

A Longitudinal Study of Loneliness Before the End of the COVID-19 Pandemic: Trajectories, Predictors, and Impact on Chinese Adolescent Mental Health

Jingyi Wang^{1,*}, Wei Zhang^{1,*}, Peige Song^{2,*}, Tingting Wang³, Ye Yao¹, Yun Chen⁴, Haijiang Lin³, Xiaoqi Yang¹, Xiaoxiao Chen^{1,3}, Chaowei Fu¹

¹School of Public Health; NHC Key Laboratory of Health Technology Assessment, Fudan University, Shanghai, People's Republic of China; ²School of Public Health and the Second Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, Zhejiang, People's Republic of China; ³Taizhou City Center for Disease Control and Prevention, Taizhou, Zhejiang Province, People's Republic of China; ⁴Yale School of Nursing, Orange, CT, 06477, USA

*These authors contributed equally to this work

Correspondence: Chaowei Fu, School of Public Health, NHC Key Laboratory of Health Technology Assessment, Fudan University, Shanghai, 200032, People's Republic of China, Email fcw@fudan.edu.cn; Xiaoxiao Chen, Taizhou City Center for Disease Control and Prevention, Taizhou, Zhejiang Province, 318000, People's Republic of China, Email tzcdccxx@126.com

Background: COVID-19 threatened global health, however little is known about the long-term courses of loneliness and their effect on mental health in adolescents. This study aimed to explore the trajectories of loneliness among adolescents in Taizhou, Zhejiang Province, China, during the last phase of the pandemic. We also aimed to identify risk factors in each loneliness course and the impact of loneliness on emotional problems, peer problems, hyperactivity and conduct problems.

Methods: The study employed multistage cluster sampling to collect four waves of data from 2347 Chinese adolescents (average baseline age of 14.7 years) covering a period of 20 months (October 2021 – May 2023). The UCLA 3-Item Loneliness Scale and the Strengths and Difficulties Questionnaire were utilized to assess loneliness and mental health problems, respectively. Growth mixture modelling was employed to identify latent classes of loneliness trajectories. Associated risk factors were investigated using multinomial logistic regression model. Mixed-effects logistic regression models were constructed to examine the long-term impact of loneliness classes on mental health outcomes.

Results: The overall percentage of loneliness increased from 22.9% at baseline to 32.2% at the fourth wave in our sample. Three classes of loneliness were identified: Decreasing Low Loneliness (58.71%), Increasing Medium Loneliness (36.52%), and Increasing High Loneliness (4.77%). Risk factors for poorer loneliness trajectories included lack of physical exercise habits, poorer mental health literacy, medium or low perceived social support, having study difficulties, being female, higher grades, and lower economic status. Loneliness classes were associated with the severity and variability of emotional problems, peer problems, hyperactivity and conduct problems (ORs for the highest loneliness class: 10.24, 4.21, 3.87, 2.68, respectively). Individuals in the higher loneliness classes experienced a significant increase in these mental health problems over time ($p < 0.05$ for interactions between loneliness classes and time).

Conclusion: During the last phase of the pandemic, a large proportion of adolescents in our study endured medium to high levels of loneliness with no signs of improvement. Both unfavorable loneliness trajectories adversely affected internalizing and externalizing problems and displayed an upward trend in these difficulties. Results highlight the importance of tackling loneliness and improving mental health in adolescents.

Keywords: adolescents, loneliness, risk factors, internalizing problems, externalizing problems, COVID-19

Introduction

Since the unprecedented breakout of the COVID-19 pandemic, it has swept the world and brought devastating impacts to all countries. Governments had no choice but to implement stringent measures to control the transmission of the coronavirus, such as strict social distancing measures, quarantines, and lockdowns. The crisis has caused large-scale influence on global economy, political policies, social integration, globalization processes, and global health.¹ Among its many impacts, the World Health Organization (WHO) has warned us against one of its most striking aspects – the undermined mental health of millions.² Researchers are focusing on understanding how restrictions imposed by governments affect mental health in the medium and long term.^{3–5} Socially restrictive measures, quarantines and lockdowns have been associated with reduced social interaction and increased loneliness that may lead to a rise in mental health problems such as symptoms of depression and anxiety.^{6–10} As the probability of observing extreme epidemics can increase up to threefold in the coming decades, empirical evidence of its psychosocial impact is urgently needed to offer advice on global responses during future Disease X outbreaks.¹¹

Loneliness refers to the dissatisfaction we feel when our social connections do not match our expectations or needs.¹² According to the evolutionary theory of loneliness, transient loneliness can motivate people to reconnect with others.¹³ However, when the reaffiliation motive fails, they can be at risk for prolonged feelings of loneliness.¹⁴ During the adolescent years, many developmental changes take place such as changes in companions, autonomy, individuation, identity exploration, and cognitive maturation.¹⁵ For example, friendship quality appears to be more important than quantity in late childhood and adolescence. These developmental psychological characteristics make adolescents particularly vulnerable to prolonged feelings of loneliness.^{14,15} According to a meta-analysis with data collected from 2000 to 2019, researchers reported high levels of loneliness for adolescents across 113 countries, ranging from 9.2% in South-East Asia to 14.4% in the Eastern Mediterranean region.¹⁶ Since the COVID-19 outbreak, these figures seem to have risen even further due to strict isolation policies implemented throughout the world, and a heavy burden has fallen on adolescents' education and normal social activities.¹⁷ During a lockdown in the UK, nearly one in two youths reported feeling lonely.¹⁸ Young people experienced the largest increase in feelings of loneliness during the early stages of the pandemic compared to other age groups.^{19,20} Worryingly, in a study among British youths in 2022, 35% of participants reported that they experienced greater loneliness than ever before, 22% encountered challenges of maintaining existing friendships, and 23% expressed concerns that they may not be able to recover from the emotional impacts of the epidemic.²¹ Similarly, a large number of Chinese adolescents experienced feelings of loneliness during school closure (33.9%) and school reopening (40.3%) at the early stages of the pandemic.²²

A variety of factors were associated with heightened feelings of loneliness in adolescents before the pandemic. Cross-sectional studies indicated that poor physical or psychological health, low economic status, poor friendship quality, bad relationships in family, being bullied, and lack of social and emotional support were linked to more severe loneliness among adolescents.^{23–26} In terms of sex, empirical findings are inconsistent. In a meta-analysis of gender differences in loneliness, some studies suggested that females were lonelier than males, while the results were the other way round in some other studies.²⁷ Although there is theoretical notion that sex differences in loneliness may emerge in adolescence, the state of research is still undecided.²⁷ In a meta-analytic study of factors related to loneliness during adolescence, older age was found to be associated with higher levels of loneliness with a low effect size.²⁸ Additionally, a cross-sectional study in Jordan reported that adolescents who did not feel lonely had higher levels of mental health literacy than those who felt lonely.²⁹ The concept of mental health literacy involves the comprehension and knowledge related to mental health, stigma, and strategies of seeking help.³⁰ Given the close relationship between mental health and loneliness, it is reasonable to assume a negative correlation between mental health literacy and sense of loneliness. Some of these factors might also act as outcomes of loneliness, however most of the previous studies of loneliness in adolescents used cross-sectional design and therefore the direction of the effect is still unclear for many factors.

Under the influence of the COVID-19 pandemic, the situations that cause adolescents to feel lonely became even more complicated. Adolescence, as a critical period of social development, is particularly sensitive to the effects of public panic and social restrictions introduced in response to the COVID-19 crisis.^{31–33} The trends in inactivity among adolescents were worsened due to the absence of routine, social distancing measures, and limited access to gymnasium

and equipment.³⁴ Many students found the adaptation to major changes in study routines difficult. A high proportion of Chinese adolescents reported having difficulty in studying at home (54.2%) and disliked remote learning (46.1%), and these difficulties were particularly problematic for adolescents who had poor parent-child relationships.³⁵ These situations need to be considered when we study loneliness and its related factors during a special period. However, predictors of loneliness courses in adolescents during the pandemic have not been fully documented. Many studies of adolescents' loneliness during the COVID-19 were cross-sectional, which can only suggest factors concurrently associated with loneliness, rather than predictors of the long-term trajectories of loneliness.

The implications of loneliness extend beyond negative feelings of isolation, as it is also related to mental health problems. Two broad dimensions are included in mental health, namely internalizing and externalizing problems.³⁶ Internalizing problems represent a spectrum of disturbances characterized by negative emotion, such as depression, anxiety, and social withdrawal. On the other hand, externalizing problems are characterized by disinhibition, including traits such as hyperactivity, aggression, and rule violation.³⁷ Existing research has shown that loneliness was associated with internalizing problems in young people, such as depression, anxiety and peer relationship problems.^{38–41} Previous studies have also spotlighted the close relationships between loneliness and externalizing problems, including hyperactivity, conduct problems and violent acts.^{42–44} For adolescents during the COVID-19 pandemic, a systematic review reported that there were close associations between elevated feelings of loneliness and increased depressive symptoms, anxiety symptoms, gaming addiction and insomnia in cross-sectional studies.⁴⁵ Although longitudinal associations were more complex, most of the prospective studies in the review found that loneliness predicted symptoms of depression and anxiety amid the pandemic period, and that social connection via online networks helped diminish the adverse impact of social distancing measures on adolescent mental health.^{45–47} Consequently, the potential ramifications of COVID-19 on loneliness are not only pertinent to population well-being, but also relevant to mental health problems which could occur or deteriorate as a result.

