Psychological effects of the COVID-19 pandemic on Wuhan's high school students

Dong Yang [a,1], Usaporn Swekwi [a,1], Chia-Ching Tu [b,*], Xiao Dai [b,2]

[a] *Rangsit University, Pathumthani, Thailand*
[b] *Krirk University, Bangkok, Thailand*

ABSTRACT

Objective: This study explored the protective mechanisms of resilience and positive emotion regulation against psychological trauma among Wuhan's high school students during the COVID-19 outbreak.
Method: We obtained 286 valid samples from four high schools in Wuhan, China. To construct a measurement model and a structural model, structural equation models using four measurement scales with valid items were adopted, including a scale of psychological trauma, a scale of resilience, a scale of positive emotional regulation, and a scale of mental health. Participants reported their answers to items on a 5-point Likert-like scale.
Results: The results revealed that psychological trauma was a negative predictor of mental health, and resilience and positive emotion regulation mediated the relationship between psychological trauma and mental health.
Conclusions: Accordingly, we concluded that resilience and positive emotion regulation interrupted the direct impact of psychological trauma on mental health, thereby greatly protecting the mental health of Wuhan's high school students during the COVID-19 outbreak.

1. Introduction

The coronavirus epidemic that started in 2019 (hereafter referred to as COVID-19) turned into a pandemic and has affected people's mental health, inducing the feelings of fear, anxiety, distress, and isolation (WHO, 2020). On January 23, 2020, COVID-19 was identified as an intensively spread disease in Wuhan city of Hubei, China (Du et al., 2020). Until March 28, the pandemic came under control in China, and Wuhan started to lift the blockade in high-risk areas (People's Government of Hubei province, 2020a,b). However, the risk of infection is still been reported, and its negative impact remains (People's Government of Hubei province, 2020a,b).

The psychological trauma caused by COVID-19 in Wuhan increased the incidence of posttraumatic stress symptoms (PTSS) in residents (Liu et al., 2020). However, compared with adults, adolescents were reported to be less likely to develop mental disorders and more likely to recover after exposure to negative events (Jacobs & Harville, 2015). Adolescents exhibited a strong potential to grow even around psychologically traumatic events (Berger, 2008) because their resilience reflected a dynamic

growing process and more positive adaptation to trauma (Berger, 2008; Cryder, Kilmer, Tedeschi, & Calhoun, 2006). Resilience, as a protective mechanism, reasonably explained the mechanism mediating the psychological effects of risk on health (Fleming & Ledogar, 2008) and played a protective role in neutralizing the effects of risk on health outcome (Fleming & Ledogar, 2008). At the same time, this protective mechanism can grow because of its evolving characteristics (Berger, 2008; Fleming & Ledogar, 2008).

Resilience is a growing feature that also contains hardiness and invulnerability; it allows successful passive adaptation to negative events (Olsson, Bond, Burns, Vella-Brodrick, & Sawyer, 2003). Daily news feeds have created extreme anxiety and distress about COVID-19 (WHO, 2020), and adolescents can cope with such conditions due to the resilience to adapt to negative events as well as positive emotion regulation, which focuses on allocating emotional meaning to negative events. According to the cognitive reappraisal theory, positive cognitive reappraisal during emotion regulation is an effective regulation strategy as it can drive changes in one's perspectives toward negative events and emotional character (McRae, 2016). Therefore, the mediating

mechanism of positive emotion regulation acts on an emotion by reconsidering the positive sides of negative events, thereby changing one's emotional response to those events and protecting their mental health (McRae, 2016).

Along these lines, this study explored the psychological influence of COVID-19 on Wuhan's adolescents and verified the mediation effects of resilience and positive emotion regulation on the relationship between psychological trauma and mental health.

2. Literature review

2.1. Psychological trauma and mental health

Traumatic events were defined as threats to life or close encounters with death and psychological trauma as a response to traumatic events through various mechanisms (Suleiman, 2008). In Wuhan, COVID-19 has exacerbated psychological trauma symptoms (feelings of tension, emotional problems, sleep disorders, loneliness, anxiety, and depression), affecting people's mental health (Guessoum et al., 2020; Liu et al., 2020; Zhang et al., 2020). Previous studies on psychological trauma have consistently found it to be a negative predictor of mental health among different groups. For example, Vietnamese refugees with a great degree of exposure to trauma showed long-term psychiatric morbidity (Steel, Silove, Phan, & Bauman, 2002). People exposed to traumatic events during the Ebola outbreak reported negative effects on their mental health (O'Leary, Jalloh, & Neria, 2018; Van Bortel et al., 2016). Exposure to COVID-19 caused poor mental health and traumatic symptoms in the general Chinese population (Wang et al., 2020), and exposure to mass traumatic events resulted in severe mental disorders among adolescents, including posttraumatic stress disorder (PTSD), depression, and suicidal ideation (Cadichon, Lignier, Cénat, & Derivois, 2017; Jacobs & Harville, 2015; Lau et al., 2010; Lewis, Langley, & Jones, 2015; Ruggiero et al., 2017). Based on these points, we propose our first research hypothesis as follows:

H1. Psychological trauma has a negatively significant effect on the mental health of Wuhan's high school students.

