International Journal of
Mental Health Promotion

Tech Science Press

http://doi.org/10.32604/ijmhp.2025.071120

ARTICLE

The Reciprocal Effects Among Cumulative Risk, Depression, and Psychache in Adolescents: A Developmental Cascade Model

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Received: 31 July 2025; Accepted: 16 October 2025; Published: 28 April 2026

ABSTRACT: Objectives: Early adolescence is a key period of ecological and physiological change, during which exposure to accumulating risks from various environmental systems can negatively impact mental health. This study aimed to investigate the potential longitudinal relationships among cumulative risk, depression, and psychache in adolescents. **Methods:** A three-wave longitudinal study spanning one year was conducted with 675 (47.5% girls; Mean age = 14.13, standard deviation [SD] = 0.45) middle school students. The Random Intercept Cross-Lagged Panel Model (RI-CLPM) was used to explore the dynamic reciprocal relationships among these variables. **Results:** At the within-individual level, cumulative risk, depression, and psychache showed relative stability over time (β ranges from 0.21 to 0.52, $p < 0.01$). Prior cumulative risk significantly and positively predicted later depression and psychache (β ranges from 0.21 to 0.52, $p < 0.01$). Prior depression significantly and positively predicted later cumulative risk and psychache (β ranges from 0.15 to 0.17, $p < 0.01$). Prior psychache significantly and positively predicted later depression (β ranges from 0.25 to 0.26, $p < 0.001$). **Conclusion:** A cascading effect of mutual influences existed among cumulative risk, depression, and psychache in early adolescents. These findings highlight the usefulness of screening for both cumulative risk and psychache to identify at-risk individuals. Additionally, including psychache assessment in early intervention strategies could enhance their effectiveness.

KEYWORDS: Cumulative risk; depression; psychache; cascading effect

1 Introduction

Early adolescence is a crucial period of ecological and physiological transition [1], marked by significant shifts in individuals' ecological contexts, such as family and peer relationships [2]. During the move to junior middle school, adolescents' peer groups shift from smaller, familiar circles to larger, less familiar ones. At this stage, they are influenced not only by family microsystems but also by school, peer, and community environments. Exposure to multiple risk factors during this period can lead to mental health issues [3]. Past research indicates that risk factors accumulate to influence adolescent behavioral problems; the more risk factors a person faces, the more severe their behavioral issues tend to be [4,5].

From a theoretical perspective, Bronfenbrenner and Evans's bioecological model of human development [6] emphasizes that human development is a dynamic process shaped by multiple ecological

subsystems. When these subsystems lack resources and interact, it is referred to as cumulative risk [7]. Compared to single risk factors, the cumulative risk model provides a more accurate explanation of cognitive delays, academic challenges, mental health issues, and physical health problems [8,9]. However, while the effect of cumulative risk on development is well-established, the opposite pathway—how and where the developing individual's mental health impacts their exposure to these ecological risks—remains a crucial and underexamined question.

We adopted Developmental Contextualism [10] to analyze this bidirectional relationship. This theory proposes that individual growth involves continuous, reciprocal interactions between people and their environments, where individuals both influence and are influenced by their surroundings. Additionally, psychache (or intense psychological pain) and depression are important but distinct signs of mental health [11–13]. Although they are closely linked, their long-term and mutual predictive effects are not well understood [14]. Most research on psychache has focused on clinical groups (e.g., cancer patients [15]), with few studies involving school-aged adolescents. To address these gaps, this study uses developmental cascade models to examine the long-term relationships among cumulative risk, psychache, and depression.

1.1 Bidirectional Relationships among Cumulative Risk, Psychache, and Depression

Cumulative risk poses a significant threat to individuals' academic, psychological, and physical health and is a well-established factor in the development and progression of depression. Studies have identified strong connections between cumulative risk and depression among Chinese left-behind children and adolescents [16,17]. Longitudinal evidence indicates that childhood cumulative risk levels can predict depression severity in adulthood [8], and the effects of cumulative family risk on depressive symptoms in youth persist over both short- and long-term follow-ups [9]. Critically, these depressive states, often stemming from risk exposure, may manifest as intense psychache, a more acute form of psychological suffering closely linked to suicide risk [15].

Psychache, usually caused by unmet psychological needs, involves an inward experience of negative emotions such as shame, guilt, fear, and despair [18]. It is a distinct construct from both physical pain and depression, and is considered a more significant predictor of suicide risk and attempts [11,19]. Indeed, unbearable psychache is regarded as the most immediate psychological precursor to suicide [18,20]. Empirical studies have consistently linked higher levels of psychache to adverse life events, including childhood abuse, parental divorce, weak peer support, and academic stress [11,21,22]. Recent cross-sectional research further identifies cumulative risk as a key predictor of psychache, showing a strong positive correlation between the number of risks and their severity [23,24]. This relationship can be understood through a downward cascade model, whereby accumulated risks impair an individual's social problem-solving skills and coping efficacy, leading to low life satisfaction and elevated anxiety and depression [3,25].

However, this relationship is not unidirectional. Adolescents' mental health (e.g., depression and psychache) may also serve as antecedents to cumulative risk [26]. This aligns with Coyne's interpersonal theory of depression, which posits that the interaction styles of depressed individuals can trigger negative responses from others, thereby worsening their social environment [27]. From the "influential child perspective", children and adolescents are active, agentic actors in shaping their environments and developmental pathways [28]. Empirical evidence shows that adolescent psychological problems can negatively influence parental practices, family socioeconomic status, and peer relationships [29,30]. For instance, lower life satisfaction can trigger negative parent-child interactions [31], potentially increasing family conflict [32]. Similarly, internalizing and externalizing symptoms can adversely affect peer

relationships and increase the risk of victimization [33], while adolescent depression is a strong predictor of later parent-child relationship quality [34].

