g., 385 or 391 participants) in some prior studies reinforce the need for more investigation.

## Familial risk factors and PUI

Identifying the antecedents of PUI could improve the pertinence and effectiveness of prevention and intervention efforts (Zhou et al., 2018). An individual's developmental outcomes are shaped by different ecological systems and individual characteristics (Bronfenbrenner, 1979). Compared to factors such as personality features and psychiatric disorders (e.g., ADHD), modifiable environmental factors (e.g., family context) may be particularly helpful as targets for intervention programs. Familial context is a particularly enduring and central social unit for the development of adolescents (Benson & Buehler, 2012; Bronfenbrenner & Ceci, 1994; Gerard & Buehler, 1999). A harmonious family context is beneficial, while a conflictual family context is averse to adolescents' well-being (Zhou et al., 2017). Within the family, childhood maltreatment and parental conflict occur with relatively common frequency, may negatively impact adolescent daily life and have been documented to relate to PUI (e.g., Wu et al., 2022; Zhou et al., 2017). According to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand, Young, Laier, Wölfling, & Potenza, 2016), individuals who have experienced maltreatment might try to deal with their social and/or emotional problems related to traumatic childhood experiences (Maguire et al., 2015) via frequent or excessive use of the internet. Based on emotional security theory (Davies & Woitach, 2008), frequent and intense inter-parental conflicts often provoke emotional insecurity in adolescents. To alleviate stressful feelings, adolescents may use the internet to escape (Zhou et al., 2017). In addition, childhood maltreatment in combination with inter-parental conflicts may also have an important impact on adolescents' use of the internet and development of PUI (Brand et al., 2016; Lam & Wong, 2015).

Studies have provided some information about links between childhood maltreatment, parental conflict and PUI (e.g., Wu et al., 2022; Zhou et al., 2017). However, it remains unclear how these potential familial risk factors may shape distinct PUI trajectories. To explore the potential impact of familial environment on developmental patterns of PUI, childhood maltreatment and parental conflict were measured at baseline in the present study.

## Relationships between PUI and adolescent adjustment

Adolescents engaging in more severe PUI may experience considerable developmental difficulties (e.g., Tóth-Király et al., 2021; Zhang et al., 2018; Zhou et al., 2017; van den Eijnden, Koning, Doornwaard, van Gurp, & ter Bogt, 2018). In this study, we focused on social, mental health and academic functioning, given that these are main developmental domains and tasks in adolescence, and difficulties in these areas may affect long-term emotional well-being, educational achievements, and occupational success (Cohen, Andrews, Davis, & Rudolph, 2017; Xu et al., 2022; Zhang et al., 2018).

Socially, youth benefit over time from building healthy social bonds with multiple individuals (e.g., parents, teachers,

and peers) during adolescence (Anderman, 2003; Xu et al., 2022). However, frequent use of the internet, and especially PUI, may preclude adolescent real-life relationships (Whang, Lee, & Chang, 2003). Compared to challenging social interactions in real life, online communications may offer a greater sense of instant satisfaction and ease of self-disclosure for adolescents (Özaslan et al., 2021; Samantray, 2015). In addition, adolescents may conceal or lie about frequency of their online behaviors (Young, 2009), and this may contribute to conflicts with others, especially with parents and teachers.

PUI has been related to a wide range of psychopathological symptoms and disorders, particularly depression and anxiety (Laconi, Vigouroux, Lafuente, & Chabrol, 2017; Salmela-Aro, Upadyaya, Hakkarainen, Lonka, & Alho, 2017). Based on the I-PACE model (Brand et al., 2016), internet use may initially serve to alleviate negative emotions; however, when increasing unchecked over time, benefits of emotional regulation may gradually disappear and be replaced by negative consequences (e.g., depression and anxiety). Moreover, self-esteem, defined as an evaluation of one's general worth (Robins, Hendin, & Trzesniewski, 2001), reflects overall psychological well-being. PUI, especially that involving social media, may promote social comparison, potentially leading to dissatisfaction with one's life and thus lower levels of self-esteem, especially in adolescents (Lai et al., 2022).

PUI also commonly triggers negative academic-related outcomes, including low academic motivation (Reed & Reay, 2015). School engagement is an observable and central manifestation of underlying motivation, and it is closely related to academic success (Skinner, Furrer, Marchand, & Kindermann, 2008; Tao, Meng, Gao, & Yang, 2022; Zhang et al., 2018). Youth with PUI often neglect or delay their school work, thus reducing their academic investment (Aznar-Díaz, Romero-Rodríguez, García-González, & Ramírez-Montoya, 2020; Liu, Xu, Zhang, Tian, & Wu, 2022; Zhang et al., 2018). Moreover, school engagement is a meta-construct comprised of behavioral, cognitive and emotional dimensions (Fredricks, Blumenfeld, & Paris, 2004; Li & Lerner, 2012). Few existing studies examine associations between PUI and different dimensions of school engagement, and exploring relationships may provide insights that may help develop improved interventions (Li & Lerner, 2012; Pietarinen, Soini, & Pyhältö, 2014; Wang & Eccles, 2011).