2.2. Psychological trauma, resilience, and mental health

Resilience played an important role as a protective mechanism by enabling adolescents to adapt to negative events (Olsson et al., 2003) and improving their response to those events, thereby reducing the negative effect of such events on overall mental health (Fleming & Ledogar, 2008; Olsson et al., 2003). In resilience theory, compensatory factors neutralize the negative effect of risk exposure on mental health through a compensatory mechanism (Wang, Zhang, & Zimmerman, 2015). A representative case revealed that a compensatory effect, namely parental support, compensated for the negative effect of violence-related factors on mental health outcomes in urban African American adolescents (Wang et al., 2015). Similarly, resilience can compensate for and neutralize the negative effects of traumatic COVID-19-related events on the mental health of adolescents. Nonetheless, studies have also reported that resilience is related to risk mechanism, and thus, any adversity with high-intensity stimulation can make an individual's mental state more vulnerable (Olsson et al., 2003). Therefore, the negative events that pose high risk may weaken one's resilience (Arnason, 2009). However, resilience was still a positive predictor of mental health outcome in adolescents (Chow & Choi, 2019; Dray et al., 2017; Siriwardhana, Ali, Roberts, & Stewart, 2014). Accordingly, in this study, resilience was explained as an adaptive and compensatory cognitive process of psychological trauma because it develops positive self-perceptions and compensates for negative events (Fleming & Ledogar, 2008; Mętel et al., 2019; Olsson et al., 2003; Reyes et al., 2019; Wang et al., 2015). Thus, we propose our second research hypothesis as follows:

H2. Resilience mediates the relationship between psychological trauma and mental health in Wuhan's high school students.

2.3. Psychological trauma, positive emotion regulation, and mental health

Emotion has been found to be a psychological response to trauma (Nickerson et al., 2015), and expressing sentiments out of control because of negative news feeds about COVID-19 has been found to cause a risk of psychological illness (WHO, 2020). Development of coping mechanisms to traumatic exposure is critical among adolescents (Vaughn-Coaxum, Wang, Kiely, Weisz, & Dunn, 2018), and exposure to negative events can develop difficulties in emotional processing, thereby affecting their mental health (Chung & Chen, 2017). Additionally, exposure to traumatic events can cause emotion dysregulation, PTSD, and depression among adolescents (Charak, Ford, Modrowski, & Kerig, 2019). A history of exposure to psychological trauma may also affect adolescents' emotional cognition (Cadamuro, Versari, Vezzali, Giovannini, & Trifiletti, 2015; John, Cisler, & Sigel, 2017; Wu, He, & Li, 2009). Positive cognitive reappraisal is an emotion regulation theory for transforming perspectives on negative events, thereby changing their emotional interpretation (McRae, 2016). Whether a stimulus causes poor mental health outcomes depends on whether it is emotionally appraised as positive or negative (McRae, 2016). Moreover, positive emotion regulation is a protective factor for mental health (Diab, Peltonen, Qouta, Palosaari, & Punamäki, 2019; Orejuela-Dávila, Levens, Sagui-Henson, Tedeschi, & Sheppes, 2019). According to the emotion regulation theory and previous studies, a positive perspective toward COVID-19 can be reconsidered, thereby changing individuals' emotional reactions to psychological trauma and protecting their mental health (Diab et al., 2019; McRae, 2016; Nickerson et al., 2015). Along these lines, we proposed our third research hypothesis:

H3. Positive emotion regulation mediates the relationship between psychological trauma and mental health in Wuhan's high school students.

2.4. Hypothetical model

We constructed the hypothetical model based on previous studies and theories, under which we proposed psychological trauma to be a negative predictor of mental health. Further, we assumed resilience and positive emotion regulation as two mediators of the relationship between psychological trauma and mental health. Fig. 1 illustrates the hypothetical model.

3. Methods

3.1. Procedure

Purposive sampling was used for this study. The four representative high schools were selected as sample schools during the COVID-19 high-risk period. The four high schools were all located in Wuhan city. They were key senior public high schools, with mental health teacher teams that rapidly responded to the COVID-19 outbreak and attended to the mental health of their students. The design of this study was reviewed and approved by the institutional review board at Suryadhep Teachers College of Rangsit University. Because the protocol was judged to pose low risk and the data were collected and processed anonymously, oral consent was recommended and obtained from school administrators, teachers, students and their parents before data collection. In addition, students were informed that they could discontinue their participation at any time. During the COVID-19 high-risk period in Wuhan, the researcher could not come in face-to-face contact with the participating high-school students. Therefore, they were provided with an online questionnaire from February 4 to March 9, which was collected by teachers in the four high schools. To reduce the difficulty in sampling,
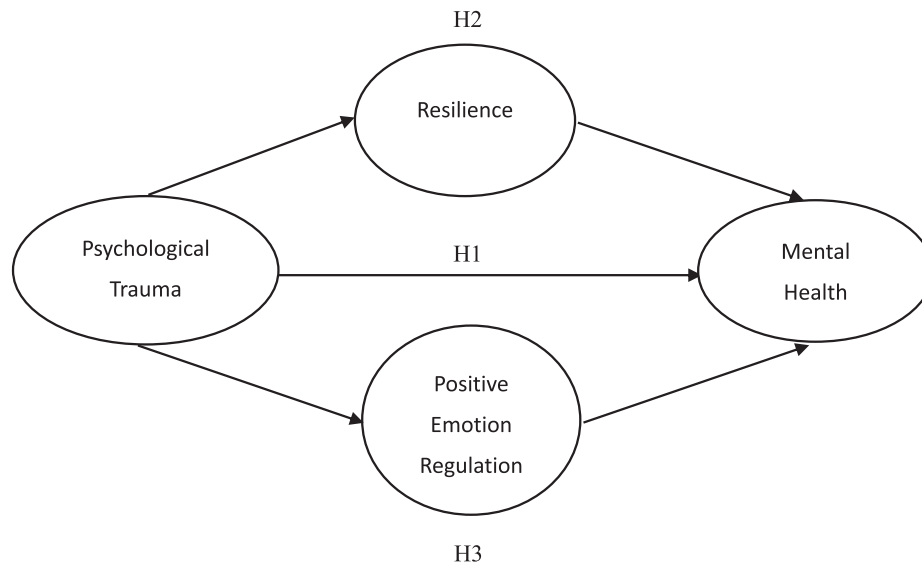
Fig. 1. Hypothetical model.

