Impact of psychosocial stressors on emotional and behavioral problems in Chinese adolescents during the COVID-19 period: the explanatory value of loneliness

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Background: Chinese adolescents experienced a variety of stressors during the COVID-19 home confinement period. This study aimed to investigate the prevalence of emotional and behavioral problems (EBPs) among adolescents during the COVID-19 period. The study also examined the relationships between psychosocial stressors and adolescents' EBPs, and explored the potential explanatory value of loneliness for any associations observed.

Methods: We conducted a cross-sectional study which included 6,587 adolescents in Taizhou, China between April 16 and May 14, 2020. Adolescents' EBPs were assessed by the Strengths and Difficulties Questionnaire (SDQ), while subjective feelings of loneliness were assessed using one item from the Children's Depression Inventory. We applied structural equation modelling to assess direct and indirect associations (explained by loneliness) between psychosocial stressors (study problems, parent-child relationship, and family or friends with COVID-19) and the total difficulties and prosocial scores.

Results: The prevalence of EBPs in the sample was 31.6% for total difficulties and 37.5% for prosocial problems. After adjustment for a range of covariates, the presence of study problems, poor parent-child relationship and family or friends with COVID-19 were significantly associated with a higher SDQ total difficulties score (β=6.20, 21.46, 5.21; P<0.01) and a lower prosocial score (β=−0.79, −4.35, −1.65; P<0.01). There was an explanatory effect of loneliness on these associations, which explained 27–37% of the total effect on the total difficulties score and 11–37% on the prosocial score.

Conclusions: The presence of psychosocial stressors during the home confinement period was related to higher EBPs in adolescents, and the relationship was partially explained by loneliness. Targeted psychosocial interventions towards loneliness and COVID-19 related stressors may improve adolescents' psychological health.

Keywords: Chinese adolescents; psychosocial stressors; home confinement; psychological health; COVID-19

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Introduction

In December 2019, the COVID-19 coronavirus disease outbreak was reported in Wuhan, Hubei Province, China (1). The coronavirus caused widespread human-to-human transmission and severe acute respiratory syndrome (2). The Chinese government conducted a series of preventive and control strategies in response to this epidemic, such as business and school closures, home confinement and social distancing, after the Chinese New Year in late January, 2020 (3). The Chinese Ministry of Education estimated that over 220 million children and adolescents were confined to their homes during the outbreak (4). By April 10, 2020, the pandemic had caused nationwide school closures in 192 countries and had affected more than one billion learners worldwide (5).

Taizhou, a city in Zhejiang Province of China, had a large population engaging in trade and learning in Wuhan before the pandemic. More than 20,000 people returned from Wuhan to Taizhou when the pandemic started (6). Thereafter, 146 confirmed cases (no deaths) were reported by 15 February 2020 in Taizhou. The government of the Zhejiang province launched the first level response on 23 January 2020. On 29 January 2020 the school term opening date was postponed, and all non-essential businesses were closed on 31 January (7). This was the first time that adolescent students in China experienced home schooling and isolation from their peers, teachers and society for a long period. Moreover, they had little outdoor activities and were more likely to have tension with parents. Although social distancing measures are necessary, it is concerning that prolonged school closure and home confinement may negatively affect adolescents' mental health (8). Previous studies on the impact of quarantine caused by the severe acute respiratory syndrome (SARS), Ebola and Middle East respiratory syndrome (MERS) epidemics reported a high prevalence of psychological symptoms and behavioral problems, such as fear, depression, anxiety, loneliness and sleep disturbance (9,10). Recent studies also revealed that the COVID-19 confinement disrupted children's behavioral and emotional patterns (11).

During this time of uncertainty, adolescents may experience a variety of psychosocial stressors which can be detrimental to their psychological health. School closures limited children's academic progress and in-person contact with their peers and increased loneliness (12). Adolescents' identity was largely dependent on peer relations and academic performance, so they were vulnerable to long-time social isolation (13). A U.S. study revealed that after social distancing guidelines were administered, 61% of parents shouted or screamed at their children, and 20% spanked or slapped their children at least once in the last two weeks (14). Being confined in an abusive environment can predispose adolescents to mental health problems. A study from China found that having relatives or acquaintances infected with SARS-CoV-2 was a risk factor for anxiety in college students (15).

Another important issue is how psychosocial stressors encountered by adolescents during home confinement affects their psychological wellbeing. Loneliness is a common emotional experience of social isolation in the pandemic, which is associated with adverse psychological health among adolescents (12). In addition, prior research suggests that people from a collectivism culture may be more vulnerable to loneliness during long-term social isolation (16), as Chinese culture emphasizes a connection between oneself and relevant others. However, there is little research addressing associations between psychosocial stressors during home confinement, loneliness, and emotional and behavioral problems (EBPs) among adolescents in China.

Therefore, our study assessed the prevalence of EBPs among Chinese adolescents in Taizhou during the school closures. We also investigated relationships between psychosocial stressors related to the pandemic and adolescents' EBPs, and explored whether loneliness explained the relationship. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/tp-21-300).