Some cross-sectional and fewer longitudinal studies have suggested that PUI may predict difficulties in social, mental health and academic domains (e.g., Tóth-Király et al., 2021; Zhang et al., 2018). Little is known whether latent distinct trajectories of PUI significantly differ with respect to social, mental health, and academic functioning. Given that previous studies suggested that variations in PUI also produced variations in adolescent adjustments over time (Tóth-Király et al., 2021), this study aimed to clarify further the relationships between the extracted trajectories and time-specific social, mental health, and academic function in a distinct geographic and cultural region to better understand these trajectories.

## Present study

The current study aimed to identify: (a) possible heterogeneous trajectories of PUI among adolescents using data from four assessments (Wave1 to Wave 4), (b) how childhood maltreatment and parental marital conflict at Wave 1 may influence developmental patterns of PUI in adolescents, and (c) the time-specific associations between distinct PUI trajectories and measures of social, mental health and academic functioning, with these measures collected from Wave 1 to Wave 4.

Based on existing findings, we hypothesized that (a) at least two developmental trajectories would be identified, with one having non-problematic internet use and another with higher levels of PUI, (b) youth experiencing more severe inter-parental conflicts and child maltreatment would be more likely to belong to a trajectory group with greater PUI, (c) a less problematic trajectory group would be associated with more cohesive social relations, fewer mental difficulties, and better academic functioning, while a more problematic trajectory group would be associated with worse performance and functioning. In previous studies, age, sex/gender, and familial socioeconomic status (SES) have been related to PUI in adolescents (Chi, Hong, & Chen, 2020; Li et al., 2018), Therefore, these variables were controlled in analyses.

## METHODS

### Participants

The current sample was derived from a larger project investigating Chinese adolescents' well-being. Adolescents participated in the assessment at four time points, from 2020 to 2022. In the fall of 2020 (i.e., Wave 1), 1,183 high school students ($M_{age}$ = 15.88, $SD$ = 1.20; 55.1% of girls) in the 10th and 11th grade were recruited from a public senior high school in Shandong, an eastern province in China. Specifically, 51.5% of students were from Grade 10 ($M_{age}$ = 15.55 years; $SD$ = 1.53) and 48.5% from Grade 11 ($M_{age}$ = 16.24 years; $SD$ = 0.48). During the follow-up from the spring of 2021 to the spring to 2022, 94.93%, 81.91%, and 82.25% of adolescents were retained, respectively. Being absent from school and transferring to another school at the time of the assessment may were main reasons for attrition. To ensure reliable and valid individual estimates of trajectories, only data from adolescents who participated during at least two time points were used. This resulted in a final sample of 1,149 participants ($M_{age}$ = 15.82, $SD$ = 0.61; 55.27% girls).

To evaluate longitudinal attrition, we conducted $t$-tests to compare adolescents who participated in all four measurements to those who missed at least once measurement in data collection on demographic variables (i.e., age, sex/gender, and SES) at Wave 1. Adolescents who missed measurements at least once during data collection did not differ from those who participated in measurements at all time points in sex/gender or SES. However, adolescents who

did not complete all waves were older ($t = 6.22$, $p < 0.001$) at Wave 1. Full Information Maximum Likelihood (FIML) analyses were employed for model estimations.

## Procedures

Adolescents were asked to complete a survey (approximately 40 min) independently, with research assistants present to answer any possible questions. At each measurement, before completing the questionnaire, the researchers informed students of the voluntary nature of participation and their right to withdraw any time without experiencing any personal expenses/consequences. After completion of the survey each time, each student received a gift (e.g., notebooks) that was worthy of approximately $3.

## Measures

***Problematic use of the internet at Wave 1 to Wave 4.*** PUI was assessed using the 26-item Chen Internet Addiction Scale (CIAS; Chen, Weng, Su, Wu, & Yang, 2003). Items (e.g., *"I feel depressed when I am offline."*) were rated on 4-point response scales ranging from 1 (*not at all true*) to 4 (*always true*). Sum scores were analyzed with higher scores indicating higher PUI risk. Participants who obtained a score less than 43 points indicated a minimal risk of PUI. Scores between 43 and 64 points were considered as at-risk PUI, and scores above 64 were considered as PUI (Poskotinova, Krivonogova, & Zaborsky, 2021; Tereshchenko et al., 2021). Cronbach's alpha for the PUI items from Wave 1 to Wave 4 were 0.98, 0.98, 0.98, 0.99, respectively.

***Inter-parental conflict at Wave 1.*** Inter-parental conflict was assessed with the 7-item measure from Grych et al.'s (1992) Children's Perception of Inter-parental Conflict Scale (CPIC) and Buehler et al.'s (1998) questionnaire. Items (e.g., *"Shouted at partner?"*) were rated on 4-point response scales ranging from 1 (*never*) to 4 (*often*). Sum scores were computed and used in analyses, with higher scores indicated higher inter-parental conflict. Cronbach's alpha in this study at Wave 1 was 0.90.

***Childhood maltreatment at Wave 1.*** Childhood maltreatment was assessed using the 28-item Childhood Trauma Questionnaire (Bernstein et al., 2003). Items (e.g., *"People in my family called me things like stupid, lazy, or ugly."*) were rated on 5-point response scales ranging from 1 (*never true*) to 5 (*very often true*). Sum scores were computed, and higher scores reflected more childhood trauma. Cronbach's alpha in this study at Wave 1 was 0.92.