1.2 Bidirectional Relationships between Psychache and Depression

Psychache and depression are fundamentally distinct and independent constructs [35]. Existing cross-sectional studies have shown high correlations between them. Chen et al. [15] found through conceptual analysis that, aside from stressful life events, psychological disorders can also cause psychache, with depression being most strongly associated with this condition. Neuropsychological evidence further indicates different neural activation patterns between psychache and depression [36]. As a result, scholars support recognizing psychache as a distinct clinical condition rather than just a symptom of depression [37]. Some researchers argue that psychache is a core part of depression, given its high occurrence among hospitalized depressed patients [12]. Üzer and Kurtses Gürsoy's [13] comparative study of 118 depressed patients and 85 healthy controls revealed moderate to strong correlations between psychache and depression. Similarly, Chinese scholars [11] have found strong links between psychache and depression in university students. This ongoing coexistence suggests a dynamic, mutually reinforcing relationship, a "vicious cycle" where each factor worsens the other [38]. However, despite the well-established cross-sectional links and theories regarding their temporal development [14], long-term studies examining their bidirectional predictive relationships over time remain rare.

1.3 Cumulative Risk Index

In research methodology, the cumulative risk model is commonly used to measure multiple risk exposures. This model considers risk exposure in an additive way without using statistical interaction tests [39]. Specifically, the cumulative risk model treats each risk factor as dichotomous (0 = no risk, 1 = risk present). Risk categories can be determined based on statistical criteria (such as the upper quartile and above) or a priori theories (for example, single-parent households or left behind experience). By summing these dichotomous risk indicators, a comprehensive cumulative risk index is created.

Conceptually, the cumulative risk model focuses on the quantity of risk exposures above a certain threshold, rather than the varying intensity of each risk. It captures significant, high-level risks while excluding moderate exposures [7]. This approach not only preserves the robust association between risk exposure and outcomes (e.g., mental disorders or behavioral problems) [40] but also offers key methodological advantages. These include reducing measurement error, enhancing validity through multiple indicators, and mitigating issues of multicollinearity [7]. Several longitudinal studies have successfully used this method to examine the impact of cumulative risk on adolescent mental health and related outcomes [41,42], providing a validated foundation for its use in the current study.

1.4 Current Study

Currently, research often employs the cross-lagged panel model (CLPM) to analyze cascade effects; however, it has faced criticism for blending between-person and within-person effects. Between-person associations reflect stable trait-like differences, such as whether adolescents with higher cumulative risk generally experience more severe depression. At the same time, within-person effects capture changes over time relative to an individual's baseline, like whether a specific increase in risk predicts subsequent changes in depression. These types of analyses address different questions and can even show opposite effects—an issue known as Simpson's paradox [43]. To resolve this, the current study employs the random-intercept cross-lagged panel model (RI-CLPM) [44] to examine the relationships among cumulative risk, depression,

and psychache. This model includes a random intercept that accounts for individual-specific stable levels, does not assume linear growth patterns, and uses residuals from repeated measures to estimate within-person bidirectional pathways. By separating between-person stability from within-person variation, the RI-CLPM offers a more robust method for analyzing temporal dynamics and enhances inferences about developmental cascades.

Based on this rationale, this study aims to: (1) examine cumulative risk as a predictor of psychache and depression in adolescents; (2) explore the dynamic, bidirectional relationships among cumulative risk, depression, and psychache over time using RI-CLPM; and (3) provide a theoretical basis for mental health interventions by highlighting the role of psychache. We propose the following hypotheses (see Fig. 1):

Hypothesis 1 (H1): *There is a bidirectional predictive effect between cumulative risk and psychache.*

Hypothesis 2 (H2): *There is a bidirectional predictive effect between cumulative risk and depression.*

Hypothesis 3 (H3): *There is a bidirectional predictive effect between depression and psychache.*

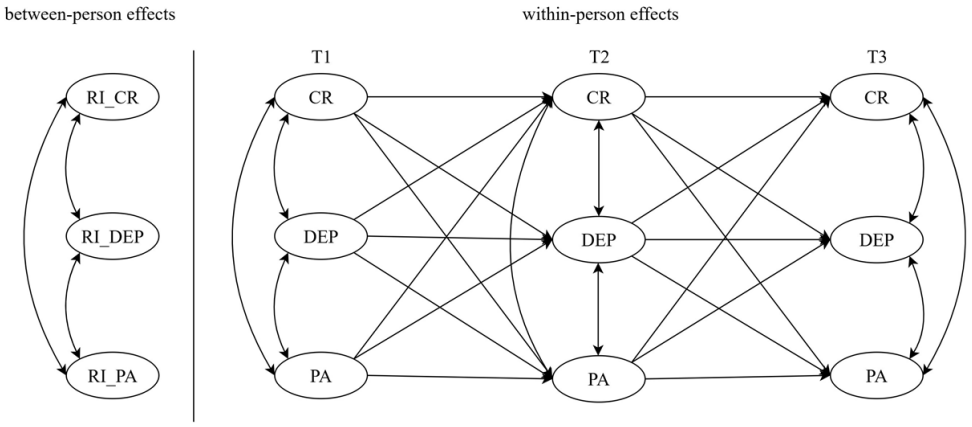

Figure 1: Hypothetical random intercept cross-lagged panel models (RI-CLPMs) for CR, DER, and PA. Notes: CR, cumulative risk; DEP, depression; PA, psychache; T1, time 1; T2, time 2; T3, time 3.

2 Materials and Methods

2.1 Participants

This study used cluster sampling to select students from all 15 seventh-grade classes at a public middle school in Nanchang, Jiangxi Province. Located in southeastern China, Nanchang is a second-tier city with moderate economic growth. In 2024, the per capita GDP of Nanchang was about 116,900 yuan, slightly above the national average. The school is situated in a newly developed urban district, and its student body includes both urban residents and rural migrant children, making the sample more representative. The school's support helped ensure the smooth conduct of the study.