While data about how the COVID-19 pandemic affected loneliness and mental health were available prior to and during the crisis, we have little information on what the trajectories of loneliness are after the pandemic has lasted for a long time and if these changes have continued at the end of the pandemic. A trajectory describes the evolution of repeated measure of loneliness over time. Modelling trajectories can classify individuals into distinct classes where people within a given subgroup share greater similarities than those from other subgroups.⁴⁸ As compared to approaches based on sample means, trajectory modelling is more useful to characterize intra- and inter-individual variability and patterns of loneliness over time so that vulnerable populations can be identified to inform personalized prevention and clinical practice.⁴⁹ Few studies reported loneliness trajectories during the pandemic. For example, a study in Spain reported three courses of loneliness in adults during the last state of the emergency.⁵⁰ However, the longitudinal changes in loneliness and its impact may be different in adolescents and may differ across countries where different approaches were implemented to manage the spread of coronavirus. Also, this study has only two time points across a period of nine months which prevents the depiction of medium- and long-term trajectories of loneliness. Additionally, there is insufficient evidence of what factors are related to loneliness trajectories in adolescents. Although some protective and risk factors against loneliness were reported during the pandemic,⁵¹ many of them were found in cross-sectional studies and were not necessarily relevant to adolescents. Much more detailed, longitudinal exploration is required for adolescents as loneliness and its increase were the highest among young people compared to the other age groups during the pandemic.⁵² Furthermore, there is a lack of scientific evidence of the impact of loneliness trajectories on mental health outcomes in adolescents, especially externalizing problems such as hyperactivity and conduct problems. Therefore, addressing these research gaps is of paramount importance to better understand and support adolescent mental health in a context of global uncertainties.

Researchers consider loneliness, its risk and protective factors, and its impact on psychological health as priorities of COVID-19 related mental health studies.⁵³ Therefore, this study aimed to explore the trajectories of loneliness in a sample of 2347 Chinese adolescents tracked across 20 months from October 2021 to May 2023 when WHO announced COVID-19 emergency over. We also sought to identify risk and resilience factors in each loneliness course, and the impact of loneliness experiences on mental health, including emotional problems, peer problems, hyperactivity and conduct problems. This information would help us understand the consequences of the pandemic on loneliness and

highlight areas to consider when seeking ways to reduce its effects in the post-pandemic period. We propose three hypotheses: (1) there are different patterns of loneliness trajectories, (2) adolescents with unfavorable demographic, social and behavior characteristics, such as low economic status, lack of social support, physical inactivity, having study problems and poor mental health literacy, are more likely to report poor loneliness trajectories, and (3) loneliness trajectories are related to the severity and variability of emotional problems, peer problems, hyperactivity and conduct problems.

Methods

Study Design and Participants

This prospective cohort study has been collecting data every six months since 2021. Data from four waves of surveys were included in the present study: Time 0 (October-December 2021), Time 1 (April-June 2022), Time 2 (September-October 2022), and Time 3 (February-May 2023). The study employed multistage cluster sampling to gather information from middle and high school students in Taizhou, Zhejiang province, China. A total of five districts/counties in Taizhou, representing both urban and rural areas, were selected for inclusion. From each district/county, three middle schools and three high schools, including both public and private schools, were randomly chosen. Two classes from each grade in every school were selected to participate in the survey. The inclusion criteria for this study were: (1) students from the selected classes, aged 12–18; (2) the ability to independently read, understand, and complete the online questionnaire; and (3) both students and their parents provided informed consent. The exclusion criteria were: (1) removal of duplicate questionnaire responses, retaining only the first submission; and (2) exclusion of questionnaires completed in an excessively short time to ensure data quality. [Table S1](#) presents the general distribution of participant characteristics in the study. The age range in our sample is 12–18 years, with an average age 14.7 (SD = 1.7), spanning 7th to 11th grades, which is representative of adolescents in Taizhou city.

Procedures

Potentially eligible students from the selected classes were invited to participate in the study and were informed about the content and procedures of the survey. Those willing to participate provided informed consent from both themselves and their parents. Class teachers then escorted them to computer rooms where they completed the online surveys via the Wenjuanxing platform (<https://www.wjx.cn>). The study procedures were conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of Taizhou Central Hospital (2022L-01-17).

[Figure S1](#) shows the flow of participants through each wave of the study. The sample size decreased from 4869 at T0 (October-December 2021) to 3925 at T1 (April-June 2022), reflecting a retention rate of 80.6%. The number further declined to 2622 at T2 (September-October 2022), resulting in a retention rate of 53.9%, and finally to 2347 at T3 (February-May 2023), with a retention rate of 48.2%. During the study period, some students were reassigned to different classes in certain schools. Since the surveys were organized according to class affiliations, this contributed to the decrease in retention.

Measures

Loneliness

Loneliness was assessed using the UCLA 3-Item Loneliness Scale, which consists of three questions: 1) How frequently do you experience a lack of companionship? 2) How often do you feel excluded or left out? 3) How frequently do you feel socially isolated?⁵⁴ Each question is rated on a scale from 1 to 3. The total score ranges from 3 to 9, with higher scores indicating a greater level of loneliness. In the growth mixture model for loneliness trajectories, continuous loneliness scores were used to capture changes in the degree of loneliness across different classes. To calculate loneliness rates, cut-off values were applied to classify individuals as either lonely or not lonely. Participants with scores of ≥ 6 were considered lonely, while those with scores < 6 were classified as not lonely.^{55,56} In this study, the Cronbach's alpha value of the UCLA scale was 0.88.

Emotional and Behavioral Problems

The self-reported version of the Strengths and Difficulties Questionnaire (SDQ) was utilized to evaluate participants' emotional problems, peer problems, hyperactivity, and conduct problems.⁵⁷ The SDQ comprises 25 items that assess four domains of difficulties and one domain of strength. In this study, we focused on the four difficulty subscales to indicate the four types of psychological problems. For example, a sample item from the peer problems subscale is: "I am usually on my own. I generally play alone or keep to myself". Each item is scored from 0 to 2, with each subscale consisting of five items and scores ranging from 0 to 10. Higher values indicate greater difficulties. The SDQ employed a 4-band categorization: close to average, slightly raised, high, and very high. Participants with "high" or "very high" categorization in the four subscales were classified as having corresponding problems. Specifically, scores of ≥ 6 on the emotional problems subscale indicated the presence of emotional issues; scores of ≥ 4 on the peer problems subscale signified peer-related difficulties; scores of ≥ 7 on the hyperactivity problems subscale reflected hyperactivity issues; and scores of ≥ 5 on the conduct problems subscale indicated conduct problems.⁵⁸ The Cronbach's alpha coefficient for internal consistency assessment of the total difficulties scores was 0.83 in this study.

Potentially Relevant Factors

Perceived Social Support

To evaluate perceived social support, the study employed the Multidimensional Scale of Perceived Social Support (MSPSS), which consists of 12 items.⁵⁹ Each item involves 7 statements ranging from "very strongly disagree" to "very strongly agree", with scores assigned from 1 to 7. For example, a sample item from the scale is: "There is a special person who is around when I am in need". The mean score for the 12 items was calculated to gauge the overall perception of social support. Mean scores falling within the range of 1 to 2.9 were classified as low support, scores between 3 and 5 moderate support, and scores from 5.1 to 7 high levels of support.

Mental Health Literacy

The assessment of mental health literacy involved the use of a simplified Chinese version of the Mental Health Literacy Questionnaire (MHLQ) developed by Epps et al on the basis of Nutbeam's health literacy theoretical model.⁶⁰ This simplified Chinese version of the questionnaire is specifically designed to evaluate the mental health literacy of middle school students and has been shown to possess strong reliability and validity when used among Chinese students.⁶¹ The brief Chinese questionnaire consists of 20 questions, each offering five options ranging from "Strongly Agree" to "Strongly Disagree" with scores from 1 to 6. For example, a sample item from the scale is: "I have the ability to address my own mental health issues". Total scores were obtained by summing up the scores for each question, where higher scores indicate poorer mental health literacy.

Lifestyle and Sociodemographic Characteristics

Participants were asked if they had difficulties in studying currently. The average daily time spent by students on electronic devices was documented. Habits of regular physical exercise (excluding physical education lessons) were categorized as either yes or no. Relationships with mothers and fathers were classified into three categories: good, average, or poor relationships. Variables strongly linked to mental health, such as stressful events (death or serious illness of a loved one within the past three months) and overall health status (completely healthy or with conditions such as hypertension, cardiovascular disease, diabetes, pulmonary disease, cancer, other chronic physical conditions, lack of outdoor activity due to disability, or any other disabilities), were also considered. Sociodemographic characteristics included sex (male/female), age, grade level (from 7th to 11th grades), and economic status (good, average, poor).