***Depression at Wave 1 to Wave 4.*** Depression was assessed using the 20-item Chinese version of Zung's self-rated depression scale (SDS; Zung, 1965). Items (e.g., *"I feel downhearted and blue."*) were rated on 4-point response scales ranging 1 (*a little of the time*) to 4 (*most of the time*). Sum scores were analyzed, with higher scores indicating greater depression. Cronbach's alpha for the depression items from Wave 1 to Wave 4 were 0.89, 0.90, 0.91, 0.91, respectively.

***Anxiety at Wave 1 to Wave 4.*** Anxiety was measured using the 20-item Chinese version of Zung's self-rating anxiety scale (SAS; Zung, 1971). Items (e.g., *"I feel more nervous and anxious than usual."*) were rated on 4-point response scales ranging from 1 (*a little of the time*) to 4 (*most of the time*). Sum scores were analyzed, with higher scores indicating greater anxiety. Cronbach's alpha for the anxiety items from Wave 1 to Wave 4 were 0.87, 0.89, 0.90, 0.89, respectively.

***Self-esteem at Wave 1 to Wave 4.*** Self-esteem was assessed using the 10-item Rosenberg Self-Esteem Scale (Rosenberg, 1965) to assess adolescents' perceptions about themselves. Items (e.g., *"On the whole, I am satisfied with myself."*) were rated on 4-point response scales ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Sum scores were computed and used in analyses with higher scores indicating higher self-esteem. Cronbach's alpha for the self-esteem items from Wave 1 to Wave 4 were 0.88, 0.88, 0.85, 0.86, respectively.

***Parental-child relationships at Wave 1 to Wave 4.*** Parental-child relationships were assessed using the 18-item Closeness to Parents Scale (Buchanan, Maccoby, & Dornbusch, 1991). Father-adolescent and mother-adolescent relationships were assessed separately with the same expressions in 9 items. Items (e.g., *"How close do you feel to your mother/father?"*) were rated on 5-point response scales ranging from 1 (*not at all*) to 5 (*very*). Sum scores were computed with higher scores indicating better relationships with parents. Cronbach's alpha for the parental-child relationship items from Wave 1 to Wave 4 were 0.96, 0.97, 0.98, 0.98, respectively.

***Teacher-student relationships at Wave 1 to Wave 4.*** Teacher-student relationships were measured with the 23-item Student-Teacher Relationship Scale (STRS), developed by Pianta (1994). Zou, Qu, and Ye (2007) revised this questionnaire from the perspective of student reports. The revised questionnaire consists of 23 items. Items (e.g., *"The current relationship with my teacher is exactly what I hope for."*) were rated on 5-point response scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sum scores were analyzed with higher scores indicating better relationships with teachers. Cronbach's alpha for the teacher-student relationship items from Wave 1 to Wave 4 were 0.92, 0.92, 0.93, 0.93, respectively.

***Peer relationships at Wave 1 to Wave 4.*** Peer relationships were assessed using the 25-item Inventory of Parent and Peer Attachment (IPPA; Armsden & Greenberg, 1987). Items (e.g., *"My friends' sense when I'm upset about something."*) were rated on 5-point response scales ranging from 1 (*almost never or never*) to 5 (*almost always or always*). Sum scores were analyzed with higher scores reflecting better relationships with peers. Cronbach's alpha for the peer relationship items from Wave 1 to Wave 4 were 0.92, 0.92, 0.92, 0.92, respectively.

***School engagement at Wave 1 to Wave 4.*** School Engagement was assessed using the 15-item Behavioral-Emotional-Cognitive School Engagement Scale (BEC-SES) to measure

tripartite school engagement (Li & Lerner, 2012). The BEC-SES include three dimensions reflecting behavioral (e.g., "*Do you often actively participate in class group discussions?*"), emotional (e.g., "*I feel part of my school*"), and cognitive (e.g., "*I think the things I learn at school are useful*") engagement. The response format ranged from 1 (*never*) to 4 (*always*). Sum scores were analyzed with higher scores indicating more school engagement. The Cronbach's alphas for the behavioral, emotional, and cognitive engagement from Wave 1 to Wave 4 ranged from 0.68 to 0.97.

## Statistical analysis

*SPSS* 25.0 and *Mplus* 8.3 were used to analyze data. Pearson correlations were used to test correlations between main variables. Latent growth curve modeling (LGCM) was employed to test the overall trajectory of PUI. Additionally, sex/gender differences in the overall trajectory of PUI were evaluated by multi-group LGCM analyses. Specifically, an initial unconstrained model was estimated that allowed all trajectory parameters to vary for girls and boys, followed by an additional nested model estimated under restrictive constraints that set all parameters to be equal between girls and boys. Model comparisons used Satorra-Bentler scaled Chi-square difference tests. Latent class growth model (LCGM) was used to determine the heterogeneity of PUI trajectories. LCGM is a person-centered approach, which identifies classes of individuals with similar change/growth trajectories on a quantitative outcome of longitudinal measurements (Jung & Wickrama, 2008). In the same class, individuals have similar responses. The robust Maximum Likelihood Estimator (*MLR*) in *Mplus* was used to handle data with non-normal distributions.