Graduate psychology students administered questionnaires during class sessions at three time points: March 2024 (T1), September 2024 (T2), and March 2025 (T3). The total participation numbers were 741, 726, and 711 at T1, T2, and T3, respectively. After excluding participants who were absent due to illness or answered regularly, a final sample of 675 participants (47.5% girls; Mean_{age} = 14.13, standard deviation [SD] = 0.45) was kept for analysis. The gender ($\chi^2_{(1)} = 0.12$, $p = 0.73$), age ($t = 1.73$, $p = 0.08$), cumulative risk ($t = -0.37$, $p = 0.72$), depression ($t = -0.97$, $p = 0.33$), and psychache ($t = -1.42$, $p = 0.16$) of the dropout

group (N = 66) showed no significant differences in T1 test scores, indicating no systematic dropout in this study. The Missing Completely at Random (MCAR) test [45] indicated that the data are missing completely at random (χ^2 = 42.41, p = 0.33).

This study was approved by the Research Ethics Committee of the School of Psychology, Jiangxi Normal University, Nanchang, China (Approval Number: IRB-JXNU-PSY-2024045). Informed consent was obtained from all subjects involved in the study. After receiving formal approval from middle school authorities, students and their parents were informed about the study, and written informed consent was obtained from all participants and their respective parents. Participants were assured that their data would remain confidential. The survey took about 30 min to finish during class, and they have the right to withdraw at any time. No additional compensation was offered, however, after completing the survey, students were given complimentary psychological counseling and group counseling sessions.

2.2 Measurements

2.2.1 Cumulative Risk

Based on bioecological theory, this study used the Cumulative Risk Questionnaire developed by previous researchers [25]. Seventeen risk factors were selected from ecological subsystems, including family, school, and peers. Each risk factor was coded dichotomously (1 = risk, 0 = no risk). Scores from all risk factors were combined to produce a total risk index with a maximum possible score of 17. The scoring criteria for each ecological risk factor are described in Table A1.

Table 1: Risk indicators.

Risk Variable	Items	Scoring Method	Risk Status Criterion	Cronbach's α
1. Family structure	7	Multiple-choice question	Not living with both biological parents	
2. Number of brothers and sisters	4	1 (0)~4 (3 or more)	At least three children in the family	
3. Parents' health	2	1 (worst)~5 (Very good)	Worse than the average level	
4. Parental education	2	1 (Primary and below)~6 (Postgraduate and above)	Parents did not graduate from high school or have a Lower level of educational experience than senior high school	
5. Parents committing illegal activities	2	0 (No)~1 (Yes)	One or both parents committing crimes	
6. Family economic strain	4	1 (Not at all true)~4 (Always true)	≥75th percentile	0.82, 0.83, 0.88
7. Parental rejection	6	1 (Not at all true)~4 (Always true)	≥75th percentile	0.87, 0.86, 0.89
8. Family functions	9	1 (Not at all true)~5 (Always true)	≤25th percentile	0.85, 0.84, 0.84
9. Parental relationship	2	1 (worst)~5 (Very good)	≤25th percentile	0.62, 0.64, 0.64
10. Parental alienation	6	1 (Not at all true)~5 (Always true)	≥75th percentile	0.87, 0.89, 0.90
11. School bonding	10	1 (Not at all true)~5 (Always true)	≤25th percentile	0.89, 0.90, 0.91
12. Peer Support	3	1 (Not at all true)~4 (Always true)	≤25th percentile	0.86, 0.87, 0.90
13. Teacher-student relationship	7	1 (Not at all true)~4 (Always true)	≤25th percentile	0.89, 0.92, 0.93
14. Classmate relationship	13	1 (Not at all true)~4 (Always true)	≤25th percentile	0.89, 0.89, 0.89
15. Peer victimization	11	1 (Not at all true)~4 (Always true)	≥75th percentile	0.92, 0.93, 0.94
16. Class environment	8	1 (Not at all true)~5 (Always true)	≤25th percentile	0.91, 0.91, 0.90
17. Deviant peer affiliation	8	1 (None)~5 (Almost all)	≥75th percentile	0.85, 0.85, 0.86

Family structure is assessed through the question "Who do you live with"? The number of siblings is evaluated with a single item. Parents' health was measured using two items, with each parent asked about

their health level. Parental educational attainment was also gauged by separately inquiring about parents' educational levels. Parents' involvement in illegal activities was measured using two items, which required participants to indicate whether their father or mother had ever been detained or imprisoned for a criminal offense. The four-item Family Economic Stress Scale [46] was used to measure family economic hardship. Participants reported the frequency of household financial stress (e.g., "We do not have enough money to buy new clothes.") over the past six months.

Parental rejection was assessed using the rejection dimension of the Short-form Parental Rearing Style Questionnaire [47]. The questionnaire includes six items rated on a 4-point scale, evaluating the extent of parental rejection by asking how parents treated their children (e.g., "My parents often treated me in a way that made me feel embarrassed.').

Family function was assessed using the Adolescent Social Ecological Risk Factors Assessment Questionnaire [48], which consists of nine items (e.g., "I can talk well with my parents.") rated on a 5-point scale.

The parental relationship was assessed using two items: "How is the relationship between your father and mother?" and "Does your father quarrel with your mother?" [49]. Cronbach's α was 0.62–0.64. Since Cronbach's alpha coefficient is significantly influenced by the number of items, scales with only two items generally have lower reliability coefficients compared to multi-item scales. Additionally, the traditional Chinese belief that "family shame should not be made public" creates additional challenges for participants when completing questionnaires. Therefore, lower scores may not necessarily indicate fewer family conflicts.