Statistical Analysis

The latent trajectories of loneliness were determined using the growth mixture model (GMM). Loneliness trajectories were modeled as a linear function from T0 to T3. Regarding the selection of latent classes, statistical indicators including Akaike information criterion (AIC), Bayesian Information Criterion (BIC), sample-size adjusted Bayesian Information Criterion (aBIC), the entropy, and Adjusted Lo-Mendell-Rubin Likelihood Ratio (ALMR-LR) test were employed to

determine the optimal number of latent classes. Smaller values of AIC, BIC and aBIC indicate a better model fit. Information entropy ranges from 0 to 1, with values closer to 1 indicating higher accuracy of model classification. The ALMR-LR test is used to compare whether a K-class model significantly outperforms a K-1 class model.⁶²

After identifying the optimal number of loneliness classes, a multinomial logistic regression model was used to compare baseline characteristics across different classes. Initially, univariate regression analyses were conducted with loneliness trajectory as the dependent variable and factors at T0 as independent variables, such as demographic characteristics, learning-related factors, physical exercise habits and so on. Variables with $p < 0.2$ in the univariate analysis were then included in the multivariable regression models. The predictors and outcomes were not examined in reverse, as our focus was specifically on factors influencing loneliness trajectories.

Mixed-effects logistic regression models for repeated measures were used to explore the relationship between loneliness trajectories and outcome variables (emotional problems, peer problems, hyperactivity, conduct problems) across the four time points. The two-level random intercept models were fitted using maximum likelihood, with loneliness trajectory as a fixed factor, time as a within-participant repeated factor, and participant ID as a random factor. These models also examined the interactions between loneliness trajectories and interview time with emotional problems, peer problems, hyperactivity, and conduct problems at each time point as outcomes. The models were adjusted for sex, grade, study problems, physical exercise habits, economic status, relationships with parents, stressful events, and students' health status. Regression coefficients were reported with 95% confidence intervals (CIs). To provide a justification for the models we used, Receiver Operating Characteristic (ROC) curves were generated for all models, and corresponding Area Under Curve (AUC) values were calculated. The regression models with the four outcome variables yielded AUC values of 0.964, 0.905, 0.971 and 0.958, respectively, indicating high predictive accuracy of the models. To further interpret our results, sample means with 95% CIs and estimated means for the four outcomes depending on loneliness trajectories were calculated and shown in figure. We investigated only one direction - from loneliness trajectories to mental health outcomes - as our focus was on how different loneliness trajectories impact the four types of mental health problems.

For descriptive statistics, frequency/percentage and median/interquartile range (IQR) were used to describe categorical and continuous variables. All reported p-values were based on two-sided test, with a significance level set at $p < 0.05$. All statistical analyses were performed using R-4.3.3 and Mplus version 7.

Results

Characteristics of the Study Population

A total of 2347 participants completed surveys at all four time points from T0 to T3. [Figure S1](#) shows the flow of participants through each wave of the study. The characteristics of the study sample at four waves are presented in [Table S1](#). Among participants involved in the analyses, 49.1% were female. The average baseline age of participants was 14.7 years ($SD = 1.7$). At baseline, 14.8% of adolescents had emotional problems, 30.8% had peer problems, 9.4% exhibited hyperactivity, and 6.6% had conduct problems. The proportions of loneliness across the entire sample at each wave were as follows: T0 22.9%, T1 30.7%, T2 31.6%, and T3 32.2%. From T0 to T3, there was a significant increase in the proportions of loneliness ($p < 0.001$) and conduct problems ($p < 0.001$), while the proportions of emotional problems ($p = 0.915$), peer problems ($p = 0.089$), and hyperactivity ($p = 0.805$) showed no significant changes.

Loneliness Trajectories

[Table 1](#) presents the model fit indices for the models with different number of classes. As the number of trajectories increased, AIC, BIC, and aBIC monotonically decreased. The 3-class model had the highest entropy value, indicating a good accuracy of model classification. Additionally, the p-value of the ALMR-LR test remains significant throughout. To obtain the best-fitting model, an "elbow" plot of aBIC ([Figure S2](#)) was utilized.⁶³ According to the elbow plot, a clear inflection point is observed at three classes. The AIC and BIC also display a similar trend of change. Therefore, the model with three classes was selected.

Table 1 Model Fit Indices for Different Model Specifications

Number of Classes	BIC	AIC	aBIC	Entropy	ALMR-LR	Number of Participants in Each Class (%)				
						1	2	3	4	5
1	32,399.08	32,347.24	32,370.49	-	-	2347(100)				
2	31,779.50	31,710.36	31,741.37	0.872	<0.001	626(26.67)	1721(73.30)			
3	30,531.26	30,444.84	30,483.60	0.996	<0.001	1378(58.71)	857 (36.52)	112(4.77)		
4	30,434.75	30,331.06	30,377.56	0.983	<0.001	1378(58.71)	786(33.49)	112(4.77)	71(3.03)	
5	30,162.51	30,041.53	30,095.78	0.933	0.007	1212(51.64)	460(19.60)	112(4.77)	397(16.92)	166(7.07)

Abbreviations: BIC, Bayesian information Criteria; AIC, Akaike's information Criteria; aBIC, Adjust Bayesian information Criteria; LMR, Lo-Mendell-Rubin.

The three loneliness trajectories are depicted in [Figure 1](#). The first class comprised 1378 individuals (58.71%), characterized by the lowest average loneliness scores and a slight decreasing trend over time. This trajectory was labeled “Decreasing Low Loneliness”. The second class included 857 individuals (36.52%) with a moderate level of loneliness scores and approximately a one-point increase in loneliness from T0 to T3, which was termed “Increasing Medium Loneliness”. The third class consisted of 112 individuals (4.77%) with the highest and continuously rising loneliness scores, and was designated as “Increasing High Loneliness”. The labeling was based on the relative levels of loneliness across the three categories rather than the artificial, binary cut-off score of the UCLA scale. Although the cut-off score followed previous literature, individuals below this threshold may still experience some degree of loneliness.

Predictors of Loneliness Trajectories

[Table 2](#) presents the descriptive statistics for baseline variables and the differences in baseline characteristics across loneliness trajectories (The results of univariate regression analysis without adjustment for potential confounders are presented in [Table S2](#)). After controlling for variables with $p < 0.2$ in [Table S2](#), a multinomial logistic regression model ([Table 2](#)), using “Decreasing Low Loneliness” as the reference category, identified several risk factors for “Increasing Medium Loneliness”: being female, higher grade level, lack of a physical exercise habit, lower mental health literacy, poorer economic status, and lower perceived social support. Similarly, lack of physical exercise habit, lower mental health literacy, and medium or low perceived social support remained risk factors for “Increasing High Loneliness” trajectory compared to “Decreasing Low Loneliness”. Additionally, adolescents with study problems also had higher odds of being in the “Increasing High Loneliness” trajectory.

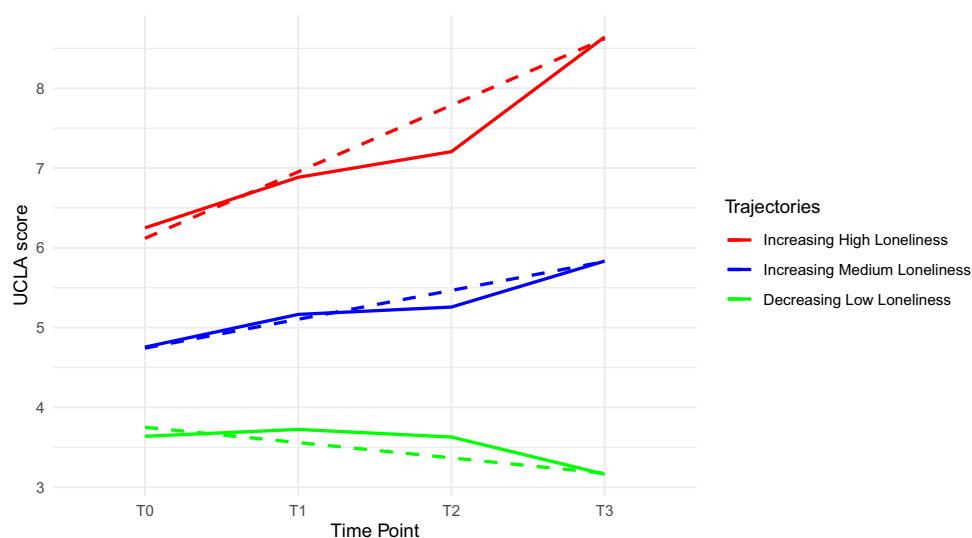


Figure 1 Estimated growth trajectory for each latent class based on the 3-class unconditional GMM. Solid lines represent sample means, dashed lines represent estimated means.