The LCGMs were specified with varying numbers of classes (i.e., 1 to 6 classes), and for each model, model fit was assessed using a combination of fit indices including the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample size-adjusted Bayesian information criterion (ABIC), Lo-Mendel-Rubin Likelihood Ratio Test (LMR-LRT), bootstrap likelihood ratio tests (BLRT), entropy, and the sample size (Nylund, Asparouhov, & Muthén, 2007). Smaller values of the AIC, BIC, and ABIC are indicative of better model fit (McDonald & Lochman, 2012). Non-statistically significant LMR-LRT and BLRT values suggest that a model with one fewer class is preferred (Nylund et al., 2007). An entropy value greater than 0.70 is indicative of a model with acceptable classification precision (Wu et al., 2022). Sample sizes within each class were deemed to be needed to be greater than 5% to be interpretable/generalizable. In addition to examining these fit indices, the qualitative nature of the classes was assessed to ascertain that they were conceptually meaningful and interpretable (Nylund et al., 2007).

Following determination of the number of trajectories, the R3-step approach based on logistic regression analysis was used to examine predictors of trajectories (Asparouhov & Muthén, 2014a). For example, R3-step approaches were used to examine the roles of childhood maltreatment and

parental conflicts at baseline in PUI trajectory membership, after controlling for the effects of age, sex/gender, and SES. Finally, this study also examined how the extracted latent classes explained the interpersonal relationships, mental health, and academic engagements over time, based on the Bolck-Croon-Hagenaars (BCH) approach. These methods consider the uncertainty in classification (Asparouhov & Muthén, 2014b; Bakk, Oberski, & Vermunt, 2014).

## Ethics

All procedures of this study were approved by the Institutional Review Board (IRB) of the State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University and the relevant school principals and teachers. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all studied adolescents and their parents. All participants were informed of the voluntary nature of participation and their right to withdraw any time without experiencing any personal expenses/consequences.

# RESULTS

## The heterogeneous trajectories of PUI

The means, standard deviations, and correlations of/between the study variables are displayed in the supplemental materials (Table S1 - Table S4). Model comparisons using LGCM showed that the linear model fit the data better than the quadratic model for PUI ($\Delta\chi^2_{SB\,(4)} = 1.83$, $p > 0.05$). The variances of the linear LGCM model for PUI included the intercept ($\sigma^2_i = 97.96$, $p < 0.001$) and slope factor ($\sigma^2_s = 8.85$, $p < 0.01$) being significantly different from zero, suggesting individual differences in pathways or trajectories of PUI. Prior to the LCGM analyses, sex/gender differences in the overall trajectory of PUI were evaluated by multi-group analysis. Based the results ($\Delta\chi^2_{SB\,(4)} = 6.29$, $p > 0.05$), there were no gender-related differences, suggesting that the overall trajectory was similar across boys and girls.

Model fit indices for the LCGM are reported in Table 1. Across models with 1–6 classes, the results indicated that the AIC and BIC scores decreased as the number of classes increased. Except for class 2, other entropy values were consistently high (above 0.80). Both the LMR-LRT and BLRT were statistically significant across all models. The classes 4 to 6 were less than 5% of the sample (only 1.82%, 1.65%, and 1.48%, respectively), and these were deemed to be statistically unrepresentative and to have limited generalizability. Furthermore, considering the meaningful of class, the three-class solution added a meaningful class to the two-class solution (initially higher and sharply increasing trajectories of PUI). However, the four-class solution, five-class solution, and six-class solution added one to three
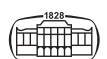
Table 1. Model fit indices for latent class growth model (N = 1,149)

| Number | Log Likelihood | AIC | BIC | ABIC | Entropy | LMRT | BLRT | Mini Class Size (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | −17715.76 | 35443.53 | 35473.81 | 35454.75 | – | – | – | – |
| 2 | −17319.58 | 34657.15 | 34702.57 | 34673.99 | 0.71 | <0.05 | <0.05 | 47.43 |
| **3** | **−17181.79** | **12729.635** | **34448.14** | **34410.02** | **0.88** | **<0.05** | **<0.05** | **7.92** |
| 4 | −17054.93 | 34139.86 | 34215.56 | 34167.92 | 0.90 | <0.05 | <0.05 | 1.82 |
| 5 | −17007.94 | 34051.89 | 34142.73 | 34085.55 | 0.89 | <0.05 | <0.05 | 1.65 |
| 6 | −16877.48 | 33796.96 | 33902.94 | 33836.24 | 0.89 | <0.05 | <0.05 | 1.48 |

*Note:* AIC = Akaike information criterion; BIC = Bayesian information criterion; ABIC = sample size-adjusted Bayesian information criterion; LMR-LRT = Lo-Mendel-Rubin Likelihood Ratio Test; BLRT = bootstrap likelihood ratio tests; Bold indicate final class solution.

classes that were similar to one or more existing classes in the three-class solution. Taking the fit indices and the interpretability of the trajectory patterns together, the three-class model was considered as the "optimal" solution. The average latent class probabilities for the most likely class membership ranged from 0.92 to 0.95, further demonstrating the robustness of the three-class model.