Parental alienation was measured using the parental alienation dimension of the Adolescent Attachment Scale [50], which includes nine items (e.g., "Talking to my parents about my problems makes me feel ashamed or foolish.") rated on a 5-point scale, with higher scores indicating a more alienated relationship as perceived by the individual.

School bonding was assessed using the School Bonding Scale [51], which contains six items (e.g., "I feel delighted to be a member of this school.") rated on a 5-point scale, with higher scores indicating stronger connections to the school.

Peer support was assessed using the peer support dimension of the Adolescent Resilience Scale [52], which includes three items (e.g., "My friend cares about me very much.") rated on a 4-point scale, with lower scores indicating less peer support.

Teacher-student and classmate relationships were assessed using the relevant sub-questionnaires of the School Atmosphere Questionnaire [53], which contains twenty items (e.g., "The teacher helps students solve problems.") rated on a 4-point scale, with lower scores indicating less support from teachers and classmates.

Peer assault was assessed using the "Multidimensional Peer-Victimization Scale" (MPVS) [54], which includes eleven items (e.g., "During this semester, other students threatened to hit me.") rated on a 4-point scale, with higher scores indicating more severe victimization.

The class environment was evaluated using the Class Order and Discipline sub-questionnaire from the My Class questionnaire [55]. It included eight items rated on a 5-point scale. Lower scores reflect a poorer classroom climate as perceived by the participants. Sample items include: "The classroom discipline in our class is better than in other classes".

Deviant peer interaction was measured using the Deviant Peer Questionnaire [49]. It includes eight items, such as "In the past 12 months, how many of your close friends have cheated on exams?" rated on a 5-point scale, with higher scores indicating a greater number of deviant peers.

2.2.2 Depression

Depression was assessed using the 7-item (e.g., "I felt that I have nothing to look forward to") Depression Anxiety Stress Scales (DASS-21) [56]. Participants responded on a 4-point scale (1 = Did not apply to me at all, 4 = Applied to me very much). The scale has sound psychometric properties for Chinese youth [57], with a Cronbach's α of 0.88. In this study, the Cronbach's α values were 0.95, 0.95, and 0.96.

2.2.3 Psychache

The Psychache Scale (PAS) [58], a 13-item questionnaire rated on a 5-point Likert scale (1 = Never, 5 = Always), was used to assess psychache levels. Sample items include: "I do not understand why I have to endure such suffering". The scale has demonstrated strong psychometric validity in Chinese adolescent populations [59], with a Cronbach's α of 0.90. In this study, it showed excellent internal consistency at three time points, with Cronbach's α values of 0.97, 0.97, and 0.98.

2.3 Data Analysis

This study used a comprehensive range of statistical methods. Harman's single-factor test was conducted to check for common method bias. Descriptive statistics (means, standard deviations, skewness, and kurtosis) and Pearson correlations were analyzed to describe the characteristics of the sample and the bivariate relationships among key variables. The intraclass correlation coefficients (ICCs), calculated from a one-way random-effects ANOVA, measured the proportion of total variance due to differences between individuals. Repeated-measures ANOVAs with polynomial contrasts assessed within-subject changes over time (T1, T2, T3), and Bonferroni-adjusted pairwise comparisons were performed following significant main effects. We employed a Random Intercept Cross-Lagged Panel Model (RI-CLPM) to examine the bidirectional relationships between variables, distinguishing between-person from within-person effects. All preliminary analyses were conducted using SPSS 27.0 (IBM Corp., Armonk, NY, USA). Measurement invariance testing and RI-CLPM construction were performed in Mplus 8.3. As tests of skewness and kurtosis revealed a non-normal distribution of the data, the models were fitted using the Maximum Likelihood Robust (MLR) estimator to obtain bias-adjusted standard errors and robust test statistics [60]. During model specification, the freely estimated model served as the baseline. Constrained models were subsequently built by progressively restricting autoregressive and cross-lagged paths to temporal equality. A more parsimonious constrained model was selected if the model fit deterioration was nonsignificant (ΔCFI [comparative fit index] ≤ 0.01 and ΔRMSEA [root mean square error of approximation] ≤ 0.015) [61].

3 Results

3.1 Common Method Bias Assessment

Harman's single-factor test identified 19, 18, and 18 factors with eigenvalues above one across the three measurement waves. The first factor accounted for 24.35%, 27.96%, and 30.12% of the variance, respectively, all of which were below the critical threshold of 40%. These findings suggest there is no significant common method bias in the three assessments [62].

3.2 Descriptive Statistics and Correlation Analyses

Cumulative risk, depression, and psychache showed significant positive intercorrelations at all time points (Table 2). Intraclass correlation (ICC) analyses revealed ICC values of 0.589, 0.546, and 0.585 for cumulative risk, depression, and psychache, respectively. These indicate that 58.9%, 54.6%, and 58.5% of

the variance was attributable to between-person differences, while 41.1%, 45.4%, and 41.5% resulted from within-person fluctuations.

Table 2: Descriptive statistics and correlations among variables.