Table 2 Estimated Relative Risk Ratios of the Predictors of Loneliness Trajectories

Variables		Overall n=2347 (100%) N (%) or Median (IQR)	Increasing Medium Loneliness	Increasing High Loneliness
			(vs Decreasing Low Loneliness)	
			RRR (95% CI)	RRR (95% CI)
Sex	Women (Ref. men)	1153 (49.1)	1.24 (1.03–1.50)*	1.06 (0.70–1.61)
Grade		2 (1,5)	1.18 (1.11–1.25)***	1.07 (0.94–1.23)
Average daily electronic device usage		1.00 (0.500,3.00)	0.99 (0.96–1.03)	0.96 (0.88–1.04)
Physical Activity	No (Ref. yes)	859 (36.6)	1.44 (1.18–1.76)***	2.21 (1.44–3.41)***
Relationship with father	Good	1798 (76.6)	Ref.	Ref.
	Average	484 (20.6)	1.09 (0.82–1.44)	1.43 (0.82–2.47)
	Poor	65 (2.8)	0.94 (0.51–1.72)	1.83 (0.73–4.58)
Relationship with mother	Good	1975 (84.2)	Ref.	Ref.
	Average	327 (13.9)	1.10 (0.80–1.52)	0.78 (0.42–1.45)
	Poor	45 (1.9)	1.42 (0.68–2.97)	1.67 (0.56–4.96)
Mental health literacy		32.0 (22.0,44.0)	1.02 (1.01–1.03)***	1.03 (1.02–1.05)***
Economic status	Good	459 (19.6)	Ref.	Ref.
	Average	1750 (74.6)	1.08 (0.85–1.39)	0.63 (0.37–1.05)
	Poor	138 (5.9)	1.79 (1.16–2.77)**	0.50 (0.18–1.37)
Study problems	Yes (Ref. no)	1137 (48.4)	1.21 (0.99–1.48)	1.84 (1.15–2.93)*
Stressful events	Yes (Ref. no)	252 (10.7)	1.22 (0.91–1.64)	1.50 (0.85–2.66)
Health status	Diseased (Ref. well)	162 (6.9)	1.39 (0.96–2.02)	1.79 (0.96–3.33)
Perceived social support	High support	1344 (57.3)	Ref.	Ref.
	Medium support	928 (39.5)	1.92 (1.56–2.38)***	2.26 (1.37–3.74)**
	Low support	75 (3.2)	3.01 (1.63–5.56)***	8.59 (3.58–20.57)***

Notes: The results of univariate regression analysis are presented in Table S2. * p<0.05. ** p<0.01. *** P<0.001.

Impact of Loneliness Trajectories on Mental Health Problems

Table 3 reports the results of four mixed-effects logistic regression models, demonstrating the influence of loneliness trajectories, time, and their interactions on the outcome variables. Using “Decreasing Low Loneliness” as the reference, it was found that individuals in the “Increasing Medium Loneliness” and “Increasing High Loneliness” trajectories had a higher probability of experiencing emotional problems, peer problems, hyperactivity, and conduct problems, although the effect sizes were smaller for the “Increasing Medium Loneliness”. In each of the four models, there was at least one significant interaction between medium or high loneliness course and time with the four emotional and behavioral problems as the outcomes. Interactions revealed that adolescents in the course “Increasing High Loneliness” experienced a statistically significant increase in emotional problems, peer problems, and hyperactivity from T0 to T3. Individuals in the “Increasing Medium Loneliness” trajectory also exhibited an increasing trend in emotional, peer and conduct

Table 3 Associations Between Loneliness Trajectories and the Four Mental Health Outcomes

	Emotional Problems		Peer Problems		Hyperactivity		Conduct Problems	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Classes of loneliness								
Decreasing low loneliness	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Increasing medium loneliness	3.81 (2.43, 5.98)	<0.001	1.33 (0.99, 1.80)	0.057	2.67 (1.52, 4.69)	<0.001	1.17 (0.70, 1.95)	0.555
Increasing high loneliness	10.24 (4.41, 23.82)	<0.001	4.21 (2.20, 8.09)	<0.001	3.87 (1.33, 11.24)	0.013	2.68 (1.01, 7.07)	0.047
Time	0.80 (0.71, 0.90)	<0.001	0.89 (0.83, 0.95)	<0.001	0.79 (0.68, 0.92)	0.002	1.11 (0.98, 1.26)	0.101
Interaction: Class × Time								
Decreasing low loneliness × Time	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Increasing medium loneliness × Time	1.19 (1.03, 1.38)	0.018	1.54 (1.39, 1.70)	<0.001	1.19 (0.99, 1.44)	0.061	1.66 (1.41, 1.95)	<0.001
Increasing high loneliness × Time	1.79 (1.38, 2.33)	<0.001	1.46 (1.17, 1.82)	<0.001	1.93 (1.42, 2.63)	<0.001	1.22 (0.90, 1.65)	0.137

problems over time compared to “Decreasing Low Loneliness”. Figure 2 depicts the changes in four outcome variables according to three loneliness trajectories, providing a visual presentation of how the scores for emotional and behavioral problems worsened notably in the “Increasing High Loneliness” and “Increasing Medium Loneliness” trajectories.

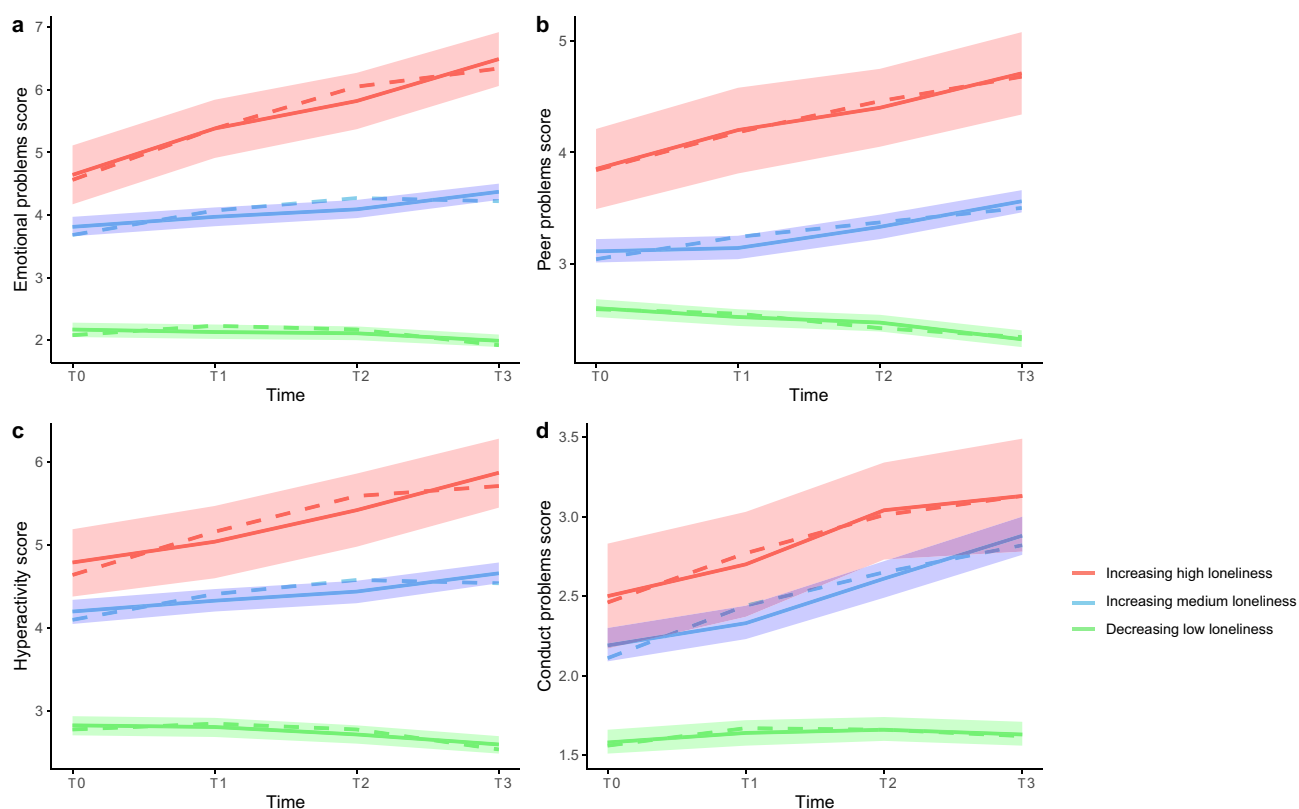


Figure 2 Changes in scores of mental health outcomes over time depending on course of loneliness. Solid lines represent sample means, and dashed lines represent estimated means. Additionally, the 95% confidence intervals of sample means were displayed. Subpart (a) illustrates the emotional problem scores of adolescents across three loneliness trajectory categories at four time points, with higher scores indicating more severe emotional issues within the group. Subpart (b) depicts the peer problem scores for the same categories over the four time points, where higher scores suggest greater peer difficulties. Subpart (c) presents the hyperactivity problem scores for the three loneliness trajectory categories at four time points, with higher scores indicating more severe hyperactivity issues. Subpart (d) outlines the conduct problem scores of adolescents in the three loneliness trajectory categories from T0 to T3, with higher scores signifying more severe conduct problems.