Three latent trajectories classes were identified (Fig. 1). The first, termed Low Decreasing (45.26% of the sample, $n = 520$), exhibited initially low and subsequently decreasing PUI trajectories and had the lowest levels of PUI over time ($M_{intercept} = 40.33$, $p < 0.001$; $M_{slop} = -3.94$, $p < 0.001$). The second, termed Moderate Increasing (46.82% of the sample, $n = 538$), exhibited higher initial levels of PUI that increased over time, with moderate levels of PUI ($M_{intercept} = 49.45$, $p < 0.001$; $M_{slop} = 1.21$, $p < 0.001$). The third, termed High Increasing (7.92% of the sample, $n = 91$), displayed higher levels of PUI at Wave 1, with increasing PUI over time ($M_{intercept} = 51.00$, $p < 0.001$; $M_{slop} = 9.37$, $p < 0.001$). The means for each time point and growth parameters of each group are shown in supplementary materials (Tables S5).

Group differences relating to PUI at each time point were also examined. For PUI at baseline, the Low Decreasing group ($M_{observed} = 38.66$; $M_{estimate} = 40.33$) exhibited lower levels

of PUI than the other two groups. There was no significant statistical difference between the Moderate Increasing ($M_{observed} = 50.40$; $M_{estimate} = 49.45$) and High Increasing groups in the initial level of PUI ($M_{observed} = 54.23$; $M_{estimate} = 51.00$). From Wave 2 to Wave 4, there were significant differences in PUI levels among the three groups. Specifically, the High Increasing group had the highest levels of PUI (observed mean from 57.64 to 80.08; estimated mean from 60.37 to 79.10). The Moderate Increasing group had a moderate level of PUI (from 50.50 to 53.27 for observed; from 50.66 to 53.08 for estimated). PUI in the Low Decreasing group was the lowest (from 36.05 to 28.04 and from 36.38 to 28.49 for observed and estimated mean respectively). Details are shown in supplementary materials (Tables S5).

## Familial predictors of distinct PUI trajectories

Compared with the Low Decreasing group, adolescents who experienced higher childhood maltreatment (OR = 1.02, 95% CI [1.003, 1.029]; OR = 1.04, 95% CI [1.018, 1.056]) were more likely to belong to the Moderate Increasing and High Increasing groups. Adolescents who experienced more childhood maltreatment were more likely to be in the High Increasing group (OR = 1.02, 95% CI [1.004, 1.038]), rather
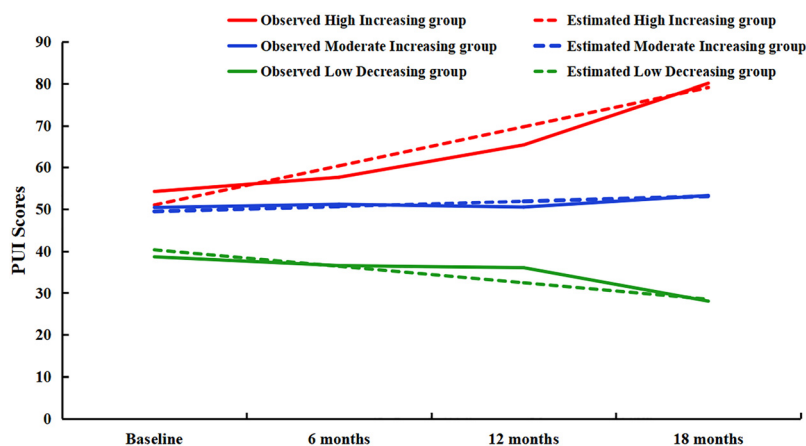


Fig. 1. Trajectories of observed and estimated growth curves for PUI across four time points

than the Moderate Increasing group. Compared with the Low Decreasing group, adolescents experiencing higher parental conflicts (OR = 1.07, 95% CI [1.022, 1.120]) were more likely in the Moderate Increasing group.

## Adolescent adjustments in different developmental trajectories of PUI

Results from the comparisons of the time-specific indicators of social, mental health, and academic functioning across the

three identified trajectories of PUI, controlling for the effects of age, sex/gender, and SES, are shown in Table 2 and Table S6. Youth in the High Increasing group showed the worst level of mental health over time, followed by those in the Moderate Increasing group, and finally those in the Low Decreasing group. In addition, with changes in PUI, differences in most indicators between the Moderate Increasing and High Increasing groups showed corresponding changes. Specifically, for depression and self-esteem, the High Increasing and Moderate Increasing groups showed