Variable	Mean ± SD	1	2	3	4	5	6	7	8	9	10
1. Gender											
2. Age	14.13 ± 0.45	−0.20**									
3. T1 CR	3.92 ± 2.85	0.01	0.04								
4. T1 DEP	6.24 ± 7.13	0	0.02	0.50***							
5. T1 PA	1.60 ± 0.80	0.09*	0	0.50***	0.73***						
6. T2 CR	3.54 ± 2.92	0	0	0.74***	0.47***	0.46***					
7. T2 DEP	4.92 ± 5.35	0.03	0	0.46***	0.64***	0.60***	0.59***				
8. T2 PA	1.43 ± 0.68	0.10*	−0.02	0.43***	0.56***	0.69***	0.55***	0.78***			
9. T3 CR	3.83 ± 3.05	−0.04	0.04	0.47***	0.32***	0.32***	0.57***	0.42***	0.38***		
10. T3 DEP	5.12 ± 6.85	0	0.06	0.32***	0.43***	0.43***	0.45***	0.60***	0.57***	0.54***	
11. T3 PA	1.49 ± 0.72	−0.03	0.04	0.33***	0.39***	0.48***	0.44***	0.54***	0.60***	0.55***	0.73***

Note: SD, standard deviation; CR, cumulative risk; DE, depression; PA, psychache; T1, time 1; T2, time 2; T3, time 3. N = 675, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

3.3 Repeated-Measures ANOVA

RM-ANOVA (Table 3) showed a significant main effect of time on cumulative risk, depression, and psychache. Notably, a significant quadratic trend was found for cumulative risk. Post-hoc analyses indicated a significant decrease in scores from T1 to T2, a significant increase from T2 to T3, and no significant difference between T1 and T3, reflecting a "decline followed by rebound" pattern. For depression, both linear and quadratic trends were present. Depression scores at T1 were significantly higher than at T2 and T3, with no significant difference between T2 and T3, suggesting an overall decline followed by stabilization. Psychache followed a similar pattern: a linear trend showed an overall decrease, while a quadratic trend confirmed an initial decline followed by a rebound. Pairwise comparisons revealed a significant decrease from T1 to T2, no significant change from T2 to T3, but a significant difference between T1 and T3.

3.4 Measurement Invariance Tests

Measurement invariance tests were conducted for the scales assessing cumulative risk, depression, and psychache across three waves. The results showed that the measurement invariance of the longitudinal data for each scale fit well (Appendix A Table A1) and satisfied the criteria for scalar invariance, allowing for subsequent analyses.

3.5 Random-Intercept Cross-Lagged Panel Model (RI-CLPM) Analysis

After controlling for gender, the unconstrained RI-CLPM showed acceptable fit (Table 4). Constrained models M4 and M2 experienced significant declines in fit. Model M3 was chosen as the final model (χ^2/df = 1.37, CFI = 0.999, TLI [Tucker-Lewis index] = 0.996, SRMR [standardized root mean square residual] = 0.015, RMSEA = 0.023, Fig. 2) based on the balance between simplicity and fit. At the between-person level, cumulative risk, depression, and psychache demonstrated significant intercorrelations. Within-person autoregressive paths indicated that cumulative risk, depression, and psychache showed a certain level of stability. Cross-lagged paths revealed that changes in cumulative risk from T1 to T2 positively predict changes in depression and psychache at T2 and T3. Similarly, changes in depression from T1 to T2 positively predict changes in cumulative risk and psychache at T2 and T3. Additionally, changes in psychache from T1 to T2 predict changes in depression at T2 and T3.

Table 3: Results of repeated-measures ANOVA and trend analysis.

Variable	T1 (Mean ± SD)	T2 (Mean ± SD)	T3 (Mean ± SD)	MD M_{T1}-M_{T2}	*p*	MD M_{T1}-M_{T3}	*p*	MD M_{T2}-M_{T3}	*p*	Trend	*df*	F	*p*	η_p^2
CR	3.92 ± 2.85	3.54 ± 2.92	3.83 ± 3.05	0.379	<0.001	−0.018	>0.99	−0.397	<0.001	linear	1	0.023	0.876	0.000
										quadratic	1	27.288	<0.001	0.039
DEP	6.24 ± 7.13	4.92 ± 5.35	5.12 ± 6.85	1.294	<0.001	1.048	0.001	−0.245	0.861	linear	1	12.984	<0.001	0.019
										quadratic	1	19.211	<0.001	0.028
PA	1.60 ± 0.80	1.43 ± 0.68	1.49 ± 0.72	0.143	<0.001	0.098	0.004	−0.045	0.211	linear	1	10.464	0.001	0.016
										quadratic	1	26.052	<0.001	0.039

Notes: SD, standard deviation; CR, cumulative risk; DE, depression; PA, psychache; T1, time 1; T2, time 2; T3, time 3; MD, mean difference; M_{T1}, mean at time 1; M_{T2}, mean at time 2; M_{T3}, mean at Time 3. N = 675, *p*-values were adjusted using the Bonferroni correction.

Table 4: Model fit and model comparisons for the random-intercept cross-lagged panel model (RI-CLPM).

Model	χ^2	*df*	CFI	TLI	SRMR	RMSEA	Model Comparison	ΔRMSEA	ΔCFI
M1	16.1	9	0.998	0.991	0.014	0.034			
M2	50.52	12	0.990	0.963	0.025	0.069	M2-M1	0.035	−0.008
M3	20.54	15	0.999	0.996	0.015	0.023	M3-M1	−0.011	0.001
M4	59.05	18	0.990	0.974	0.029	0.058	M4-M1	0.024	−0.008

Note: *df*, degree of freedom; CFI, comparative fit index; TLI, Tucker-Lewis index; SRMR, standardized root mean square residual; RMSEA, root mean square error of approximation. M1, unconstrained model; M2, autoregressive paths fixed to be time-invariant; M3, cross-lagged paths fixed to be time-invariant; M4, autoregressive and cross-lagged paths fixed to be time-invariant.