Discussion

The present study identified three distinct trajectories of loneliness in Chinese adolescents during the last phase of the COVID-19 pandemic. Around 4.8% of the participants reported “increasing high loneliness”, 36.5% “increasing medium loneliness”, and 58.7% “decreasing low loneliness”. In the 20 months until the end of the pandemic, loneliness levels increased remarkably in the highest and medium loneliness trajectories, and decreased slightly in the lowest trajectory. Factors at T0 including lack of physical activity, lower social support, poorer mental health literacy, and having study problems, were all risk factors for being in a higher loneliness group. There was also evidence that being female, higher grade, and lower household income predicted being in the medium loneliness class, although not the highest class. The adolescents with “increasing high loneliness” and “increasing medium loneliness” were more likely to report emotional problems, peer problems, hyperactivity and conduct problems. They also had higher increases of these problems from T0 to T3 compared to those with “decreasing low loneliness”.

It is concerning that 41.3% of participants were in the medium and high loneliness trajectories across the four time points. At T3, 32.2% of adolescents had loneliness total scores above the cut-off score and were considered as “lonely”. Data based on nationally representative samples within World Health Organization regions pre-COVID-19 suggest that only 9.2% to 14.4% of adolescents experienced loneliness.¹⁶ Our study did not include adolescents outside of Taizhou, but the findings nonetheless indicate that there are a large number of adolescents feeling high levels of loneliness in China. It is also notable that loneliness for the medium and high groups had a consistent growth, particularly around the end of the pandemic. The start of the survey at T3 coincided with one month following the official end of zero-COVID-19 policy in China. Although there are no more social distancing measures, people went through an abrupt outbreak of COVID-19 before life returned to normal, so it might be a response to worries over infection for themselves and those they care about. However, it is also possible that fatigue due to the long-term pandemic and socially restrictive measures may have exacerbated the existing feelings of loneliness. Moreover, the economy in Taizhou is largely dependent on international trade. As globalization decreased in China during the pandemic, various goods trade was disrupted and local economy was affected.¹ As shown in [Table S1](#), the proportion of good economic status steadily declined from 19.6% at T0 to 15.2% at T3. The negative impact on family income may aggravate household tensions and intensify adolescent loneliness.⁶⁴ Apart from pandemic-related reasons for the increase in loneliness, there could be more factors which has played a role in the trend even before the crisis, such as internet consumption, weaker levels of social networks, and deterioration of mental health problems. A study across 37 countries reported worldwide increases in adolescent loneliness from 2012 to 2018, in conjunction with the rise of internet use and smartphone access.⁶⁵ In regards to the lowest loneliness trajectory among 58.7% of participants, there is a gradual decrease over the 20 months, with the lowest level recorded at the last assessment. Shortly after the survey at T2, China’s State Council announced new guidelines on a national level which optimized COVID-19 response and loosened some restrictions.⁶⁶ Whether the indication of improvement of loneliness in this group is a result of the optimization of epidemic prevention and control policy remains to be explored in future research. Nevertheless, it is striking that loneliness levels in some adolescents had marked changes over time. Our findings suggest that the adolescents with medium to high levels of loneliness showed poor adaptation to the circumstances and had growing sensations of loneliness over time.

The finding on physical inactivity being a risk factor for loneliness echoes previous studies during both the pandemic and ordinary times.^{67,68} Several intervention studies found that physical activity programs contributed to a reduction in loneliness.^{69,70} Potential moderators and mediators may exist within this relationship such as social support, given that social elements were involved in many physical activity interventions.⁶⁸ Furthermore, physical activity is known to boost mood and reduce symptoms of depression and anxiety, which are often associated with loneliness.⁷¹ Exercise triggers the release of endorphins, which can enhance emotional well-being, leading to a more positive outlook and reduced feelings of social isolation.⁷² Similarly, our finding that adolescents with low and medium social support had higher odds of being lonelier than those with high support is consistent with research showing a negative association between social support and loneliness.⁷³ Perceived social support reassures people that they are not alone in dealing with challenges and that help is available if required. This perception offers a sense of security and comfort.⁷⁴ Even if someone does not frequently use the support available, just believing that it is there when needed can reduce feelings of loneliness.⁷⁵

There has been some evidence that friend support had a greater impact on feelings of loneliness than family and significant other support as adolescents begin to expand the connections beyond their family circle and attach increasing importance to friendship.⁷³ It is notable that poor mental health literacy was a risk factor for higher loneliness. People without sufficient mental health literacy are at risk for both lack of knowledge around positive health behaviors and difficulties identifying psychosocial problems and making sound decisions.⁷⁶ Those with greater mental health literacy may be more likely to obtain adequate assistance and utilize available resources to address their psychosocial difficulties.⁷⁷ Having study problems was also identified as a risk factor for loneliness. Existing studies have confirmed the influence of loneliness on student engagement and academic achievement, while our study proved that adolescents with self-perception of poor academic performance were also more likely to have chronic loneliness.⁷⁸ Low academic achievement can lead to negative perceptions and stigma, both from peers and adults. Adolescents who struggle academically may be labeled as “not smart enough” or “lazy”, which can damage their social status among peers.⁷⁹ Research has shown that students who do not meet academic expectations are at higher risk of being socially isolated, leading to reduced social engagement and greater loneliness.⁸⁰ These variables, on the other hand, can be considered as resilience factors that protect against loneliness, namely regular physical activity, high level of social support, good mental health literacy, and academically supportive campus culture, highlighting the importance of future interventions targeting these aspects which could potentially reduce perceptions of loneliness in adolescents.

Although being female, higher grade, and poor economic status predicted being in the “increasing medium loneliness” class, they did not have significant associations with the “increasing high loneliness” group. Given the large effect size of certain factors on the highest level of loneliness, eg low perceived social support (RRR=8.59), their impact may override the influence of variables such as sex, grade, and economic status which played less of a role. In addition, baseline economic status cannot capture the decline in household economic conditions over time. Whether changes in financial status would better account for different trajectories of loneliness needs to be explored in future research.

Furthermore, adolescents with higher levels of loneliness demonstrated a greater likelihood of both internalizing problems (emotional and peer problems) and externalizing problems (hyperactivity and conduct problems) compared to those in the group with low level of loneliness. In most cases, individuals with medium and high levels of loneliness also reported a significant increase in mental health problems from T0 to T3, which could be attributed to the increasing prevalence of chronic loneliness. In the whole sample, emotional problems, peer problems, and hyperactivity did not significantly increase from T0 to T3 (Table S1). A possible reason is that over half of the participants were in the “Decreasing Low Loneliness” group whose mental health status may be relatively stable during the pandemic. A systematic review and meta-analysis found that while some adolescents experienced increases in depression and anxiety, others reported stable or even decreased symptoms during the pandemic.⁸¹ This stability was noted particularly among groups with lower exposure to psychological stressors, highlighting the complex nature of adolescent mental health responses during COVID-19 and the importance of identifying vulnerable subgroups who require better health-care. As a potential stressor, chronic loneliness is closely associated with depressive symptoms, maladaptive social cognition, and poor recovery following a mental health crisis.^{82–84} Researchers have suggested that transient loneliness may serve an evolutionary purpose by prompting people to reestablish connections for the sake of survival and genetic continuity.⁸⁵ However, chronic loneliness poses potential risks due to its tendency to create a self-reinforcing loneliness loop where lonely persons become increasingly distrustful of others and anticipate negative relationships, and as a result, they would prefer to avoid future social interactions.⁸⁵ Our results are also consistent with existing studies about loneliness trajectories which found that both high and medium trajectories were at increased risk for depression, anxiety, self-harm and suicidal ideation.^{50,86} All these findings indicate that adolescents who experience chronic loneliness at any degree, not limited to those with high level of loneliness, may benefit from strategies aimed at decreasing loneliness. Furthermore, our study adds to the existing evidence that, in addition to internalizing problems, prolonged high levels of loneliness had negative impact on externalizing problems, including hyperactivity and conduct problems. Adolescents experiencing loneliness may exhibit externalizing behaviors as a way to express frustration, seek attention, or cope with negative emotions.⁸⁷ Loneliness is often linked to emotion dysregulation which can lead to increased irritability, poor impulse control, and difficulty managing social relationships, and then may manifest as problematic behavior.⁸⁸

Moreover, adolescents with externalizing behaviors might struggle to form and maintain friendships, which could perpetuate feelings of loneliness, creating a negative cycle.⁸⁹

One noteworthy strength of our study is the use of longitudinal data, which allowed us to examine changes in loneliness across four time points during the last phase of the pandemic and to classify subgroups with distinct loneliness patterns. As adolescents had different mental health responses during crisis, it is important to identify vulnerable populations to guide tailored prevention strategies and clinical interventions. Another strength pertains to the investigation of the impact of loneliness trajectories on externalizing problems including hyperactivity and conduct problems, as most of the existing studies just focus on internalizing problems such as depression and anxiety. Some studies found that adolescents with ADHD were lonelier than those without ADHD, however they did not establish the direction of the effect.⁴³ Our study confirmed that sustained high levels of loneliness can intensify symptoms of externalizing problems.