every participant was provided a facial cleanser delivered by express mail service. A sufficient sample size was obtained in this sampling; however, 18 from 304 samples were deleted, 8 of which had responses from high school students not from Wuhan and 10 were duplicate responders. As a result, 286 valid samples were retained. A summary of the sample demographics is presented in Table 1.

3.2. Measurement instrument

The questionnaire was designed according to the Chinese version of the child's reaction to traumatic events scale (Chen & Lai, 2012), the Chinese version of the 10-item Connor–Davidson Resilience Scale (Campbell-Sills & Stein, 2007; Cheng, Dong, He, Zhong, & Yao, 2020), the Chinese version of the cognitive emotion regulation scale (Jermann, Van der Linden, d'Acremont, & Zermatten, 2006; Zhu et al., 2008), and the Chinese version of the World Health Organization quality of life scale (Zhang, Cheng, Chin, & Lee, 2013). These scales, which have acceptable reliability and validity, have high representativeness for Chinese groups in psychological trauma, resilience, positive emotional regulation, and mental health (Chen & Lai, 2012; Cheng et al., 2020; Zhu et al., 2008; Zhang et al., 2013). The variable definitions and measuring tools are as follows.

3.2.1. Psychological trauma
The psychological trauma caused by COVID-19 exposure included a

Table 1
Sample demographics.

Characteristic	N	%
Gender		
Male	132	46.2
Female	154	53.8
Grade		
Tenth grader	137	47.9
Eleventh grader	119	41.6
Twelfth grader	30	10.5
Only-Child or Non-Only Child		
Only-Child	171	59.8
Non-Only Child	115	40.2
Live with Family during the COVID-19 Outbreak Period		
Live with Family	255	89.2
Live without Family	31	10.7

tense feeling, a worry of being infected, refusal to contact others, moodiness, and insomnia (Chen & Lai, 2012). We measured this variable using a scale related to psychological trauma (Chen & Lai, 2012), which contains five items measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

3.2.2. Resilience
Resilience is a psychological function of adapting to stressors and coping with trauma (Campbell-Sills & Stein, 2007). The Resilience Scale was used to measure individuals' level of coping with stressors; it comprises 10 items relating to the level of resilience (Campbell-Sills & Stein, 2007), measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

3.2.3. Positive emotion regulation
Through positive emotion regulation, individuals perceive negative events as positively as possible and stimulate positive emotions (Jermann et al., 2006). In this study, we measured the variable using a scale related to positive emotion regulation to test the extent of positive thinking in individuals (Jermann et al., 2006). It contains five items measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

3.2.4. Mental health
Mental health is a self-cognition to life satisfaction, life meaning, thinking and studying abilities, and body image satisfaction (Zhang et al., 2013). The scale was used to measure the level of mental health; it comprises six items relating to mental health (Zhang et al., 2013), measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

3.3. Analytical method

SPSS and AMOS were applied as tools in the analysis of the collected samples, and structural equation modeling was used to construct the measurement model and structural model (Bollen, 1989; Byrne, 2010; Kline, 2010; Schumacker & Lomax, 2004).

Further, SPSS was used to evaluate the samples, and valid samples were executed using AMOS. Confirmatory factor analysis was used for the measurement model. An accepted measurement model includes reasonable reliability and validity. Therefore, as a first step, the measurement model was validated using maximum likelihood estimation, and model parameters including model fit, factor loading, and variance

were obtained. The model fit was determined using eight fit indices: $\chi 2$, $\chi 2$/df, RMSEA, CFI, NFI, GFI, TLI, and PNFI (Bollen, 1989; Schumacker & Lomax, 2004). The standard set for the factor loading was equal to or greater than 0.70 (Hair et al., 2006), and no negative variance was noted. Moreover, these parameters were required for statistical significance (Bagozzi & Yi, 2012; Fornell & Larcker, 1981). The normality of samples was assessed in terms of skewness, kurtosis, and Mardia's coefficient (Bollen & Long, 1993; Bollen, 1989; Raykov & Marcoulides, 2008). The Cronbach's alpha coefficient was used to confirm reliability, and composite reliability (CR) and average variance extracted (AVE) were used to confirm convergent validity. Lastly, calculation of 95% confidence interval of the correlation coefficient using bootstrap confirmed the discriminant validity (Torkzadeh, Koufteros, & Pflugh-oeft, 2003).