Methods

Participants and design

A cross-sectional study was conducted among adolescent students in Taizhou, Zhejiang Province, China between April 16 and May 14, 2020. Random cluster sampling was used in this study: (I) 12 middle schools and 12 high schools were randomly selected from districts of Taizhou; (II) Key schools, ordinary schools and private schools each accounted for one third; (III) from each school, two classes were randomly selected from each grade; (IV) all the students in the selected classes were invited to complete an online questionnaire. Inclusion criteria were as follows: (I) ability to give online informed consent; (II) ability to read, understand, and complete

questionnaires independently. A total of 7,242 participants provided written informed consent and completed the questionnaires. Completion time on the survey of more than one hour or unavailability of school information were considered as invalid questionnaires and were deleted. A total of 6,587 participants were included in the analysis. All study procedures involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethical committee of the School of Public Health, Fudan University (IRB approval number 2020040817). Written informed consent was given by all individual participants.

Measures

The self-report version of the Strengths and Difficulties Questionnaire (SDQ) was used to assess EBPs over the past six months (17). The SDQ consists of 25 items measuring four difficulties (emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems), as well as prosocial behavior. Each item is scored 0, 1, or 2, and each subscale has five items with scores ranging from 0 to 10. The scores for the first four subscales were summed to generate a total difficulties score ranging from 0 to 40, while the prosocial behavior subscale assessed the level of strengths with scores from 0 to 10. In previous studies, the Chinese student version of the SDQ showed good reliability and validity. Average Cronbach's alpha for the internal consistency of the total difficulties score and the prosocial score was 0.74 and 0.72 respectively, and the average test-retest reliability was 0.77 and 0.71 respectively (18). In this study, Cronbach's alpha for the internal consistency of the total difficulties and prosocial scores were 0.83 and 0.76 respectively. The 4-band categorization for the SDQ was used: close to average, slightly raised/slightly lowered, high/low, and very high/very low (www.sdqinfo.org).

Subjective feelings of loneliness were assessed using item 20 from the Chinese version of the Children's Depression Inventory (CDI) (19,20). This item consists of three statements scored from 0 to 2, and participants were instructed to choose the best statement that described their feelings during the last two weeks: "I do not feel lonely", "I feel lonely many times", or "I always feel lonely". The responses were categorized into never *vs.* many times or always. A broader measure of loneliness was derived using three items from the CDI, including item 20, item 22 ("I have plenty of friends", "I have some friends but I wish I had more", or "I do not have any friends") and item 25

("Nobody really loves me", "I am not sure if anybody loves me", or "I am sure that somebody loves me") (21). A sum score was produced ranging from 0 to 6.

The questions about study problems asked participants whether they currently had difficulty in studying at home; whether they had difficulty in studying before school closures; and whether they like remote learning. Relationships with mothers and fathers were divided into 2 categories: good or normal relationship *vs.* poor relationship. Family or friends with COVID-19 was dichotomized into no or yes. Sociodemographic characteristics were sex, age, economic status, father's education, and mother's education.

Statistical analysis

Continuous variables were described as mean (standard deviation, SD) and categorical variables as frequency and percentage. Chi-square was used to compare the distributions of categorical variables among different SDQ groups. Mean differences of continuous variables among different SDQ groups were tested by one-way ANOVA.