*Table 2.* Mean and standard error in family predictors and adolescent adjustment outcomes across latent PUI development trajectories

| | | Time point | Profile 1 (Low decreasing) N = 520 | Profile 2 (Moderate increasing) N = 538 | Profile 3 (High increasing) N = 91 | Summary of significant differences |
|---|---|---|---|---|---|---|
| Predictors | | | | | | |
| | Childhood maltreatment | Baseline | 36.32 (0.60) | 39.49 (0.63) | 44.56 (1.98) | 1 < 2 < 3 |
| | Parental conflicts | Baseline | 9.83 (0.19) | 11.06 (0.19) | 11.57 (0.58) | 1 < 2 = 3 |
| Outcomes | | | | | | |
| Social relationship | Parent-child relationship | Baseline | 69.22 (0.77) | 65.08 (0.67) | 62.82 (2.04) | 1 > 2 = 3 |
| | | 6 months | 70.75 (0.80) | 65.37 (0.69) | 65.63 (1.93) | 1 > 2 = 3 |
| | | 12 months | 68.82 (1.01) | 62.15 (0.81) | 62.26 (1.98) | 1 > 2 = 3 |
| | | 18 months | 69.27 (1.10) | 62.78 (0.70) | 63.12 (1.74) | 1 > 2 = 3 |
| | Teacher-student relationship | Baseline | 91.98 (0.69) | 85.21 (0.62) | 82.03 (1.62) | 1 > 2 = 3 |
| | | 6 months | 91.47 (0.76) | 83.15 (0.66) | 80.48 (1.72) | 1 > 2 = 3 |
| | | 12 months | 89.82 (0.88) | 80.50 (0.70) | 74.27 (1.41) | 1 > 2 > 3 |
| | | 18 months | 91.45 (0.89) | 79.54 (0.66) | 74.80 (1.09) | 1 > 2 > 3 |
| | Peer relationship | Baseline | 96.85 (0.74) | 91.07 (0.65) | 88.55 (1.78) | 1 > 2 = 3 |
| | | 6 months | 98.11 (0.74) | 90.93 (0.651) | 88.38 (1.71) | 1 > 2 = 3 |
| | | 12 months | 95.59 (0.88) | 87.45 (0.732) | 84.07 (1.79) | 1 > 2 = 3 |
| | | 18 months | 96.77 (0.96) | 86.94 (0.692) | 81.81 (1.26) | 1 > 2 > 3 |
| Mental health | Depression | Baseline | 34.20 (0.45) | 38.95 (0.44) | 40.08 (1.17) | 1 < 2 = 3 |
| | | 6 months | 33.54 (0.47) | 39.48 (0.47) | 41.62 (1.13) | 1 < 2 = 3 |
| | | 12 months | 33.98 (0.57) | 40.83 (0.50) | 44.73 (1.09) | 1 < 2 < 3 |
| | | 18 months | 33.00 (0.56) | 40.19 (0.48) | 46.68 (0.94) | 1 < 2 < 3 |
| | Anxiety | Baseline | 29.84 (0.35) | 33.52 (0.38) | 35.60 (1.14) | 1 < 2 = 3 |
| | | 6 months | 29.46 (0.39) | 34.61 (0.43) | 37.87 (1.18) | 1 < 2 < 3 |
| | | 12 months | 29.22 (0.43) | 35.12 (0.45) | 40.16 (1.32) | 1 < 2 < 3 |
| | | 18 months | 28.09 (0.38) | 34.64 (0.42) | 43.49 (1.23) | 1 < 2 < 3 |
| | Self-esteem | Baseline | 32.21 (0.28) | 29.84 (0.25) | 28.46 (0.68) | 1 > 2 = 3 |
| | | 6 months | 31.95 (0.29) | 28.97 (0.26) | 27.60 (0.67) | 1 > 2 = 3 |
| | | 12 months | 31.75 (0.32) | 28.41 (0.24) | 26.04 (0.54) | 1 > 2 > 3 |
| | | 18 months | 32.27 (0.32) | 28.23 (0.24) | 25.66 (0.45) | 1 > 2 > 3 |
| School engagements | Behavioral engagement | Baseline | 17.40 (0.12) | 16.71 (0.12) | 16.07 (0.34) | 1 > 2 = 3 |
| | | 6 months | 17.47 (0.13) | 16.46 (0.13) | 15.87 (0.32) | 1 > 2 = 3 |
| | | 12 months | 17.02 (0.16) | 15.63 (0.14) | 14.73 (0.30) | 1 > 2 > 3 |
| | | 18 months | 17.13 (0.16) | 15.68 (0.14) | 14.48 (0.28) | 1 > 2 > 3 |
| | Emotional engagement | Baseline | 17.44 (0.14) | 16.74 (0.13) | 16.14 (0.37) | 1 > 2 = 3 |
| | | 6 months | 17.51 (0.13) | 16.42 (0.13) | 15.33 (0.38) | 1 > 2 > 3 |
| | | 12 months | 17.11 (0.16) | 15.77 (0.15) | 14.41 (0.39) | 1 > 2 > 3 |
| | | 18 months | 16.94 (0.17) | 15.86 (0.14) | 14.40 (0.30) | 1 > 2 > 3 |
| | Cognitive engagement | Baseline | 17.82 (0.16) | 17.12 (0.15) | 16.65 (0.43) | 1 > 2 = 3 |
| | | 6 months | 18.20 (0.15) | 16.94 (0.16) | 16.71 (0.45) | 1 > 2 = 3 |
| | | 12 months | 17.67 (0.20) | 16.26 (0.18) | 15.59 (0.50) | 1 > 2 = 3 |
| | | 18 months | 17.57 (0.22) | 16.19 (0.17) | 15.60 (0.39) | 1 > 2 = 3 |

*Note*: " = " represents that the difference between the two groups has not reached statistical significance. The ">", "<" represents that the difference between the two groups have reached statistical significance at 0.05 level.
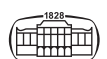
statistically significant differences only at Waves 3 and 4. For anxiety, there were statistically significant differences between these two groups from Waves 2 to 4. Similar trends were revealed for scores relating to teacher-student relationships, peer relationships and behavioral and emotional engagement. Although adolescents in the High Increasing group showed the worst patterns in parent-child relationships and school cognitive engagement over time, there were no significant differences with the Moderate Increasing group.