The main effect and structural model were established based on the hypothetical model. Next, the standardized regression coefficients and model fit were estimated, and the path coefficients and explained variances were reported in the main effect and structural model. Furthermore, bootstrap estimation was used to evaluate indirect effects and individual indirect effects, and the total and direct effects were reported in the multiple mediation model (MacKinnon, 2008; Preacher & Hayes,

2008). Finally, we used PRODCLIN2 to verify the individual mediating roles in the structural model (Mackinnon, Fritz, Williams, & Lockwood, 2007).

4. Results

4.1. Measurement model

Based on the results of the factor loadings in the measurement model (Fig. 2), we retained 22 items in total. Four items were deleted because their loadings were lower than 0.70: two items on psychological trauma and two on mental health.

The standardized factor loadings of four variables were between 0.70 and 0.89, and the factor loadings of all items reached statistical significance. There were no negative error variances, and the *t* values of all variances reached statistical significance (Table 2). Further, the samples met univariate and multiple normality; the absolute values of skewness and kurtosis ranged from 0.06 to 1.19 and from 0.05 to 0.91, respectively (Bollen & Long, 1993). The Mardia's coefficient 253.86 was found to be lower than p (p + 2) = 528 (Bollen, 1989; Raykov & Marcoulides, 2008). Next, the model fit indicated the measurement model fits with
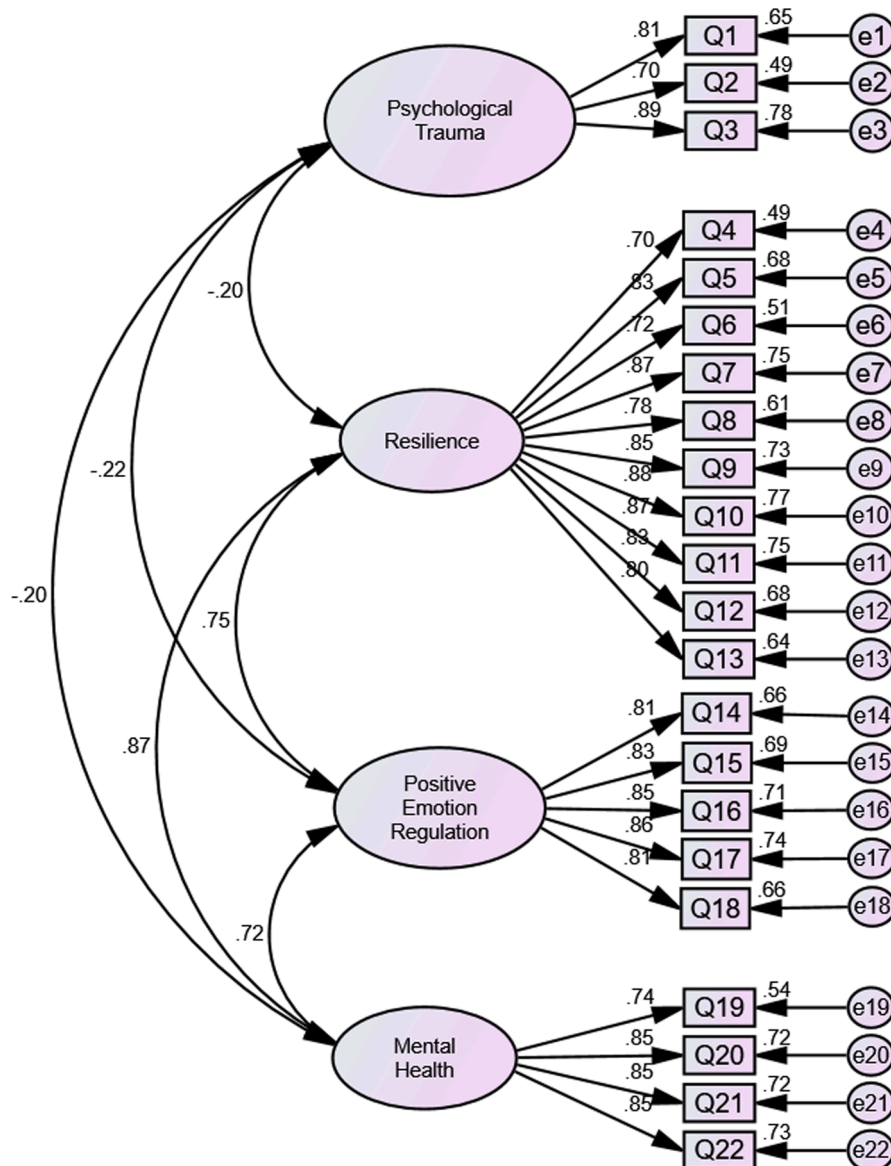

Fig. 2. Measurement model.

Table 2
The Mean, SD, Standardized Regression Coefficient (SRC), and t Value in Psychological Trauma (PT), Positive Emotion Regulation (PER), Resilience (R), and Mental Health (MH).