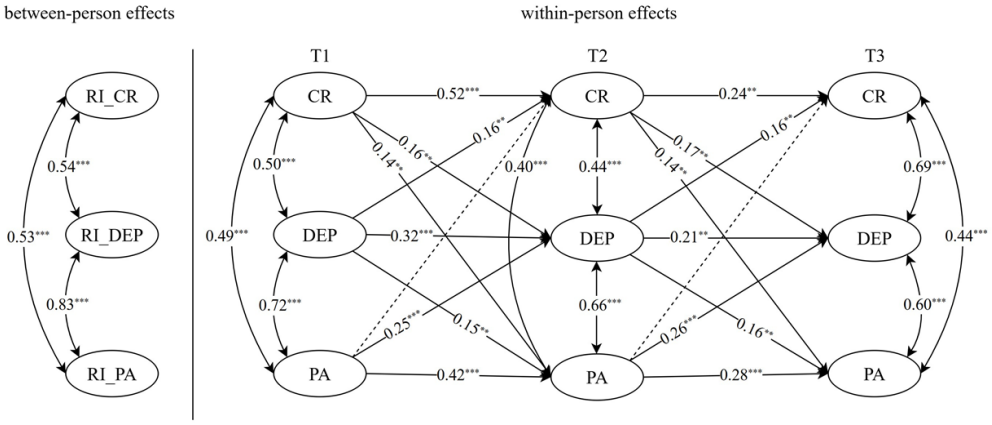

Figure 2: The random intercept cross-lagged panel model (RI-CLPM) involving cumulative risk (CR), depression (DEP), and psychache (PA). Note: All parameters of the report are standardized. RI, random intercept; T1, time 1; T2, time 2; T3, time 3; single-headed arrows (→) represent standardized cross-lagged and autoregressive path coefficients; double-headed arrows (↔) represent correlations between constructs; dashed arrows (- - →) indicate nonsignificant regression paths. $^{**}p < 0.01$, $^{***}p < 0.001$.

4 Discussion

This longitudinal study used an RI-CLPM to examine the within-person, temporal relationships among cumulative risk, depression, and psychache in adolescents. Overall, the results partially supported our hypotheses: cumulative risk prospectively predicted both depression (H2 supported) and psychache (H1 supported); depression predicted later psychache and, notably, also predicted subsequent cumulative risk (H2 supported); however, psychache did not significantly predict future cumulative risk (H1 partly supported). A reciprocal relationship was confirmed between depression and psychache (H3 supported).

4.1 Developmental Trends and Contextual Interpretation

The changing patterns over time of these constructs, specifically, the "decline-rebound" of cumulative risk and the overall decline with a slight rebound of depression and psychache, reflect detailed developmental and contextual changes across grades.

The initial elevation at T1 (Grade 7, second semester) may be due to the ecological and physiological changes typical of early adolescence [1], as students experience restructuring of peer groups and increased socio-cognitive challenges [63]. The subsequent decrease at T2 (Grade 8, first semester) suggests a period of adjustment, possibly aided by growing autonomy, stable relationships, and improved self-efficacy, protective

factors against psychache [64]. This phase may represent an initial adaptation period during which new social opportunities lead to short-term psychological benefits [65].

The rebound in cumulative risk at T3 (Grade 8, second semester) signals a critical period characterized by increased academic challenges, such as more difficult subjects like physics, anxiety about the high school entrance exam in the next year, as well as changing peer relationships, including identity exploration and social exclusion. During this period, their parents might prioritize academic achievement over emotional support, which can leave adolescents' emotional needs unmet [66]. However, even with renewed risks, the fact that depression and psychache did not return to T1 levels might suggest the development of psychological resilience [67], where better cognitive maturity and emotion regulation skills help protect against adversity.

4.2 Within-Person Cascades: From Cumulative Risk to Mental Health

At the within-person level, cumulative risk consistently predicted later depression and psychache. This aligns with cumulative risk and bioecological theories [6], and can be understood through the lens of developmental cascades. Specifically, as proposed by Ellis et al. [3], a downward cascade happens when negative social experiences disrupt a child's stress-response systems, which may in turn initiate upward cascading effects on broader psychopathological symptoms. Similarly, the Allostatic Load Theory [68] and Toxic Stress Theory [69] also consistently suggest that when individuals are continuously and chronically exposed to environmental challenges, their neurobiological or neuroendocrine responses will remain in a fluctuating or elevated stress state. Prolonged physiological stress can lead to irreversible changes in physiological systems. Additionally, when personal resources are insufficient to cope with these accumulated stressful events, it can lead to the fixation of cognitive-behavioral patterns [70]. Thus, even after external risks diminish, individuals may remain vulnerable to depression and psychache due to entrenched cognitive and physiological responses.

4.3 The Reciprocal Relationship between Depression and Psychache

Our findings provide strong long-term evidence for the bidirectional relationship between depression and psychache, confirming our hypothesis (H3) and supporting the comorbidity model suggested in previous research [14]. This reciprocal pattern shows that although these two constructs are separate, they become intertwined in a self-reinforcing cycle of suffering through developmental cascade processes [71]. Combining Karen Horney's [38] concept of the "vicious cycle" with the cascade model framework offers an effective way to understand this mechanism.

On the one hand, depression predicts the subsequent intensification of psychache. Depressive states are characterized by a cluster of cognitive distortions—including pervasive pessimism, irrational guilt, and a negative cognitive triad centered on the self, the world, and the future [72]. Individuals often adopt maladaptive coping strategies, such as behavioral avoidance and persistent self-blame, in an attempt to manage their distress. These strategies align with what Horney called "neurotic solutions", such as moving toward others (compulsively seeking affection and approval) or moving away from others (withdrawing and becoming self-reliant). Instead of alleviating suffering, these rigid strategies ultimately prove ineffective and create inescapable internal dilemmas. For example, a strong need for approval (a "moving toward" strategy) conflicts with feelings of worthlessness caused by depression, generating profound shame and guilt, core components of psychache [16]. Therefore, the cognitive and behavioral features of depression directly contribute to psychache, setting off a cascade from emotional dysfunction to intense, self-generated pain.