Structural equation modelling (SEM) was used to assess whether the effects of study problems (model 1), parent-child relationship (model 2) and family or friends with COVID-19 (model 3) on the total difficulties and prosocial scores were explained by loneliness. Explanatory effects were defined as the product of path a and path b (or path b') using the delta test (see *Figures 1-3*). Effect sizes of the explanatory effect of loneliness were calculated using MacKinnon's formula (22), namely the explained percentage which was computed as the indirect effect divided by the total effect. In all analyses, models were adjusted for sex, age, economic status, father's education and mother's education. Model 1 additionally adjusted for having difficulty in studying at school before the pandemic. Model estimates and standard errors took into account the complex survey design with clustered samples. Maximum likelihood with missing values estimation was adopted to handle missing data. As recommended by Hu and Bentler (23), several model fit indices were used including χ^2 (P>0.05), root mean square error of approximation (RMSEA <0.06), comparative fit index (CFI >0.95) and Tucker-Lewis index (TLI >0.95). Unstandardized (β) and standardized path coefficients (b) were estimated. Two-sided P value <0.05 was considered statistically significant. Sensitivity analysis 1 was conducted using SEM for the explanatory effects of loneliness as the sum of items 20, 22 and 25 from the CDI. Loneliness in sensitivity analysis 2 was classified as never/many times and
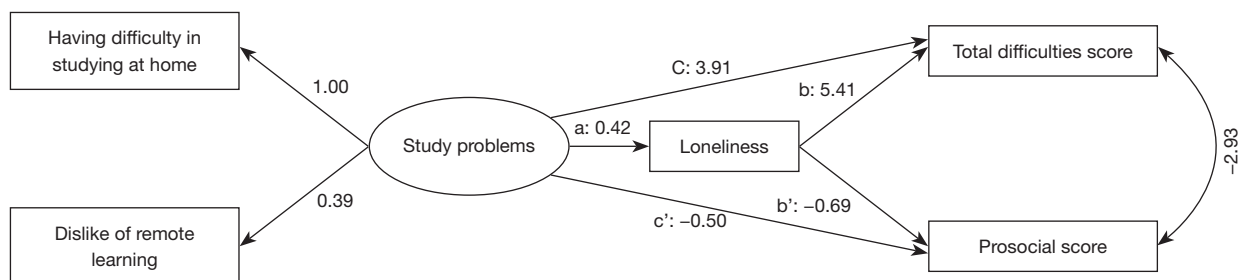
Figure 1 Model 1 of associations between study problems, loneliness, total difficulties score and prosocial score. Data shown are unstandardized coefficients and all associated P values are less than 0.05. Model 1 adjusted for sex, age, economic status, whether having difficulty in studying in school, father's education and mother's education.
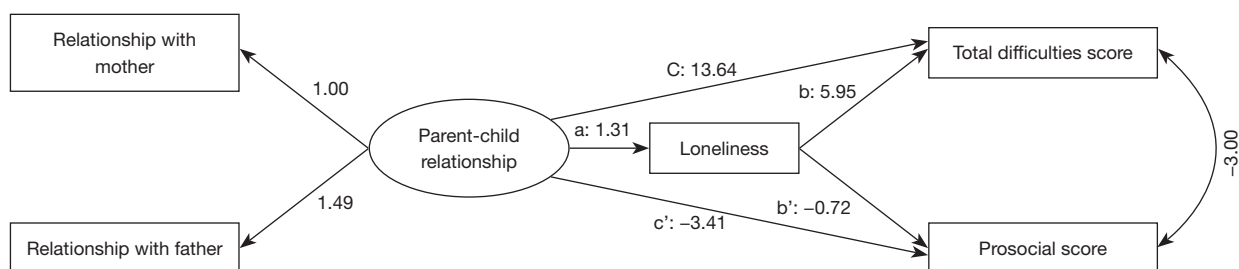

Figure 2 Model 2 of associations between parent-child relationship, loneliness, total difficulties score and prosocial score. Data shown are unstandardized coefficients and all associated P values are less than 0.05. Model 2 adjusted for sex, age, economic status, father's education and mother's education.

Figure 3 Model 3 of associations between family or friends with COVID-19, loneliness, total difficulties score and prosocial score. Data shown are unstandardized coefficients and all associated P values are less than 0.05. Model 3 adjusted for sex, age, economic status, father's education and mother's education.
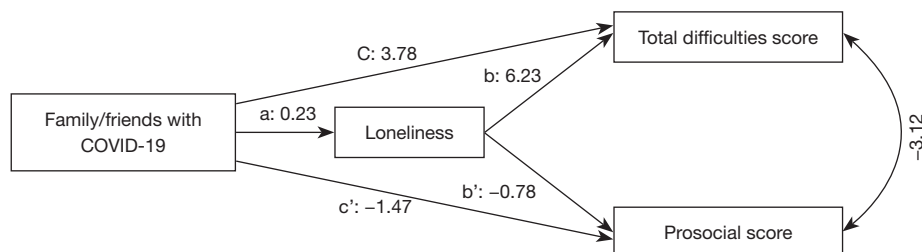
always. Stata version 15.1 (StataCorp LP, College Station, TX, USA) was used for all statistical analyses.

Results

General characteristics of participants

General characteristics of the 6,587 participants are shown in *Table 1*. The sex ratio was about 1:1, and the average age was 15.6 (1.7) years. The prevalence of adolescent EBPs was 31.6% for total difficulties and 37.5% for prosocial problems. When cut-points for a four-fold classification of SDQ scores were used, 722 (11.0%) participants had very high total difficulties score and 481 (7.2%) had high score in the whole sample. Regarding the prosocial scale, 503 (7.6%) and 1,009 (15.3%) participants had very low and low scores respectively. Age, gender, economic status and parents' education were associated with the prevalence of EBPs.