Var.	No.	Questionnaire Items	Mean	SD	SRC	t Value
PT	Q1	My body often feels tense	2.03	1.30	0.81	7.34[***]
	Q2	I am not willing to touch with others	2.27	1.40	0.70	9.92[***]
	Q3	I am often worried about getting infected	2.15	1.35	0.89	4.45[***]
R	Q4	I am able to adapt to change	3.81	1.15	0.70	11.47[***]
	Q5	I can deal with whatever comes	3.30	1.22	0.83	10.88[***]
	Q6	I try to see humorous side of problems	3.55	1.20	0.72	11.42[***]
	Q7	Coping with stress can strengthen me	3.68	1.17	0.87	10.44[***]
	Q8	I tend to bounce back after illness or hardship	3.67	1.24	0.78	11.16[***]
	Q9	I can achieve goals despite obstacles	3.67	1.13	0.85	10.63[***]
	Q10	I can stay focused under pressure	3.48	1.25	0.88	10.28[***]
	Q11	I am not easily discouraged by failure	3.65	1.18	0.87	10.46[***]
	Q12	I think of self as strong person	3.65	1.23	0.83	10.89[***]
	Q13	I can cope with unpleasant feelings	3.56	1.24	0.80	11.08[***]
PER	Q14	I will think of something better than these unpleasant experiences	3.93	1.21	0.81	10.10[***]
	Q15	I think about some happy things, not those things that have happened	3.87	1.24	0.83	9.78[***]
	Q16	It is useless to be sad and painful all the time, so I will choose to look at this event more positively	4.18	1.11	0.85	9.53[***]
	Q17	I will think of something happier with having nothing to do with this event	3.91	1.21	0.86	9.24[***]
	Q18	I would rather look at the status quo positively because I don't want to feel painful	3.76	1.31	0.81	10.09[***]
MH	Q19	I feel that my life is meaningful	4.07	1.17	0.74	10.71[***]
	Q20	I can concentrate (thinking, studying, remembering) on what I want to do	3.70	1.22	0.85	9.29[***]
	Q21	I can accept my appearance	3.84	1.19	0.85	9.20[***]
	Q22	I am satisfied with myself	3.76	1.19	0.85	9.17[***]

[***] $p < .001$

samples: $\chi^2 = 655.00$ ($p < .001$), $\chi^2/df = 3.23$, RMSEA = 0.09, CFI = 0.91, NFI = 0.88, GFI = 0.83, TLI = 0.90, and PNFI = 0.77 (Bollen, 1989; Schumacker & Lomax, 2004).

The Cronbach's alpha, CR, and AVE values of each variable ranged from 0.84 to 0.95, from 0.84 to 0.95, and from 0.65 to 0.69, respectively (Table 3). Using bootstrap estimation, we established the correlation coefficient at 95% confidence interval, with a lack of 1 point between confidence intervals indicating the discriminant validity of the measurement model (Torkzadeh et al., 2003). Therefore, the measurement

Table 3
Cronbach's Alpha, CR and AVE.

Index	Psychological Trauma	Resilience	Positive Emotion Regulation	Mental Health
Cronbach's alpha	0.84	0.95	0.92	0.89
CR	0.84	0.95	0.92	0.89
AVE	0.65	0.67	0.69	0.68

model had reasonable reliability and validity because we noted acceptable factor loadings, model fit, reliability, convergent validity, and discriminant validity.

Finally, we separated every variable by its instructions during the measurement process (for example, if the instruction was regarding psychological trauma, we asked, "In the following questions, please describe your psychological state during the COVID-19 breakout). This was an effective method because it helped participants understand the research purpose of every variable and reduced the common method variance (CMV) from the self-report (Peng, Kao, & Lin, 2006). In addition, a single factor model was structured with 22 items ($\chi^2 = 1514.85$, $df = 209$) and compared with the measurement model ($\chi^2 = 655.00$, $df = 203$). However, the parameters differed between the two models ($\Delta\chi^2 = 859.85$, $\Delta df = 6$, $p < .001$), indicating that there was no major CMV (Mossholder, Bennett, Kemery, & Wesolowski, 1998).

4.2. Main effect

The main effect was constructed on the basis of psychological trauma and mental health. The standardized regression coefficients of the main effect were found to be between 0.68 and 0.90, and the main effect had a reasonable fit with the sample data: $\chi^2 = 31.72$ ($p < .01$), $\chi^2/df = 2.44$, RMSEA = 0.07, GFI = 0.97, CFI = 0.98, NFI = 0.97, TLI = 0.97, and PNFI = 0.60 (Bollen, 1989; Schumacker & Lomax, 2004). Psychological trauma explained 4% of the variance in mental health ($\gamma = -0.20$, $p < .01$); therefore, hypothesis 1 was supported. Fig. 3 presents the data regarding the main effect.

4.3. Structural model

Fig. 4 presents the structural model with path coefficients and explained variances. The standardized regression coefficients of the structural model ranged from 0.69 to 0.88; the model fit of the structural model was acceptable, with the following values: $\chi^2 = 833.72$ ($p < .001$), $\chi^2/df = 4.09$, RMSEA = 0.10, GFI = 0.80, CFI = 0.88, NFI = 0.85, TLI = 0.86, and PNFI = 0.75 (Bollen, 1989; Schumacker & Lomax, 2004). Further, in the structural model, psychological trauma explained 5% of the variance in resilience ($\gamma = -0.23$, $p < .001$) and 6% of the variance in positive emotion regulation ($\gamma = -0.24$, $p < .001$). Resilience ($\gamma = 0.81$, $p < .001$) and positive emotion regulation ($\gamma = 0.21$, $p < .001$) jointly explained 72% of the variance in mental health.