On the other hand, psychache also predicts later increases in depressive symptoms [71]. When individuals experience frustration of psychological needs, it triggers unbearable psychache, including deep shame and feelings of worthlessness. To escape this pain, individuals blame their suffering on faults in the "real self", gradually detach from it, and instead turn to the fantasy and construction of an "idealized self" as a coping strategy [73]. By internalizing a set of "should" rules, they force themselves to conform to this perfect image. However, since this image is inherently unattainable, individuals inevitably fail to achieve it. The inability to meet these unattainable standards leads to intense self-directed hostility and severe self-criticism. This cycle of self-rejection and hatred drains psychological resources, promotes helplessness and hopelessness, and directly leads to anhedonia and low energy, key signs of depression. Furthermore, as psychache is typically a stable and enduring trait, its persistent presence creates a chronic background of suffering that makes individuals increasingly susceptible to major depressive episodes over time [74], demonstrating a progression from persistent self-induced pain to clinical emotional dysfunction.

Essentially, the two conditions create a vicious cycle aligned with the developmental cascade model. Depression offers the cognitive and interpersonal foundations for psychache (shame, guilt, isolation), while psychache, in turn, intensifies depression through self-hatred and the breakdown of the authentic self. Each condition enhances and maintains the other, trapping the individual in a cycle of suffering that is hard to escape without external help [73]. Our longitudinal model provides strong empirical support for this mechanism, demonstrating that these states are not merely correlated but are dynamically and causally connected within individuals over time through cascading processes [71].

4.4 From Depression and Psychache to Cumulative Risk

Finally, this study found that adolescent depression prospectively predicts increases in cumulative risk, a finding consistent with prior research [34]. This pathway can be explained by Coyne's interpersonal theory of depression [27], combined with the influential child perspective from developmental psychology. Coyne's theory emphasizes how depressive symptoms, such as low mood, fatigue, and expressions of hopelessness, initially serve as appeals for support [75], but often lead to frustration, disapproval, or eventual disengagement from others, thereby weakening relational quality over time and increasing exposure to contextual risks [34].

Critically, these interpersonal dynamics align with the influential child perspective, which suggests that children and adolescents are not simply passive recipients of environmental influence but actively shape their social environments through their characteristics and behaviors. Depressed adolescents, through their negative self-referential thoughts and maladaptive interaction patterns (e.g., excessive reassurance-seeking, self-criticism, emotional withdrawal), may unintentionally increase interpersonal stress and provoke negative responses from parents, teachers, and peers, ultimately contributing to the cycle of risks.

In contrast, psychache did not significantly predict future cumulative risk. This may be due to its internalized and less observable nature, which limits its ability to influence social contexts actively [37]. Individuals experiencing intense psychache might maintain adequate social functioning without showing overt negative behaviors that provoke rejection or conflict. From the influential child perspective, although these individuals are still engaged in meaning-making and coping, their strategies, such as quiet withdrawal and self-isolation, are less likely to elicit adverse reactions from others [76]. Instead, such responses may provoke concern or supportive efforts, thereby buffering against further risk accumulation [27,34]. Thus, while psychache involves deep inner suffering, it does not function through the same interpersonal mechanisms as depression to increase overall risk.

4.5 Limitations and Future Directions

This study explores the connections between cumulative risk, depression, and psychache within the developmental cascade framework. By adding psychache as a separate component in the cascade, we expand the scope of traditional developmental cascades. Psychache is not only a consequence of cumulative risk but also worsens the risk of depression, creating a feedback loop. This helps explain why some adolescents exposed to risk develop severe psychological issues (such as suicidality linked to psychache) rather than or in addition to depression. Furthermore, the observed risk rebound in eighth grade offers empirical evidence for identifying the best timing for interventions.

While the results of this study are promising, several limitations should be acknowledged. First, relying solely on self-report measures can introduce self-perception and social desirability biases, which may undermine validity [62]. Second, using a non-clinical adolescent sample limits the generalizability of the results to clinical or more severe populations. Third, the study did not assess protective or vulnerability factors (e.g., resilience, cognitive flexibility) that could influence the relationships between risk and mental health outcomes [67]. Fourth, the homogeneous sample from a single school may reduce representativeness and lead to sampling bias, weakening external validity. Fifth, the three-wave design, conducted over a year, is insufficient to capture long-term, nonlinear developmental trajectories, such as multi-year risk accumulation or adaptation, and may overlook critical turning points or interpret fluctuations as trends.

Nonetheless, this study offers insights into external risks and adolescent mental health. Future research should clarify how internal factors (e.g., personality, coping mechanisms) and external stressors (e.g., social support, academic pressure) interact to influence well-being. For example, traits like poor emotion regulation and high interpersonal sensitivity are strong cross-cultural predictors of symptoms [77]. Including neuroendocrine markers (e.g., cortisol) and neuroimaging alongside psychological assessments can reveal complex mechanisms [78]. Machine learning models within an ecological framework can improve risk detection and prediction accuracy by modeling complex interactions among variables [79], overcoming the limitation of equally weighted cumulative risk indices. Targeted interventions based on RI-CLPM pathways (e.g., psychache to depression) should be tested, using cognitive restructuring for maladaptive beliefs and behavioral activation to disrupt negative cycles. Finally, the timing of interventions is essential. The “resurgence trend” in the second semester of eighth grade may indicate a shift from reactive symptoms to self-sustaining pathology, highlighting a key “chronicity turning point” for preventive efforts.

5 Conclusions

This study employed a Random Intercept Cross-Lagged Panel Model (RI-CLPM) to examine within-person dynamics among cumulative risk, depression, and psychache over time. Controlling for stable traits, the results support the cumulative risk hypothesis and developmental cascades framework, emphasizing distinct stage-specific dynamics. Risk exposures across family, school, and peer environments significantly impacted adolescent mental health, with fluctuations especially evident during the “pressure rebound phase” in the second semester of eighth grade. Families and schools should actively monitor both risk and protective factors during this critical period to promote adaptive development. These findings provide valuable guidance for school-based mental health practices by recommending the use of cumulative risk screening to identify vulnerable students and including psychache assessment in early detection systems, while avoiding stigmatizing labels. Additionally, interventions should address not only cumulative risk but also psychache, particularly during developmental transitions. Strategies such as cognitive-behavioral therapy and emotion regulation training can help break maladaptive cycles and enhance stress-coping skills.