Table 1 Characteristics of participants

Characteristics	Total	Strengths & Difficulties Questionnaire (SDQ) total difficulties score level					Strengths & Difficulties Questionnaire (SDQ) prosocial score level				
		Close to average [0–13]	Slightly raised [15–17]	High [18–19]	Very high [20–40]	P value	Close to average [7–10]	Slightly lowered [6]	Low [5]	Very low [0–4]	P value
n (%)	6,587	4,504 (68.4)	880 (13.4)	481 (7.2)	722 (11.0)		4,115 (62.5)	960 (14.6)	1,009 (15.3)	503 (7.6)	
SDQ total difficulties score (range 0–40)	11.8 (5.8)	8.6 (3.4)	16.0 (0.8)	18.5 (0.5)	22.3 (2.7)	<0.001	8.6 (1.2)	6 (0.0)	5 (0.0)	3.1 (1.2)	<0.001
Sociodemographic variables											
Age, years[a]	15.6 (1.7)	15.6 (1.7)	15.7 (1.7)	15.8 (1.7)	15.7 (1.6)	<0.001	15.6 (1.7)	15.6 (1.7)	15.6 (1.7)	15.5 (1.6)	0.494
Gender, n (%)						0.032					<0.001
Male	3,290 (49.9)	2,263 (50.2)	427 (48.5)	216 (44.9)	384 (53.2)		1,943 (47.2)	488 (50.8)	548 (54.3)	311 (61.8)	
Female	3,297 (50.1)	2,241 (49.8)	453 (51.5)	265 (55.1)	338 (46.8)		2,172 (42.8)	472 (49.2)	461 (45.7)	192 (38.2)	
Economic status, n (%)						<0.001					<0.001
High/middle	6,136 (93.2)	4,268 (94.8)	797 (90.6)	432 (89.8)	639 (88.5)		3,872 (94.1)	897 (93.4)	912 (90.4)	455 (90.5)	
Low	451 (6.8)	236 (5.2)	83 (9.4)	49 (10.2)	83 (11.5)		243 (5.9)	63 (6.6)	97 (9.6)	48 (9.5)	
Father's education, n (%)						<0.001					<0.001
Primary school or lower	1,225 (18.6)	763 (16.9)	198 (22.5)	98 (20.4)	166 (23.0)		709 (17.2)	177 (18.4)	209 (20.7)	130 (25.8)	
Middle school	3,137 (47.6)	2,171 (48.2)	407 (46.2)	228 (47.4)	331 (45.8)		1,966 (47.8)	469 (48.9)	490 (48.6)	212 (42.2)	
High school	1,512 (23.0)	1,031 (22.9)	204 (23.2)	116 (24.1)	161 (22.3)		945 (23.0)	221 (23.0)	242 (24.0)	104 (20.7)	
College or higher	713 (10.8)	539 (12.0)	71 (8.1)	39 (8.1)	64 (8.9)		495 (12.0)	93 (9.7)	68 (6.7)	57 (11.3)	
Mother's education, n (%)						<0.001					0.042
Primary school or lower	1,650 (25.0)	1,034 (23.0)	258 (29.3)	138 (28.7)	220 (30.5)		1,004 (24.4)	242 (25.2)	171 (26.9)	133 (26.4)	
Middle school	2,931 (44.5)	2,042 (45.3)	385 (43.7)	209 (43.4)	295 (40.9)		1,806 (43.9)	439 (45.7)	469 (46.5)	217 (43.1)	
High school	1,323 (20.1)	909 (20.2)	166 (18.9)	97 (20.2)	151 (20.9)		839 (20.4)	186 (19.4)	193 (19.1)	105 (21.0)	
College or higher	683 (10.4)	519 (11.5)	71 (8.1)	37 (7.7)	56 (7.7)		466 (11.3)	93 (9.7)	76 (7.5)	48 (9.5)	
Psychological stressors											
Loneliness						<0.001					<0.001
No	4,353 (66.1)	3,632 (80.6)	391 (44.4)	161 (33.5)	169 (23.4)		2,960 (71.9)	576 (60.0)	558 (55.3)	259 (51.5)	
Yes	2,234 (33.9)	872 (19.4)	489 (55.6)	320 (66.5)	553 (76.6)		1,155 (28.1)	384 (40.0)	451 (44.7)	244 (48.5)	

Table 1 (*continued*)

Table 1 (*continued*)

Characteristics	Total	Strengths & Difficulties Questionnaire (SDQ) total difficulties score level					Strengths & Difficulties Questionnaire (SDQ) prosocial score level				
		Close to average [0–13]	Slightly raised [15–17]	High [18–19]	Very high [20–40]	P value	Close to average [7–10]	Slightly lowered [6]	Low [5]	Very low [0–4]	P value
Having difficulty in studying at home, n (%)						<0.001					<0.001
No	3,018 (45.8)	2,431 (54.0)	292 (33.2)	137 (28.5)	158 (21.9)		2,017 (49.0)	394 (41.0)	405 (40.1)	202 (40.2)	
Yes	3,569 (54.2)	2,073 (46.0)	588 (66.8)	344 (71.5)	564 (78.1)		2,098 (51.0)	566 (59.0)	604 (59.9)	301 (59.8)	
Having difficulty in studying in school, n (%)						<0.001					<0.001
No	3,655 (55.5)	2,799 (62.1)	411 (46.7)	185 (38.5)	260 (36.0)		2,420 (58.8)	491 (51.2)	494 (49.0)	250 (49.7)	
Yes	2,932 (44.5)	1,705 (37.9)	469 (53.3)	296 (61.5)	462 (64.0)		1,695 (41.2)	469 (48.8)	515 (51.0)	253 (50.3)	
Remote learning, n (%)						<0.001					<0.001
Like	3,555 (54.0)	2,594 (57.6)	420 (47.7)	224 (46.6)	317 (43.9)		2,325 (56.5)	508 (52.9)	492 (48.8)	230 (45.7)	
Dislike	3,032 (46.0)	1,910 (42.4)	460 (52.3)	257 (53.4)	405 (56.1)		1,790 (43.5)	452 (47.1)	517 (51.2)	273 (54.3)	
Relationship with mother, n (%)						<0.001					0.001
Good/normal	6,461 (98.1)	4,462 (99.1)	853 (96.9)	461 (95.8)	685 (94.9)		4,051 (98.4)	940 (97.9)	988 (97.9)	482 (95.8)	
Poor	126 (1.9)	42 (0.9)	27 (3.1)	20 (4.2)	37 (5.1)		64 (1.6)	20 (2.1)	21 (2.1)	21 (4.2)	
Relationship with father, n (%)						<0.001					<0.001
Good/normal	6,409 (97.3)	4,447 (98.7)	839 (95.3)	457 (95.0)	666 (92.2)		4,024 (97.8)	938 (97.7)	974 (96.5)	473 (94.0)	
Poor	178 (2.7)	57 (1.3)	41 (4.7)	24 (5.0)	56 (7.8)		91 (2.2)	22 (2.3)	35 (3.5)	30 (6.0)	
Family/friends with COVID-19, n (%)						<0.001					<0.001
No	6,541(99.3)	4,491 (99.7)	871 (99.0)	471 (97.9)	708 (98.1)		4,099 (99.6)	951 (99.1)	1,004 (99.5)	487 (96.8)	
Yes	46 (0.7)	13 (0.3)	9 (1.0)	10 (2.1)	14 (1.9)		16 (0.4)	9 (0.9)	5 (0.5)	16 (3.2)	