However, some limitations of our study should be taken into account. First, although we used cluster sampling from 30 schools in Taizhou, adolescents from other areas in China were not included. While Taizhou may effectively reflect the situation in southeastern coastal regions of China, the findings may not be generalizable to other geographical areas of the country. Therefore, caution should be exercised when interpreting the extent to which these results can be applied to the broader Chinese adolescent population. Second, even though reliable assessment tools were utilized in our study, the measures employed for loneliness and mental health problems are brief version or screening scale, which might limit their capacity to offer comprehensive insights. Third, these analyses focused on loneliness trajectories in adolescents during the pandemic, but how they compare to experiences of loneliness in the post-pandemic period remains to be investigated in future studies. Fourth, this study only explored the predictive value of risk factors on loneliness trajectories, however these factors could also be outcomes of loneliness. Similarly, the emotional and behavioral problems may influence subsequent loneliness. Future research should examine these reverse relationships. Fifth, the study primarily focused on the predictors and mental health outcomes of loneliness trajectories. However, future studies could delve deeper into potential moderators, such as differences between early, middle, and late adolescence.

There are a number of implications from our findings. The results presented here indicate the exceptionally high level of loneliness with no signs of improvement for many adolescents, which had great impact on internalizing and externalizing problems. The study highlights the importance of considering how to tackle loneliness both within the context of COVID-19 and more generally. It is consistent with the goal of a new Commission launched recently by WHO to address loneliness as a pressing health threat and foster social connection.⁹⁰ In order to deal with the growing number of reports about loneliness in adolescents, due in part to the COVID-19 pandemic, it is necessary to design effective and easy to implement strategies involving the wider school community. Many parents and caregivers may struggle to spot signs of loneliness and mental health problems in adolescents, although they have a lot of impact on how their children think. Thus, efforts should be made to provide them with regular low-level training on how to identify indications of these problems combined with guidance for dealing with them and information about helpful resources. Regular training sessions for teachers and support staff in school would also bring benefit to students as teachers play important role in improving adolescent mental well-being. Apart from common mental health problems, adolescent loneliness should be monitored continuously in school, and timely support should be offered to those who report loneliness, particularly chronic loneliness.⁸⁶ Our results of the predictors of loneliness trajectories suggest that strategies to improve physical activity, social support, mental health literacy, and assist students with poor academic performance may help reduce their loneliness. Some interventions aimed at tackling loneliness, such as social prescribing, should be adapted for adolescents and be promoted to make sure that young people are aware of them.⁹¹ Together, these approaches may help lessen adolescent loneliness and possibly decrease their risk of internalizing and externalizing problems.

Conclusions

Overall, our findings suggest that loneliness in more than half of the participants were low and decreasing during the final stage of the pandemic, but for many adolescents, these levels were medium to high with no indications of reduction. People with inadequate physical activity, lower social support, poorer mental health literacy, and study problems were at a greater risk of experiencing higher levels of loneliness. Both unfavorable loneliness trajectories adversely affected internalizing and externalizing problems and displayed an upward trend in these problems, thus highlighting the disparity

of the impact on mental health between trajectories. Future research should investigate whether the observed loneliness patterns persist and evaluate their influence on mental health. The COVID-19 pandemic brought a great disruption to people's lives, and adolescents were heavily affected. More interventions and guidelines are urgently needed to diminish loneliness in adolescents. Strategies that facilitate meaningful social interactions for young people should be prepared in the event of an outbreak of Disease X in the future.

Data Sharing Statement

The data and code that support the findings of this study are available from the corresponding author (CF) upon reasonable request.

Ethics Approval and Consent to Participate

The study procedures were conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of Taizhou Central Hospital (2022L-01-17). The age range of the adolescents participating in the study is 12 to 18 years. Online consent was received from all individual participants and their parents included in the study.

Acknowledgments

We would like to thank the study members for their participation. We are grateful to the Taizhou City Center of Disease Prevention and Control (CDC) and local CDCs for their dedication and hard work. This paper has been uploaded to ResearchSquare as a preprint: <https://www.researchsquare.com/article/rs-4210447/v1>.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

JW was sponsored by the China Medical Board (grant number #22-472) and the National Natural Science Foundation of China (grant number 72104053). CF was sponsored by the General Project of Shanghai Municipal Health Commission (grant number 202240115). HL and XC were sponsored by the Special Support Program for High Level Talents in Taizhou (grant number TZ2022-2). This work was also supported by the Science and Technology Plan Projects of Taizhou (grant number 22ywa62).

Disclosure

The authors declare that they have no competing interests in this work.

References

1. Zhang Y, Sun F, Huang Z, Song L, Jin S, Chen L. Predicting the impact of the COVID-19 pandemic on globalization. *J Clean Prod.* 2023;409:137173. doi:10.1016/j.jclepro.2023.137173
2. Freeman M. The world mental health report: transforming mental health for all. *World Psychiatry.* 2022;21(3):391–392. doi:10.1002/wps.21018
3. Galea S, Merchant RM, Lurie N. The mental health consequences of COVID-19 and physical distancing the need for prevention and early intervention. *EDITORIAL Mat Jama Int Med.* 2020;180(6):817–818. doi:10.1001/jamainternmed.2020.1562
4. Williams SN, Armitage CJ, Tampe T, Dienes K. Public perceptions and experiences of social distancing and social isolation during the COVID-19 pandemic: a UK-based focus group study. *BMJ Open.* 2020;10(7):e039334. doi:10.1136/bmjopen-2020-039334
5. Orban E, Li LY, Gilbert M, et al. Mental health and quality of life in children and adolescents during the COVID-19 pandemic: a systematic review of longitudinal studies. *Front Public Health.* 2023;11:1275917. doi:10.3389/fpubh.2023.1275917
6. Liu CH, Zhang E, Wong GTF, Hyun S, Hahm HC. Factors associated with depression, anxiety, and PTSD symptomatology during the COVID-19 pandemic: clinical implications for US young adult mental health. *Psychiatry Res.* 2020;290:113172. doi:10.1016/j.psychres.2020.113172
7. Leigh-Hunt N, Baggeley D, Bash K, et al. An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public Health.* 2017;152:157–171. doi:10.1016/j.puhe.2017.07.035