# DISCUSSION

The current study enriches our knowledge of the heterogeneous nature of the development of PUI. Three trajectories were identified that were linked to potential risk factors involving familial and other social relationships, mental health and, academic engagement. Implications are discussed below.

## The heterogeneous trajectories of PUI

Three developing trajectories of PUI among adolescents were identified in this study, similar to research by Coyne et al. (2020). Our study complements information to understand the heterogeneous development patterns of PUI. Based on the findings, 45.26% of adolescents in the Low Decreasing group started at a relatively low level of PUI and demonstrated a decreasing developmental pattern. In this group, the mean sum-score of PUI was lower than 43, reflecting non-pathological PUI (Poskotinova et al., 2021; Tereshchenko et al., 2021). Adolescents in the Moderate Increasing group (46.82%) were characterized by moderate initial PUI severity, followed by a relatively small increase over time. Scores for PUI in this group were between 43 and 64 from the baseline to Wave 4, which indicated that adolescents in this groups were on average at risk of developing PUI. The current study identified that approximately 7.92% of adolescents were in a High Increasing group of PUI trajectory, in which there was an initial high level of PUI severity followed by a pattern of rapid increase. The sum-score for this group increased from 51 to approximately 80, with the later waves reflecting on average an "addictive" state.

According to the observed means, the Low Decreasing and High Increasing trajectories demonstrated greater changes from Waves 3 to 4. Possible explanations may include the following. From Wave 3 to Wave 4, adolescents were in grades 11 and 12, ones that are approaching times for college entrance examination. Thus, they may have encountered more academic pressures. For adolescents in the High Increasing group, internet use may have developed into a frequently used strategy to cope with academic stress. Therefore, they may have demonstrated even greater PUI. While for adolescents in Low Decreasing group, they may have allocated less time to engage in events unrelated to learning (e.g., using the internet) given life experiences such

as college entrance examinations. These currently speculative possibilities warrant direct examination.

## Familial factors predicting distinct PUI trajectories

To understand the antecedents of distinct PUI trajectories, potential risk predictors were examined. Identifying potential risk factors may help target the development of PUI in adolescents. Consistent with the I-PACE model and emotional security theory (Brand et al., 2016; Davies & Woitach, 2008), childhood maltreatment and parental conflicts statistically predicted risk PUI trajectories (i.e., Moderate Increasing and High Increasing group). These family-based adverse events may make individuals more vulnerable to react intensively to stress and develop PUI. Specifically, youth might overuse the internet to avoid or allay negative affect after having been exposed to significant stressors. Thus, individuals experiencing higher levels of childhood maltreatment and parental conflict may experience higher levels of PUI, including at study onset. Over time, without any intervention, immersing in internet virtual worlds may become a maladaptive coping mechanism used repeatedly to alleviate stress during adolescence (Wu et al., 2022). Thus, adolescents who experienced higher levels of childhood maltreatment and parental conflicts may show increased PUI over time. This possible explanation warrants further direct examination.

In addition, a role for parental conflict in relation to PUI was only observed in the Moderate Increasing group, relative to the Low Decreasing group. One possible explanation is that our study measured verbal conflict between parents, and no other forms (e.g., physical violence). Therefore, perhaps associations were observed between parental conflict and distinct PUI trajectories. These and other possibilities warrant examination.

## Adolescent adjustment and PUI trajectories

The current study also examined whether different patterns of PUI statistically predicted adolescent adjustments (i.e., social functioning, mental health, and academic engagement). The present study found differential associations with indicators of social, mental health, and academic functioning across the identified trajectory groups, highlighting the importance of distinguishing the trajectories with respect to adolescent health. Consistent with hypotheses, our results showed that, compared to the other two PUI patterns, adolescents with a low-decreasing pattern exhibited better mental health (low depression, low anxiety and high self-esteem), interpersonal relationships (good parent-child, peer and teacher-student relationships) and school functioning (high behavioral, emotional and cognitive engagement). However, more severe PUI may more severely interfere with adolescent mental health, school performance, and interpersonal relationships. These findings, aligning with prior studies (e.g., Coyne et al., 2020; Zhou, Zhu, Sun, & Huang, 2022), highlight PUI associations with negative behavioral outcomes.