Data are mean (SD) or n (%). [a], Age had 152 missing values.

Over one third (33.9%) of participants reported feelings of loneliness and they were more likely to have higher total difficulties and lower prosocial scores compared to those who were not lonely. In addition, adolescents with EBPs were more likely to report psychological stressors, such as difficulty in studying at home or in school, dislike of remote learning, poor relationship with the mother or father, and family or friends with COVID-19.

Psychological stressors, loneliness, and EBPs

Table 2 and *Figures 1-3* present statistical results of the multivariable models 1-3. The models had relatively good fit indices for model 1 (χ^2 =91.46, P<0.05; RMSEA 0.04, 95% CI: 0.03–0.05; CFI 0.99; TLI 0.94); model 2 (χ^2 =5.33, P>0.05; RMSEA <0.001, 95% CI: 0.00–0.01; CFI 1.00; TLI 1.00); and model 3 (χ^2 =0.00, P>0.05; RMSEA 0.00, 95% CI: 0.00–0.00; CFI 1.00; TLI 1.00).

The factor of study problems was treated as a latent variable with two indicators: difficulty in studying at home and dislike of remote learning (b=0.31, P<0.001). There was a significant indirect effect (b=0.34 for path a; b=0.45 for path b; β=2.29 for path a x b) (*Table 2*), indicating that loneliness explained the relationship between study problems and the total difficulties score. Loneliness also explained the association between study problems and the prosocial score (b=–0.15 for path b'; β=–0.29 for path a x b'). After controlling for the indirect effect of loneliness, the direct effect of study problems on total difficulties score (b=0.26 for path c) and prosocial score (b=–0.09 for path c') still remained significant. The total effect of study problems on the total difficulties score (β=6.20 for path a x b + c, effect size =0.37) and prosocial score (β=–0.79 for path a x b + c', effect size =0.37) was also statistically significant. Both effect sizes were in the moderate range according to Cohen's guidelines (24,25). All these results suggested a partial explanatory effect of loneliness for the association between study problems and the total difficulties and prosocial scores (*Figure 1*).

In Model 2, analysis of the latent factor of parent-child relationship along with the indicators of this construct (relationship with mother and relationship with father) was significant (b=0.56, P<0.001). Sex, age, economic status, father's education and mother's education were adjusted. There was a significant indirect effect (b=0.18 for path a; b=0.50 for path b; β=7.82 for path a x b), indicating that loneliness explained the association between parent-child relationship and the total difficulties score. The direct

effect of parent-child relationship on the total difficulties score (b=13.64 for path c) remained after controlling for the indirect effect of loneliness. The total effect of parent-child relationship on the total difficulties score (β=21.46 for path a x b + c) was also statistically significant. As shown in *Table 2*, the indirect effect yielded a medium effect size of 36%. Similarly, loneliness partially explained the association between parent-child relationship and the prosocial score (*Figure 2*).

In Model 3, after adjusting for sex, age, economic status, father's education and mother's education, there was a significant indirect effect (b=0.23 for path a; b=6.23 for path b; β=1.43 for path a x b), indicating that loneliness explained the relationship between family or friends with COVID-19 and the total difficulties score. The direct and total effects of family or friends with COVID-19 on total difficulties score (b=3.78 for path c; β=5.21 for path a x b + c) were both statistically significant. Effect size for the indirect effect was 27%. There was also a partial explanatory effect of loneliness for the association between family or friends with COVID-19 and prosocial score, although the effect size was smaller (*Figure 3*).