8. Ravens-Sieberer U, Erhart M, Devine J, et al. Child and adolescent mental health during the COVID-19 pandemic: results of the three-wave longitudinal COPSy study. *J Adolesc Health*. 2022;71(5):570–578. doi:10.1016/j.jadohealth.2022.06.022
9. Ravens-Sieberer U, Kaman A, Otto C, et al. Seelische Gesundheit und psychische Belastungen von Kindern und Jugendlichen in der ersten Welle der COVID-19-Pandemie – Ergebnisse der COPSy-Studie. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*. 2021;64(12):1512–1521. doi:10.1007/s00103-021-03291-3
10. Kaplan V. The burnout and loneliness levels of housewives in home-quarantine during Covid 19 pandemic. *Cyprus Turkish J Psych Psychol*. 2021;3(2):115–22.
11. Marani M, Katul GG, Pan WK, Parolari AJ. Intensity and frequency of extreme novel epidemics. *Proc Natl Acad Sci U S A*. 2021;118(35). doi:10.1073/pnas.2105482118
12. Peplau L, Perlman D. *Loneliness: A Sourcebook of Current Theory, Research, and Therapy*. Wiley Interscience; 1982.
13. Cacioppo S, Grippo AJ, London S, Goossens L, Cacioppo JT. Loneliness: clinical import and interventions. *Perspect Psychol Sci*. 2015;10(2):238–249. doi:10.1177/1745691615570616
14. Qualter P, Vanhalst J, Harris R, et al. Loneliness across the life span. *Perspectives Psychol Sci*. 2015;10(2):250–264. doi:10.1177/1745691615568999
15. Laursen B, Hartl AC. Understanding loneliness during adolescence: developmental changes that increase the risk of perceived social isolation. *J Adolescence*. 2013;36(6):1261–1268. doi:10.1016/j.adolescence.2013.06.003
16. Surkalim DL, Luo MY, Eres R, et al. The prevalence of loneliness across 113 countries: systematic review and meta-analysis. *BMJ*. 2022;376. doi:10.1136/bmj-2021-067068
17. Ernst M, Niederer D, Werner AM, et al. Loneliness before and during the COVID-19 pandemic: a systematic review with meta-analysis. *Am Psychologist*. 2022;77(5):660–677. doi:10.1037/amp0001005
18. Mental Health Foundation. Loneliness during Coronavirus. Available From: <https://www.mentalhealth.org.uk/coronavirus/loneliness-during-coronavirus>. Accessed 15, Apr, 2024.
19. Bu F, Steptoe A, Fancourt D. Loneliness during a strict lockdown: trajectories and predictors during the COVID-19 pandemic in 38,217 United Kingdom adults. *Soc Sci Med*. 2020;265:113521. doi:10.1016/j.socscimed.2020.113521
20. Pierce M, Hope H, Ford T, et al. Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. *Lancet Psychiatry*. 2020;7(10):883–892. doi:10.1016/s2215-0366(20)30308-4
21. Prince's Trust. The prince's trust NatWest youth index 2022. Available from: <https://www.princes-trust.org.uk/about-The-trust/news-views/princes-trust-natwestyouth-index-2022>. Accessed 15, Apr, 2024.
22. Chen Y, Wang J, Lin H, et al. Network structure of emotional and behavioral problems, loneliness, and suicidal thoughts in adolescents at the school closure and reopening stage in China. *Transl Pediatr*. 2023;12(7):1373–1385. doi:10.21037/tp-23-33
23. Lodder GMA, Scholte RHJ, Goossens L, Verhagen M. Loneliness in early adolescence: friendship quantity, friendship quality, and dyadic processes. *J Clin Child Adolesc Psychol*. 2017;46(5):709–720. doi:10.1080/15374416.2015.1070352
24. Heshmati S, Blackard MB, Beckmann B, Chipidza W. Family relationships and adolescent loneliness: an application of social network analysis in family studies. *J Family Psychol*. 2021;35(2):182–191. doi:10.1037/fam0000660
25. Bayat N, Fokkema T, Mujakovic S, Ruiter RAC. Contextual correlates of loneliness in adolescents. *Child Youth Services Rev*. 2021;127:106083. doi:10.1016/j.childev.2021.106083
26. Yang KM, Petersen KJ, Qualter P. Undesirable social relations as risk factors for loneliness among 14-year-olds in the UK: findings from the millennium cohort Study. *Int J Behavioral Develop*. 2022;46(1):3–9. doi:10.1177/0165025420965737
27. Maes M, Qualter P, Vanhalst J, Van den Noortgate W, Goossens L. Gender differences in loneliness across the lifespan: a meta-analysis. *European J Personality*. 2019;33(6):642–654. doi:10.1002/per.2220
28. Mahon NE, Yarcheski A, Yarcheski TJ, Cannella BL, Hanks MM. A meta-analytic study of predictors for loneliness during adolescence. *Nurs Res*. 2006;55(5):308–315. doi:10.1097/00006199-200609000-00003
29. Alsaraireh F, Al-Oran H, Althnaibat H, Leimoon H. The determinants of mental health literacy among young adolescents in South of. *ASEAN J Psych*. 2023;24:1–15. doi:10.54615/2231-7805.47295
30. Seedak S, Turnbull N, Phajan T, Wanchai A. Improving mental health literacy in adolescents: systematic review of supporting intervention studies. *Trop Med Int Health*. 2020;25(9):1055–1064. doi:10.1111/tmi.13449
31. Kung CSJ, Kunz JS, Shields MA. COVID-19 lockdowns and changes in loneliness among young people in the U.K. *Soc Sci Med*. 2023;320:115692. doi:10.1016/j.socscimed.2023.115692
32. Yıldırım M, Çiçek İ. Fear of COVID-19 and smartphone addiction among Turkish adolescents: mitigating role of resilience. *Family J*. 2022;10664807221139510. doi:10.1177/10664807221139510
33. Kaplan VKR, Bütün B. COVID-19 pandemisine bağlı karantina sürecinin ergenlerin gelecek beklentileri ve anksiyete düzeylerine etkisi. *Child Dev J*. 2021;4(7):12–23.
34. Alliot O, Fairbrother H, van Sluijs E. Adolescents' physical activity during and beyond the Covid-19 pandemic: a qualitative study exploring the experiences of young people living in the context of socioeconomic deprivation. *BMC Public Health*. 2024;24(1):2450. doi:10.1186/s12889-024-19777-z
35. Wang J, Wang H, Lin H, et al. Study problems and depressive symptoms in adolescents during the COVID-19 outbreak: poor parent-child relationship as a vulnerability. *Global Health*. 2021;17(1):40. doi:10.1186/s12992-021-00693-5
36. Krueger RF, Markon KE. Understanding psychopathology: melding behavior genetics, personality, and quantitative psychology to develop an empirically based model. *Curr Dir Psychol Sci*. 2006;15(3):113–117. doi:10.1111/j.0963-7214.2006.00418.x
37. Royuela-Colomer E, Orue I, Visu-Petra L, Fernández-González L. The association between mindful parenting, and internalizing and externalizing symptoms in adolescence. *J Child Family Stud*. 2024;33(6):1844–1856. doi:10.1007/s10826-023-02704-y
38. Hicks R. *Peer Relationships and Loneliness During Adolescence: The Effects of Social Networks and Close Friendships*. Ottawa: National Library of Canada= Bibliothèque nationale du Canada; 1994.
39. Eccles AM, Qualter P, Madsen KR, Holstein BE. Loneliness in the lives of Danish adolescents: associations with health and sleep. *Scandinavian J Public Health*. 2020;48(8):877–887. doi:10.1177/1403494819865429

40. Hards E, Loades ME, Higson-Sweeney N, et al. Loneliness and mental health in children and adolescents with pre-existing mental health problems: a rapid systematic review. *Br J Clin Psychol*. 2022;61(2):313–334. doi:10.1111/bjc.12331
41. Çiçek I. Mediating role of self-esteem in the association between loneliness and psychological and subjective well-being in university students. *Int J Contemporary Edu Res*. 2021;8:83–97. doi:10.33200/ijcer.817660
42. Kiuru N, Salmela-Aro K, Laursen B, et al. Profiles of loneliness and ostracism during adolescence: consequences, antecedents, and protective factors. *Child Psychiatry Human Dev*. 2024. doi:10.1007/s10578-024-01664-8
43. Jong A, Odoi CM, Lau J, Hollocks M J. Loneliness in young people with ADHD: a systematic review and meta-analysis. *J Atten Disord*. 2024;28(7):1063–1081. doi:10.1177/10870547241229096
44. Christiansen J, Qualter P, Friis K, et al. Associations of loneliness and social isolation with physical and mental health among adolescents and young adults. *Perspectives in Public Health*. 2021;141(4):226–236. doi:10.1177/17579139211016077
45. Farrell AH, Vitoroulis I, Eriksson M, Vaillancourt T. Loneliness and well-being in children and adolescents during the COVID-19 pandemic: a systematic review. *Children-Basel*. 2023;10(2). doi:10.3390/children10020279
46. Houghton S, Kyron M, Hunter SC, et al. Adolescents' longitudinal trajectories of mental health and loneliness: the impact of COVID-19 school closures. *Journal of Adolescence*. 2022;94(2):191–205. doi:10.1002/jad.12017
47. Çiçek I, Şanlı M, Arslan G, Yıldırım M. Problematic social media use, satisfaction with life, and levels of depressive symptoms in university students during the COVID-19 pandemic: mediation role of social support. *Psihologija*. 2023;57. doi:10.2298/PSI220613009C.
48. Jung T, Wickrama KAS. An introduction to latent class growth analysis and growth mixture modeling. *Soc Personal Psychol Compass*. 2008;2(1):302–317. doi:10.1111/j.1751-9004.2007.00054.x
49. Nguena Nguefack HL, Pagé MG, Katz J, et al. Trajectory modelling techniques useful to epidemiological research: a comparative narrative review of approaches. *Clin Epidemiol*. 2020;12:1205–1222. doi:10.2147/clep.S265287
50. Domènech-Abella J, Gabarrell-Pascuet A, García-Mieres H, et al. Loneliness during the last phase of the COVID-19 pandemic in Spain: a longitudinal study of group-based trajectories, risk factors, and consequences in mental health. *Article; Early Access Psychiatry Res*. 2023;326. doi:10.1016/j.psychres.2023.115327
51. Barjaková M, Garnero A, d'Hombres B. Risk factors for loneliness: a literature review. *Rev Social Sci Med*. 2023;334. doi:10.1016/j.socscimed.2023.116163.
52. Li LZ, Wang SH. Prevalence and predictors of general psychiatric disorders and loneliness during COVID-19 in the United Kingdom. *Psychiatry Res*. 2020;291:113267. doi:10.1016/j.psychres.2020.113267
53. Holmes EA, O'Connor RC, Perry VH, et al. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *Lancet Psychiatry*. 2020;7(6):547–560. doi:10.1016/S2215-0366(20)30168-1
54. Hughes ME, Waite LJ, Hawkey LC, Cacioppo JT. A short scale for measuring loneliness in large surveys: results from two population-based studies. *Res Aging*. 2004;26(6):655–672. doi:10.1177/0164027504268574
55. Dost K, Heinrich F, Graf W, et al. Predictors of loneliness among homeless individuals in Germany during the COVID-19 pandemic. *Int J Environ Res Public Health*. 2022;19(19):12718. doi:10.3390/ijerph191912718
56. Steptoe A, Shankar A, Demakakos P, Wardle J. Social isolation, loneliness, and all-cause mortality in older men and women. *Proc Natl Acad Sci U S A*. 2013;110(15):5797–5801. doi:10.1073/pnas.1219686110
57. Goodman R. The strengths and difficulties questionnaire: a research note. *J Child Psychol Psychiatr*. 1997;38(5):581–586. doi:10.1111/j.1469-7610.1997.tb01545.x
58. Youthmind. Scoring the strengths & difficulties questionnaire for age 4-17 or 18+. Available from: <https://www.sdqinfo.org/py/sdqinfo/c0.py>. Accessed November 19, 2024.
59. Zimet GD, Dahlem NW, Zimet SG, Farley GK. The multidimensional scale of perceived social support. *J Personality Assess*. 1988;52(1):30–41. doi:10.1207/s15327752jpa5201_2
60. Ming Z, Chen Z. Psychological literacy: concept, assessment, intervention, and function. *Adv Psychol Sc*. 2020;28(01):1–12. [in Chinese]. doi:10.3724/SP.J.1042.2020.00001
61. Zongsheng Y. A study on the current situation and relationship of psychological literacy and mental health level of middle school students [Master's thesis]. Yunnan Normal University (in Chinese); 2016.
62. Kim SY. Determining the number of latent classes in single- and multi-phase growth mixture models. *Struct Equation Model*. 2014;21(2):263–279. doi:10.1080/10705511.2014.882690
63. Petras H, Masyn K. General growth mixture analysis with antecedents and consequences of change. In: Piquero AR, Weisburd D, editors. *Handbook of Quantitative Criminology*. Springer New York; 2010:69–100.
64. Pinchoff J, Friesen EL, Kangwana B, et al. How has COVID-19-related income loss and household stress affected adolescent mental health in Kenya? *J Adolesc Health*. 2021;69(5):713–720. doi:10.1016/j.jadohealth.2021.07.023
65. Twenge JM, Haidt J, Blake AB, McAllister C, Lemon H, Le Roy A. Worldwide increases in adolescent loneliness. *J Adolesc*. 2021;93:257–269. doi:10.1016/j.adolescence.2021.06.006
66. Standing Committee of Political Bureau of CPC. Central Committee discusses optimizing COVID-19 response. Available from: https://english.www.gov.cn/news/topnews/202211/11/content_WS636d8b3dc6d0a757729e2e1e.html. Accessed November 19, 2024.
67. McKeon G, Tiedemann A, Sherrington C, et al. Feasibility of an online, mental health-informed lifestyle program for people aged 60+ years during the COVID-19 pandemic. Article. *Health Promot J Austr*. 2022;33(3):545–552. doi:10.1002/hpja.538
68. Pels F, Kleinert J. Loneliness and physical activity: a systematic review. *Int Rev Sport Exerc Psychol*. 2016;9(1):231–260. doi:10.1080/1750984X.2016.1177849
69. Tse MMY, Tang SK, Wan VTC, Vong SKS. The effectiveness of physical exercise training in pain, mobility, and psychological well-being of older persons living in nursing homes. *Pain Manag Nurs*. 2014;15(4):778–788. doi:10.1016/j.pmn.2013.08.003
70. Savikko N, Routasalo P, Tilvis R, Pitkala K. Psychosocial group rehabilitation for lonely older people: favourable processes and mediating factors of the intervention leading to alleviated loneliness. *Int J Older People Nurs*. 2010;5(1):16–24. doi:10.1111/j.1748-3743.2009.00191.x
71. Singh B, Olds T, Curtis R, et al. Effectiveness of physical activity interventions for improving depression, anxiety and distress: an overview of systematic reviews. *Br J Sports Med*. 2023;57(18):1203–1209. doi:10.1136/bjsports-2022-106195