Acknowledgement: We extend our gratitude and appreciation to all participants for their time and experience, as well as to the parents who allowed their children to take part in this research. We also thank the following individuals for their help with data collection: Xuezhi Liu, Ph.D., Peifeng Huang, Ph.D., Yihong Wang, Ph.D., Yuzhuo Liang, Ph.D., Liuyan Ren, Ph.D., Qi Dai, MAP, Bin Hu, MAP, Fan Li, MAP, Min Rao, and Jingjing Lian, MAP.

Funding Statement: This research was funded by the National Education Planning Science Commissioned Project, grant number: WBB240477, and the 2024 Research Achievements of Jiangxi Provincial University Ideological and Political Research Association, grant numbers: XLJK24101 and XLJK24106.

Author Contributions: The authors confirm contribution to the paper as follows: formal analysis, writing—original draft preparation, funding acquisition, Kai Jing; resources, project administration, funding acquisition, Jingqun Wang; Conceptualization, methodology, writing—review and editing, supervision, Baojuan Ye; Validation, Visualization, Qi Dai; Investigation, data curation, Xian Gong and Guorong Wang. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials: Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

Ethics Approval: This study was approved by the Research Ethics Committee of the School of Psychology, Jiangxi Normal University, Nanchang, China (approval number: IRB-JXNU-PSY-2024045). Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflicts of interest to report regarding the present study.

Appendix A

Table A1: The model fit indices for analysis of measurement invariance of longitudinal data.

Variable	Model	χ^2	df	CFI	TLI	SRMR	RMSEA	ΔCFI	ΔRMSEA
Economic difficulties	M1	186.521	38.000	0.968	0.944	0.036	0.071		
	M2	214.967	44.000	0.963	0.945	0.046	0.071	0.005	0.000
	M3	224.333	50.000	0.962	0.950	0.044	0.067	0.001	0.004
Parents refuse	M1	295.352	113.000	0.973	0.964	0.026	0.046		
	M2	310.666	123.000	0.973	0.966	0.031	0.044	0.000	0.002
	M3	372.000	134.000	0.965	0.960	0.031	0.048	0.008	0.004
Family functions	M1	803.176	277.000	0.941	0.926	0.060	0.049		
	M2	821.676	293.000	0.941	0.929	0.063	0.048	0.000	0.001
	M3	910.000	312.000	0.933	0.925	0.067	0.050	0.008	0.002
Parental estrangement.	M1	392.060	114.000	0.964	0.951	0.027	0.056		
	M2	403.547	124.000	0.964	0.955	0.030	0.054	0.000	0.002
	M3	443.671	134.000	0.960	0.954	0.032	0.054	0.004	0.000
School bonding	M1	515.293	111.000	0.956	0.939	0.044	0.068		
	M2	551.548	121.000	0.953	0.941	0.052	0.068	0.003	0.000
	M3	568.050	131.000	0.952	0.945	0.054	0.065	0.001	0.003
Peer intimacy	M1	18.333	15.000	0.999	0.998	0.012	0.017		
	M2	21.672	19.000	0.999	0.999	0.020	0.013	0.000	0.004
	M3	22.615	21.000	1.000	0.999	0.016	0.010	0.001	0.003
Teacher-student relationship	M1	472.385	159.000	0.975	0.967	0.031	0.050		
	M2	491.941	171.000	0.975	0.969	0.037	0.049	0.000	0.001
	M3	599.825	185.000	0.967	0.963	0.039	0.054	0.008	0.005

Table A1: *Cont.*

Variable	Model	χ^2	df	CFI	TLI	SRMR	RMSEA	ΔCFI	ΔRMSEA
Support from classmates	M1	1780.374	615.000	0.926	0.911	0.063	0.049		
	M2	1844.901	639.000	0.924	0.911	0.066	0.049	0.002	0.000
	M3	1924.464	663.000	0.920	0.911	0.068	0.049	0.006	0.000
Multidimensional peer-victimization	M1	1813.313	452.000	0.926	0.914	0.048	0.062		
	M2	1860.825	472.000	0.925	0.916	0.051	0.061	0.001	0.001
	M3	1916.013	492.000	0.923	0.917	0.051	0.061	0.002	0.000
Class environment	M1	1075.000	219.000	0.939	0.924	0.064	0.071		
	M2	1140.000	233.000	0.936	0.924	0.073	0.071	0.003	0.000
	M3	1171.418	247.000	0.934	0.927	0.074	0.069	0.002	0.002
Deviant peer affiliation	M1	833.642	217.000	0.938	0.922	0.053	0.060		
	M2	904.895	230.000	0.933	0.919	0.062	0.061	0.005	0.001
	M3	911.493	242.000	0.933	0.924	0.057	0.060	0.000	0.001
Depression	M1	353.39	163	0.978	0.92	0.029	0.039		
	M2	372.26	175	0.977	0.973	0.033	0.038	0.001	0.001
	M3	390.35	187	0.976	0.974	0.033	0.037	0.001	0.001
Psychache	M1	2635.625	651.000	0.943	0.935	0.032	0.063		
	M2	2693.177	675.000	0.942	0.936	0.034	0.062	0.001	0.001
	M3	2745.155	699.000	0.941	0.938	0.034	0.061	0.001	0.001

Note: M1, configural invariance model; M2, metric invariance model; M3, scalar invariance model. df, degree of freedom; CFI, comparative fit index; TLI, Tucker-Lewis index; SRMR, standardized root mean square residual; RMSEA, root mean square error of approximation.

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