Sensitivity analyses based on the broader measure of loneliness also revealed that study problems, poor parent-child relationship and family or friends with COVID-19 were positively associated with total difficulties score through direct and indirect effect (explained by loneliness) with larger effect sizes than those of the primary analyses (42–66%) (Table S1). After controlling for the indirect effect of loneliness, the direct effect of study problems and parent-child relationship on prosocial score did not remain significant, indicating a full explanatory effect. Sensitivity analyses using loneliness classified as never or many times *vs.* always were largely consistent with the primary analyses (Table S2). Although the effect sizes were smaller (5–28%), they still represented a "practically" significant effect (25).

Discussion

We suggest that home confinement may lead to an increase in psychological problems among Chinese adolescents during the COVID-19 pandemic. In comparison, two studies found that social distancing and isolation measures increased children's conduct problems, emotional problems, hyperactivity and peer relationship problems (11,26). The ongoing Co-SPACE survey in the UK reported an increase in the proportion of secondary school age children who were likely to have hyperactivity/inattention and conduct

Table 2 Statistical results of the multivariable models

	β	SE	b	P	Effect size
Model 1					
Study problems → loneliness (path a)	0.42	0.06	0.34	<0.001	
Loneliness → total difficulties score (path b)	5.41	0.25	0.45	<0.001	
Study problems → total difficulties score (path c)	3.91	0.65	0.26	<0.001	
Indirect effect via loneliness (a x b)	2.29	0.27	–	<0.001	
Total effect of study problems on total difficulties score (a x b + c)	6.20	0.86	–	<0.001	0.37
Loneliness → prosocial score (path b')	−0.69	0.07	-0.15	<0.001	
Study problems → prosocial score (path c')	−0.50	0.22	-0.09	0.035	
Indirect effect via loneliness (a x b')	−0.29	0.03	–	<0.001	
Total effect of study problems on prosocial score (a x b + c')	−0.79	0.22	–	0.002	0.37
Study problems ~					
Dislike of remote learning	0.39	0.02	0.31	<0.001	
Model 2					
Parent-child relationship → loneliness (path a)	1.31	0.23	0.18	<0.001	
Loneliness → total difficulties score (path b)	5.95	0.20	0.50	<0.001	
Parent-child relationship → total difficulties score (path c)	13.64	2.74	0.16	<0.001	
Indirect effect via loneliness (a x b)	7.82	1.28	–	<0.001	
Total effect of parent-child relationship on total difficulties score (a x b + c)	21.46	3.78	–	<0.001	0.36
Loneliness → prosocial score (path b')	−0.72	0.03	-0.16	<0.001	
Parent-child relationship → prosocial score (path c')	−3.41	1.21	-0.10	0.011	
Indirect effect via loneliness (a x b')	−0.94	0.16	–	<0.001	
Total effect of parent-child relationship on prosocial score (a x b + c')	−4.35	1.34	–	0.004	0.22
Parent-child relationship ~					
Relationship with father	1.49	0.17	0.56	<0.001	
Model 3					
Family/friends COVID-19 with→ loneliness (path a)	0.23	0.05	0.05	<0.001	
Loneliness → total difficulties score (path b)	6.23	0.18	0.52	<0.001	
Family/friends COVID-19 with→ total difficulties score (path c)	3.78	1.19	0.07	<0.001	
Indirect effect via loneliness (a x b)	1.43	0.30	–	<0.001	
Total effect of family/friends with COVID-19 on total difficulties score (a x b + c)	5.21	1.36	–	0.001	0.27
Loneliness → prosocial score (path b')	−0.78	0.04	-0.18	<0.001	
Family/friends with COVID-19→ prosocial score (path c')	−1.47	0.43	-0.07	0.003	
Indirect effect via loneliness (a x b')	−0.18	0.04	–	<0.001	
Total effect of family/friends with COVID-19 on prosocial score (a x b + c')	−1.65	0.44	–	0.001	0.11

β = unstandardized estimate; b = standardized estimate. Effect size is the proportion explained, which is calculated by dividing the indirect effect by the total effect.

problems over a one-month period early in lockdown (27). It was notable that over one-third of adolescent students in our study reported feelings of loneliness. This is consistent with two studies which found the prevalence of loneliness among UK adults as 27–36% during the pandemic (28,29). The data for children are scarce, but early indications are that more than one third of adolescents experienced high levels of loneliness in the pandemic, which is similar to the results of our study.