4.4. Multiple mediating effects

First, the main effect of psychological trauma on mental health without resilience and positive emotion regulation was found to be -0.20 ($t = -2.94$, $p < .01$). Next, resilience and positive emotion regulation were added as mediators to the relationship between psychological trauma and mental health, and the direct effect of psychological trauma on mental health reduced to -0.01 ($t = -0.11$, $p > .05$). The total effect, direct effect, indirect effect, and individual indirect effects of the structural model (Table 4) showed that resilience and positive emotion regulation completely mediated the relationship between psychological trauma and mental health. In Table 4, the confidence interval estimates of the overall effect, indirect effects, and individual indirect effects did not contain 0, indicating that their parameters were all statistically significant. The overall effect of psychological trauma on mental health was -0.18; resilience and positive emotional regulation played mediating roles, and the indirect effects of psychological trauma and mental health reached -0.18. Therefore, the direct effect of psychological trauma on mental health reduced to 0. Individual indirect effects, resilience, and positive emotional regulation exhibited indirect effects of -0.15 and -0.12, respectively, in the relationship between psychological trauma and mental health, all playing mediating roles.

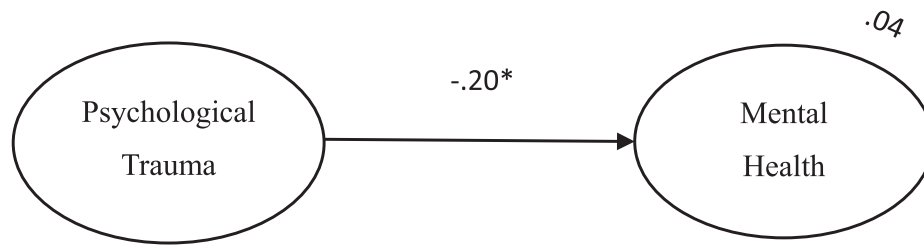Second, we used PRODCLIN2 to second assess whether resilience and
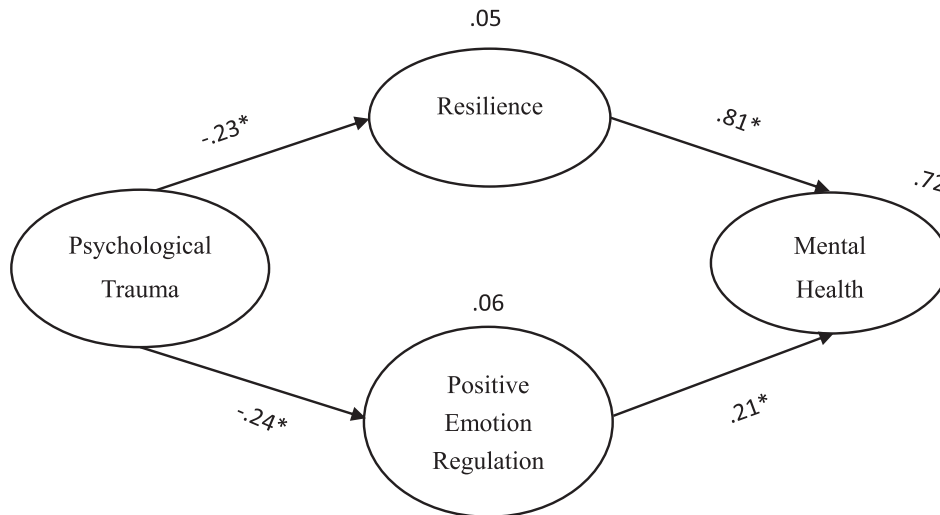
Fig. 3. The main effect.

Fig. 4. Structural model.

Table 4
Bootstrap Method Estimates 95% Confidence Interval.

Total, direct, and indirect effect	Path Coefficient	Bias-Corrected		Percentile	
		Lower	Upper	Lower	Upper
Total effect (PT → MH)	−0.18[**]	−0.44	−0.10	−0.44	−0.09
Direct effect (PT → MH)	0	−0.12	0.05	−0.12	0.05
Indirect effect (PT → MH)	−0.18[**]	−0.38	−0.09	−0.38	−0.09
Individual indirect effect (PT → R → MH)	−0.15[**]	−0.26	−0.05	−0.25	−0.05
Individual indirect effect (PT → PER → MH)	−0.12[**]	−0.21	−0.05	−0.21	−0.04

[**] $p < .01$.

positive emotion regulation jointly played mediating roles in the structural model (Mackinnon et al., 2007). The variables' estimated parameters were added to PRODCLIN2, and resilience was verified as the mediator in the main effect because the Mackinnon PRODCLIN2 95% confidence interval was found to be between −0.23 and −0.06. Thus, hypothesis 2 was also supported. Further, positive emotion regulation was verified as the mediator in the main effect because the Mackinnon PRODCLIN2 95% confidence interval was found to be between −0.07 and −0.01. Thus, hypothesis 3 was supported. The results indicated no direct effect of psychological trauma on mental health because its effect was interrupted by resilience and positive emotion regulation.

5. Discussion

In this study, hypothesis 1 was proven to be the main effect. The result was consistent with those of previous studies and indicated that psychological trauma was a negative predictor of mental health among Wuhan's high school students (Cadichon et al., 2017; Jacobs & Harville, 2015; Lau et al., 2010; Lewis et al., 2015; O'Leary et al., 2018; Ruggiero

et al., 2017; Steel et al., 2002; Van Bortel et al., 2016; Wang et al., 2020; Zhang et al., 2020). The results also revealed that psychological trauma caused by COVID-19 exposure during Wuhan's high-risk period requires the necessary intervention because of the risk of PTSS (Liu et al., 2020).