72. Holland C, Cole M, Owens J. Exercise and mental health: a vital connection. *Br J Sports Med.* 2024;58:691–692. doi:10.1136/bjsports-2024-108562
73. Zhang X, Dong SH. The relationships between social support and loneliness: a meta-analysis and review. *Acta Psychol.* 2022;227:103616. doi:10.1016/j.actpsy.2022.103616
74. Liu N, Li X, Ding X, Liu H, Zhang X. Mediating roles of perceived social support and sense of security in the relationship between negative life events and life satisfaction among left-behind children: a cross-sectional study. *Front Psychol.* 2022;13:1100677. doi:10.3389/fpsyg.2022.1100677
75. Li G, Li Y, Lam AIF, et al. Understanding the protective effect of social support on depression symptomatology from a longitudinal network perspective. *BMJ Ment Health.* 2023;26(1). doi:10.1136/bmjment-2023-300802
76. Degan TJ, Kelly PJ, Robinson LD, et al. Health literacy in people living with mental illness: a latent profile analysis. *Psychiatry Res.* 2019;280. doi:10.1016/j.psychres.2019.112499
77. Liu Y, Meng HD, Conner KO, Qiao MT, Liu DP. The influence of health literacy and social support on loneliness among patients with severe mental illness in Rural Southwest China. *Front Psychol.* 2021;12. doi:10.3389/fpsyg.2021.564666
78. Mizani H, Cahyadi A, Hendryadi H, Salamah S, Sari SR. Loneliness, student engagement, and academic achievement during emergency remote teaching during COVID-19: the role of the god locus of control. *Hum Soc Sci Commun.* 2022;9(1). doi:10.1057/s41599-022-01328-9
79. Dolphin L, Hennessy E. Labelling effects and adolescent responses to peers with depression: an experimental investigation. *BMC Psychiatry.* 2017;17(1):228. doi:10.1186/s12888-017-1389-9
80. Malakcioglu C. Emotional loneliness, perceived stress, and academic burnout of medical students after the COVID-19 pandemic. *Front Psychol.* 2024;15:1370845.
81. Madigan S, Racine N, Vaillancourt T, et al. Changes in depression and anxiety among children and adolescents from before to during the COVID-19 pandemic: a systematic review and meta-analysis. *JAMA Pediatrics.* 2023;177(6):567–581. doi:10.1001/jamapediatrics.2023.0846
82. Martin-Maria N, Caballero FF, Lara E, et al. Effects of transient and chronic loneliness on major depression in older adults: a longitudinal study. *Int J Geriatr Psychiatry.* 2021;36(1):76–85. doi:10.1002/gps.5397
83. Masi CM, Chen HY, Hawkey LC, Cacioppo JT. A meta-analysis of interventions to reduce loneliness. *Pers Soc Psychol Rev.* 2011;15(3):219–266. doi:10.1177/1088868310377394
84. Ma RM, Wang JY, Lloyd-Evans B, Marston L, Johnson S. Trajectories of loneliness and objective social isolation and associations between persistent loneliness and self-reported personal recovery in a cohort of secondary mental health service users in the UK. *BMC Psychiatry.* 2021;21(1). doi:10.1186/s12888-021-03430-9
85. Cacioppo JT, Cacioppo S, Boomsma DI. Evolutionary mechanisms for loneliness. *Cogn Emot.* 2014;28(1):3–21. doi:10.1080/02699931.2013.837379
86. Hosozawa M, Cable N, Yamasaki S, et al. Predictors of chronic loneliness during adolescence: a population-based cohort study. *Child Adolesc Psychiatr Ment Health.* 2022;16(1). doi:10.1186/s13034-022-00545-z
87. Zhang W, Wang Z. Negative life events and adolescents' externalizing problems: a moderated mediation model. *Curr Psychol.* 2023;42(23):19596–19606. doi:10.1007/s12144-022-03109-8
88. Iannattone S, Mezzalana S, Bottesi G, Gatta M, Miscioscia M. Emotion dysregulation and psychopathological symptoms in non-clinical adolescents: the mediating role of boredom and social media use. *Child Adolesc Psychiatr Ment Health.* 2024;18(1):5. doi:10.1186/s13034-023-00700-0
89. Allen JP, Costello MA, Hellwig AF, Stern JA. Pathways from adolescent close friendship struggles to adult negative affectivity. *Dev psychopathol.* 2024;1–10. doi:10.1017/S0954579423001542
90. WHO. WHO launches commission to foster social connection. Available from: <https://www.who.int/news/item/15-11-2023-who-launches-commission-to-foster-social-connection>. Accessed, 2024.
91. Mann F, Bone JK, Lloyd-Evans B, et al. A life less lonely: the state of the art in interventions to reduce loneliness in people with mental health problems. *Soc Psychiatry Psychiatr Epidemiol.* 2017;52(6):627–638. doi:10.1007/s00127-017-1392-y

Psychology Research and Behavior Management

Dovepress

Publish your work in this journal

Psychology Research and Behavior Management is an international, peer-reviewed, open access journal focusing on the science of psychology and its application in behavior management to develop improved outcomes in the clinical, educational, sports and business arenas. Specific topics covered in the journal include: Neuroscience, memory and decision making; Behavior modification and management; Clinical applications; Business and sports performance management; Social and developmental studies; Animal studies. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/psychology-research-and-behavior-management-journal>