To our knowledge, this is the first study to partition the effects of home confinement-related psychosocial stressors during the COVID-19 epidemic on EBPs of Chinese adolescents into direct and indirect effects (explained by loneliness). Our results revealed that study problems (having difficulty in studying at home and dislike of remote learning), poor parent-child relationship and family or friends with COVID-19 were positively related with total the SDQ difficulties score and negatively with the prosocial score directly and indirectly. It is widely accepted that personal factors, family environment, and negative life events play a significant role in the development of adolescent students' mental health (30). In this study, 46.0% of the students disliked remote learning and 54.2% had difficulty in studying at home. Those students may worry about their academic performance, struggle against lack of self-discipline, and have a sense of isolation (31). These experiences can adversely affect adolescent psychological wellbeing. In addition, some parents had to bear economic pressure because of unemployment and economic recession. It was also difficult for young parents to balance work, caregiving and homeschooling during the time of school closures (32). Recent studies showed that the confinement caused an emotional impact on parents that affected regular interactions with their children, leading to changes in children's behavior and psychological wellbeing (11,33). For some adolescents, being at home may be a quality family time, but for some, if home is not a comfortable place, this may be particularly difficult (34). It is intuitively understandable that families or friends of infected people are vulnerable populations because of the uncertainty about their own infection or the disease status of their families and friends (35). Future research is needed that addresses how mental health consequences for vulnerable groups can be alleviated under pandemic conditions (36).

In addition, we found a partial explanatory effect of loneliness on the relationships between psychosocial stressors and total the difficulties and prosocial scores. The findings provide support for the positive relationship

between loneliness and adolescents' EBPs. Loneliness is considered as the psychological state that results from dissatisfaction with the discrepancy between desired and actual social relationships (37). Levels of loneliness may be worsened by enforced social distancing and home confinement. Experiencing loneliness may make adolescents more vulnerable to EBPs such as emotional problems, conduct problems, hyperactivity and peer problems in the pandemic (12). The effect of loneliness on psychological health may be transmitted through biological, psychological and behavioral mechanisms. Loneliness has been found to affect biology, human brain activation and animal brain structures and processes (38). Loneliness may also change adolescents' perception of stressful events caused by the pandemic and predispose them to psychological risk factors. For example, researchers found that loneliness in children and adolescents was associated with poor self-esteem, perceived social competence, and insecure attachment (39,40). Additionally, lonely young people are more likely to utilize negative strategies to cope with stress, such as withdrawing and not seeking help (41). Prosocial behavior represents a series of acts that are beneficial to others or society as a whole (42). Almost all the empirical studies have found that loneliness has an adverse effect on individual prosocial behavior (43,44), and our results support these previous findings. Our study indicated that loneliness may serve as an important intervention target. If loneliness could be mitigated, such interventions may reduce adolescents' psychological problems and increase prosocial behavior. However, future research using longitudinal designs is needed to confirm this speculation.

This study had several limitations. First, while there was a large sample size with good representation of students in Taizhou, Zhejiang Province, which was one of the developed areas of China, it remains unclear whether the results from this sample can be extrapolated to other populations, because the severity of COVID-19 was different in other cities or countries. Moreover, behavioral reactions and psychological maladjustment to infectious diseases, school closures and home confinement might be associated with cultural factors, such as individualism and collectivism (45). Second, loneliness was assessed by just one item from the CDI and the nature of loneliness might not be sufficiently captured by this. However, results based on three items from the CDI and on a different classification of the single item were consistent with primary analyses. Third, causality between psychosocial stressors, loneliness and EBPs cannot be inferred from a cross-sectional study. A

longitudinal design is needed to examine these findings.

Conclusions

In conclusion, this study showed that psychosocial stressors during home confinement (study problems, poor parent-child relationship and family or friends with COVID-19) were possible risk factors for adolescents' EBPs during the COVID-19 pandemic. Loneliness may serve as an important intervention target for psychosocial stressors and psychological and behavioral problems. Psychosocial interventions may ameliorate students' difficulties in studying, improve parent-child relationship, mitigate concerns about COVID-19 and reduce feelings of loneliness. Adolescents need quality time with their peer group for identity and support. Social connectedness improves opportunities to obtain resilience to adversity. Therefore, it is important to use creative approaches to staying connected during school closures (e.g., various virtual social contact), and to provide adolescents with a sense of belonging within the family and a wider community (34). Adolescence is a significant transitional period of psychological development during which deviant behaviors and negative emotions can become deeply-rooted problems. Tracking psychological adaptation after the epidemic is also necessary.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/tp-21-300

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethical committee of School of Public Health, Fudan University (IRB approval number 2020040817). Written informed consent was given by all individual participants.

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Table S1 Sensitivity analysis 1 of the multivariable models