With respect to social relationships, adolescents demonstrating risk development patterns of PUI may more likely spend more time engaging in online activities rather than interacting with peers. Moreover, they may have more delinquent behaviors at school and more conflicts with teachers. Thus, these adolescents may be more likely to exhibit poor peer and teacher-student relationships. Similarly, adolescents in the Moderate Increasing and High Increasing groups have more severe mental health concerns. According to the I-PACE model of Brand et al. (2016), while initial use of the internet may be beneficial (e.g., may reduce depressive and anxiety symptoms), these benefits may be offset when PUI emerges, making use increasingly maladaptive and contributing to psychopathological symptoms (e.g., depression and anxiety). Thus, adolescents in these two groups may experience more serious depression and anxiety symptoms. Additionally, the use of social media may lead to improper upward comparisons, that may exacerbate feelings of inferiority in adolescents and erode their self-esteem (Tian, Qin, Cao, & Gao, 2021). In terms of academic engagement, adolescents with higher PUI may allocate less time to study and homework, or have negative avoidance emotions towards their studies, such that they may exhibit lower behavioral and emotional academic engagement.

This study also revealed time-structured associations between PUI and adolescent functioning. With changes in PUI, differences in most indicators between the High Increasing and Moderate Increasing groups showed corresponding changes. For example, there were no differences between the Moderate Increasing and High Increasing groups with respect to all measures at the initial time point. With a significant increase in PUI severity, adolescents in these two latent classes showed greater differences in some areas of functioning. This finding may shed additional light on suggestions that PUI may trigger of (be primary to) these issues (Coyne et al., 2020). These possible explanations may benefit from additional direct studies.

With regard to social and academic functioning, several results are noteworthy. Regarding social functioning, there were no significant differences in parent-child relationships between the Moderate Increasing and High Increasing groups, across all waves. This may be because, compared with teachers and peers, parents may have a greater responsibility to prevent their children from experiencing PUI and have a lower tolerance for their children's PUI. Specifically, as their children show signs of problems, parents may impose certain strategies (such as intervening with their children, increasing monitoring and restrictions) to protect their adolescent from maladjustments (Su et al., 2018). In addition, parent-child relationships may not be independent from adolescents' effects on their parents (Kapetanovic & Skoog, 2021). Adolescents with maladaptive behavior tend to disclose less information and communicate less with adults, especially parents. Adolescents may think that the less information their parents have about them, the less likely parents may be to restrict their behaviors. Therefore, parent-child relationships may become estranged.

With regard to academic engagement, the present study found that cognitive engagement did not show differences between the Moderate Increasing and High Increasing groups over time, but both behavioral and emotional engagement showed differences. One explanation is that cognitive engagement involves students' use of basic and deep learning strategies (Hong et al., 2020). Compared with emotional and behavioral engagement, cognitive engagement may be closer to the motivation component of learning (Ben-Eliyahu, Moore, Dorph, & Schunn, 2018), and thus may not be as susceptible to changing with the degree of PUI severity.

Some study limitations exist. First, generalizability may be limited as the current sample includes only students from the 10th and 11th grades of China. Therefore, further studies could be extended to other age groups and other countries to explore trajectories of PUI. Second, although family factors, including childhood maltreatment and inter-parental conflicts, are important to PUI, more factors should be assessed, such as personal characteristics. Third, outcomes (e.g., interpersonal relationships, depression, and anxiety) in this study may also be antecedent factors to PUI (e.g., Choi et al., 2015; Liu & Kuo, 2007). Therefore, future studies should further investigate directionalities with respect to these variables. Finally, this study, like many others, relies on self-report. Future research should use multi-informant sampling.

Despite these limitations, this study provides a meaningful understanding of PUI trajectories during adolescence and the clinical/functioning correlates of these trajectories. Thus, it has several important implications for the prevention and treatment of PUI. First, it is important to consider different targeted intervention strategies for adolescents with PUI, given that PUI may have different developmental patterns. Second, given that childhood maltreatment and parental conflict were potential risk factors for more severe developmental PUI trajectories, family-based interventions, such as improving parental abilities to resolve conflicts and maintain relationships with their children, may be effective in preventing PUI. Finally, this study illustrates how distinct developmental patterns of PUI are associated with multiple indicators of social, emotional and academic functioning, which provides a more comprehensive perspective and better supports the meaningfulness of considering the heterogeneity of PUI developmental trajectories.

## CONCLUSIONS

This study provides important insight into the heterogeneous development of adolescent PUI and suggests that PUI is not a "one size fits all" concern. In addition, this study not only suggests an important role for family environment in preventing PUI in adolescents, but also notes potentially harmful relationships between PUI and poor functioning in youths. The current results may help clinicians and other

groups identify individuals at elevated risk, and promote the development and implementation of better PUI prevention and treatment strategies among adolescents.

*Authors' contribution:* XMG: study concept and design, analysis and interpretation of data, statistical analysis, writing of the original draft. JLZ: statistical analysis and interpretation of data. YL, LXX, YH: participate in investigation and data curation. MNP: review and edit the draft. JTZ: study supervision, review and edit the draft.

*Conflict of interest:* The authors declare no conflict of interest. Dr Potenza is an Associate Editor of the Journal of Behavioral Addictions.

*Data sharing:* The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

## SUPPLEMENTARY MATERIAL

Supplementary data to this article can be found online at https://doi.org/10.1556/2006.2023.00021.

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