Further, hypotheses 2 and 3 were also supported because the mediating effect of resilience and positive emotion regulation in the structural model resulted in disappearance of the main effect.

Consistent with the findings of previous studies, according to hypothesis 2 in the structural model, psychological trauma negatively affected resilience (Arnason, 2009; Olsson et al., 2003) and resilience greatly and positively affected mental health among Wuhan's high school students (Chow & Choi, 2019; Dray et al., 2017; Siriwardhana et al., 2014) However, the negative effect of psychological trauma on resilience was insufficient to disturb high school students' ability to adopt resilience because the risk mechanism of resilience was found to be ineffective (Olsson et al., 2003). By contrast, the strong resilience of Wuhan's high school students exerted a considerable positive effect on their mental health. The mediating role of resilience in the main effect revealed the students' adaptability to COVID-19, thereby weakening the main effect and providing a protective mechanism to their mental health (Mętel et al., 2019). According to previous studies, the reason underlying this result was that their adaptability prevented the negative effects of psychological trauma on mental health by making them resistant to negative stimuli (Fleming & Ledogar, 2008; Olsson et al., 2003). As per the compensatory mechanism of resilience (Wang et al., 2015), resilience adequately neutralized the negative effect of psychological trauma on the mental health of high school students.

For hypothesis 3 in the structural model, psychological trauma was found to play a negative role in positive emotion regulation (Cadamuro et al., 2015; John et al., 2017; Wu et al., 2009), and positive emotion regulation was a positive predictor of mental health (Diab et al., 2019; Orejuela-Dávila et al., 2019). The psychological trauma of exposure to

COVID-19 may have had negative effects on emotion cognition among Wuhan's high school students, but at the same time, positive emotion regulation positively affected their mental health. Hence, the mediating role of positive emotion regulation in the main effect protected the emotional balance of Wuhan's high school students. Such a mediating function drives positive reappraisal of negative events, and thus, the emotional response to psychological trauma may transform its effects on mental health, thereby weakening the effect of the trauma (McRae, 2016; Nickerson et al., 2015).

Distinctly, the mediating effect of the structural model revealed that Wuhan's high school students were able to maintain their mental well-being during the high-risk period of COVID-19, because of their resilience, hardiness, and invulnerability (Olsson et al., 2003). Nonetheless, one neglected reason is that 89.2% of the high school students lived with their families during the high-risk period, which helped them resist psychological trauma. Thus, it can be said that the social interactions around them helped them maintain their resilience (Sippel, Pietrzak, Charney, Mayes, & Southwick, 2015). Moreover, because of the flexible nature of resilience, the students may also mentally grow despite exposure to COVID-19 and thus develop stronger protective mechanism to negative events (Berger, 2008; Fleming & Ledogar, 2008; Olsson et al., 2003).

Resilience is closer to an individual's trait or ability of coping with stressors (Campbell-Sills & Stein, 2007; Olsson et al., 2003); however, negative emotions caused by exposure to traumatic events during the COVID-19 period (WHO, 2020) are inevitable. Consequently, positive emotion regulation became a reasonable active method to cope with the emotional responses to psychological trauma among Wuhan's high school students (McRae, 2016). At the same time, positive cognitive reappraisal enhanced the efficacy of positive emotion regulation by repeated training, thereby reducing the negative effects of emotional events (Denny & Ochsner, 2014). Therefore, practicing positive emotion regulation can enhance an individual's positive cognitive reappraisal ability toward psychological trauma, thereby strengthening their ability to apply positive emotion regulation strategies to deal with negative emotional stimuli.

6. Conclusion

The findings of this study revealed that resilience and positive emotion regulation can strongly interrupt and hinder the negative effects of psychological trauma on the mental health of Wuhan's high school students.

6.1. Research suggestions

Resilience and positive cognitive reappraisal constitute effective training in group counseling, and negative effects caused by trauma can be reduced through the promotion of resilience and positive emotional regulation (Arnetz, Nevedal, Lumley, Backman, & Lublin, 2009; Woud, Postma, Holmes, & Mackintosh, 2013), thereby preventing negative mental health outcomes (Denny & Ochsner, 2014; Pfefferbaum, Reissman, Pfefferbaum, Klomp, & Gurwitch, 2008). The evidence from the multiple mediating model in this study indicates that resilience and positive emotional regulation functioned as intervening variables for the psychological trauma of Wuhan's high school students. We have the following two suggestions based on the study's results.

First, Wuhan's high school students benefited from family support, which helped them maintain their resilience during a period of high COVID-19 risk (Jacobs & Harville, 2015). However, we suggest that schools design relevant group counseling courses for psychological trauma and resilience to increase students' resilience to the conditions created by COVID-19 and their resistance to negative events.

Second, schools should arrange corresponding psychology courses to train students in positive emotional regulation and to strengthen their emotional strategies for coping with negative events and reduce

negative emotions resulting from exposure to COVID-19. More notably, the training of positive emotional regulation increases students' emotional cognitive ability to navigate subsequent traumatic events.

6.2. Limitations and suggestions for future research

Although the effect of COVID-19 has reduced in Wuhan, psychological trauma resulting from exposure to COVID-19 is likely to increase the incidence of PTSS. Therefore, we recommend that follow-up studies should focus on the effect of PTSS on mental health.

In this study, resilience and positive emotion regulation acted as two powerful protective mechanisms against psychological trauma. However, the role played by social support in the development of resilience was neglected. Therefore, in follow-up research, resilience should be studied in combination with social support to explore psychological trauma.