Model	β	SE	b	P	Effect size
Model 1					
Study problems → loneliness (path a)	1.14	0.16	0.35	<0.001	
Loneliness → total difficulties score (path b)	2.39	0.10	0.53	<0.001	
Study problems → total difficulties score (path c)	3.35	0.65	0.23	<0.001	
Indirect effect via loneliness (a x b)	2.72	0.32	—	<0.001	
Total effect of study problems on total difficulties score (a x b + c)	6.07	0.88	—	<0.001	0.45
Loneliness → prosocial score (path b')	-0.57	0.03	-0.34	<0.001	
Study problems → prosocial score (path c')	-0.12	0.19	-0.02	0.544	
Indirect effect via loneliness (a x b')	-0.65	0.08	—	<0.001	
Total effect of study problems on prosocial score (a x b + c')	-0.77	0.22	—	0.002	0.84
Study problems ~					
Dislike of remote learning	0.39	0.02	0.30	<0.001	
Model 2					
Parent-child relationship → loneliness (path a)	5.34	0.85	0.28	<0.001	
Loneliness → total difficulties score (path b)	2.58	0.06	0.57	<0.001	
Parent-child relationship → total difficulties score (path c)	7.16	2.34	0.08	0.006	
Indirect effect via loneliness (a x b)	13.78	2.09	—	<0.001	
Total effect of parent-child relationship on total difficulties score (a x b + c)	20.93	3.58	—	<0.001	0.66
Loneliness → prosocial score (path b')	-0.57	0.02	-0.34	<0.001	
Parent-child relationship → prosocial score (path c')	-1.20	1.16	-0.04	0.311	
Indirect effect via loneliness (a x b')	-3.04	0.46	—	<0.001	
Total effect of parent-child relationship on prosocial score (a x b + c')	-4.24	1.32	—	0.004	0.72
Parent-child relationship ~					
Relationship with father	1.40	0.16	0.55	<0.001	
Model 3					
Family/friends with COVID-19→ loneliness (path a)	0.82	0.26	0.07	0.004	
Loneliness → total difficulties score (path b)	2.67	0.06	0.59	<0.001	
Family/friends with COVID-19→ total difficulties score (path c)	3.01	0.69	0.06	<0.001	
Indirect effect via loneliness (a x b)	2.20	0.70	—	0.005	
Total effect of family/friends with COVID-19 on total difficulties score (a x b + c)	5.21	1.36	—	0.001	0.42
Loneliness → prosocial score (path b')	-0.58	0.18	-0.35	<0.001	
Family/friends with COVID-19→ prosocial score (path c')	-1.17	0.34	-0.06	0.002	
Indirect effect via loneliness (a x b')	-0.48	0.15	—	0.005	
Total effect of family/friends with COVID-19 on prosocial score (a x b + c')	-1.65	0.44	—	0.001	0.29

β = unstandardized estimate; b = standardized estimate. Effect size is the proportion explained, which is calculated by dividing the indirect effect by the total effect.

Table S2 Sensitivity analysis 2 of the multivariable models

Model	β	SE	b	P	Effect size
Model 1					
Study problems → loneliness (path a)	0.09	0.02	0.15	<0.001	
Loneliness → total difficulties score (path b)	7.12	0.41	0.29	<0.001	
Study problems → total difficulties score (path c)	5.55	0.84	0.37	<0.001	
Indirect effect via loneliness (a x b)	0.64	0.11	—	<0.001	
Total effect of study problems on total difficulties score (a x b + c)	6.18	0.90	—	<0.001	0.10
Loneliness → prosocial score (path b')	-0.91	0.19	-0.10	<0.001	
Study problems → prosocial score (path c')	-0.71	0.23	-0.13	0.006	
Indirect effect via loneliness (a x b')	-0.08	0.02	—	0.002	
Total effect of study problems on prosocial score (a x b + c')	-0.79	0.23	—	0.002	0.10
Study problems ~					
Dislike of remote learning	0.39	0.02	0.31	<0.001	
Model 2					
Parent-child relationship → loneliness (path a)	0.77	0.19	0.24	0.001	
Loneliness → total difficulties score (path b)	7.20	0.31	0.29	<0.001	
Parent-child relationship → total difficulties score (path c)	14.52	3.34	0.18	<0.001	
Indirect effect via loneliness (a x b)	5.53	1.23	—	<0.001	
Total effect of parent-child relationship on total difficulties score (a x b + c)	20.05	3.97	—	<0.001	0.28
Loneliness → prosocial score (path b')	-0.81	0.25	-0.09	0.004	
Parent-child relationship → prosocial score (path c')	-3.43	1.32	-0.11	0.017	
Indirect effect via loneliness (a x b')	-0.62	0.21	—	0.009	
Total effect of parent-child relationship on prosocial score (a x b + c')	-4.05	1.28	—	0.004	0.15
Parent-child relationship ~					
Relationship with father	1.28	0.18	0.52	<0.001	
Model 3					
Family/friends with COVID-19→ loneliness (path a)	0.09	0.03	0.04	0.011	
Loneliness → total difficulties score (path b)	8.12	0.33	0.33	<0.001	
Family/friends with COVID-19→ total difficulties score (path c)	4.51	1.15	0.08	0.001	
Indirect effect via loneliness (a x b)	0.70	0.24	—	0.009	
Total effect of family/friends with COVID-19 on total difficulties score (a x b + c)	5.21	1.36	—	0.001	0.13
Loneliness → prosocial score (path b')	-1.02	0.17	-0.11	<0.001	
Family/friends with COVID-19→ prosocial score (path c')	-1.56	0.41	-0.08	0.001	
Indirect effect via loneliness (a x b')	-0.09	0.03	—	0.019	
Total effect of family/friends with COVID-19 on prosocial score (a x b + c')	-1.65	0.44	—	0.001	0.05

β = unstandardized estimate; b = standardized estimate. Effect size is the proportion explained, which is calculated by dividing the indirect effect by the total effect.