Lastly, this study investigated only Wuhan's high school students, but the effect of COVID-19 on mental health might be different among adolescents in other countries. Therefore, future studies should focus on this effect among youth groups of other countries.

7. Compliance with Ethical Standards

Participants' rights and animal protection statements:

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975 (in its most recently amended version). Informed consent was obtained from all participants included in the study.

Declaration of Competing Interest

This study did not accept any sponsorship funds. All authors (Dong Yang, Usaporn Swekwi, Chia-Ching Tu and Xiao Dai) state that there are no conflicts of interest.

References

Arnason, G. (2009). The concept of resilience: A functional account. *UP Manlia Journal Special Issue*, 105–117.

Arnetz, B. B., Nevedal, D. C., Lumley, M. A., Backman, L., & Lublin, A. (2009). Trauma resilience training for police: Psychophysiological and performance effects. *Journal of Police and Criminal Psychology, 24*(1), 1–9. https://doi.org/10.1007/s11896-008-9030-y

Bollen, K. A., & Long, J. S. (1993). *Testing structural equation models* (Vol. 154). Sage.

Bollen, K. A. (1989). *Structural equations with latent variables*. Wiley.

Bagozzi, R. P., & Yi, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science, 40*(1), 8–34.

Byrne, B. B. (2010). *Structural equation modeling using AMOS: Basic concepts, applications, and programming* (2nd ed.). Routledge.

Berger, R. (2008). Fostering post-traumatic growth in adolescent immigrants. *Resilience in Action: Working with Youth Across Cultures and Contexts, 87–110.*

Chow, S. K. Y., & Choi, E. K. Y. (2019). Assessing the mental health, physical activity levels, and resilience of today's junior college students in self-financing institutions. *International Journal of Environmental Research and Public Health, 16*. https://doi.org/10.3390/ijerph16173210

Chen, Y. C., & Lai, C. H. (2012). Psychometric properties of the Chinese version of the child's reaction to traumatic events scale. *Formosa Journal of Mental Health, 25*(2), 163–189. https://doi.org/10.30074/FJMH.201206_25(2).0001.

Campbell-Sills, L., & Stein, M. B. (2007). Psychometric analysis and refinement of the Connor-Davidson Resilience Scale (CD-RISC): Validation of a 10-item measure of resilience. *Journal of Traumatic Stress, 20*(6), 1019–1028. https://doi.org/10.1002/jts.20271

Cryder, C. H., Kilmer, R. P., Tedeschi, R. G., & Calhoun, L. G. (2006). An exploratory study of posttraumatic growth in children following a natural disaster. *American Journal of Orthopsychiatry, 76*(1), 65–69.

Cadamuro, A., Versari, A., Vezzali, L., Giovannini, D., & Trifiletti, E. (2015). Cognitive performance in the aftermath of a natural disaster: The role of coping strategies, theory of mind and peer social support. *Child & Youth Care Forum, 44*, 93–113. https://doi.org/10.1007/s10566-014-9272-z

Cadichon, J. M., Lignier, B., Cénat, J.-M., & Derivois, D. (2017). Symptoms of PTSD among adolescents and young adult survivors six years after the 2010 Haiti earthquake. *Journal of Loss & Trauma, 22*(8), 646–659. https://doi-org.ermg.lib.knu.edu.tw/10.1080/15325024.2017.1360585.

Charak, R., Ford, J. D., Modrowski, C. A., & Kerig, P. K. (2019). Polyvictimization, emotion dysregulation, symptoms of posttraumatic stress disorder, and behavioral health problems among justice-involved youth: A latent class analysis. *Journal of Abnormal Child Psychology, 47*(2), 287–298. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10802-018-0431-9.

Chung, M. C., & Chen, Z. S. (2017). Child abuse and psychiatric comorbidity among Chinese adolescents: Emotional processing as mediator and PTSD from past trauma as moderator. *Child Psychiatry & Human Development, 48*(4), 610–618. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10578-016-0687-7.

Cheng, C., Dong, D., He, J., Zhong, X., & Yao, S. (2020). Psychometric properties of the 10-item Connor-Davidson Resilience Scale (CD-RISC-10) in Chinese undergraduates and depressive patients. *Journal of Affective Disorders, 261*, 211–220. https://doi.org/10.1016/j.jad.2019.10.018

Diab, M., Peltonen, K., Qouta, S. R., Palosaari, E., & Punamäki, R. L. (2019). Can functional emotion regulation protect children's mental health from war trauma? A Palestinian study. *International Journal of Psychology, 54*(1), 42–52.

Du, Z., Wang, L., Cauchemez, S., Xu, X., Wang, X., Cowling, B. J., & Meyers, L. A. (2020). Risk for transportation of 2019 novel coronavirus disease from Wuhan to other cities in China. *Emerging Infectious Diseases, 26*(5). https://doi.org/10.3201/eid2605.200146

Dray, J., Bowman, J., Campbell, E., Freund, M., Hodder, R., Wolfenden, L., … Wiggers, J. (2017). Effectiveness of a pragmatic school-based universal intervention targeting student resilience protective factors in reducing mental health problems in adolescents. *Journal of Adolescence, 57*, 74–89. https://doi.org/10.1016/j.adolescence.2017.03.009

Denny, B. T., & Ochsner, K. N. (2014). Behavioral effects of longitudinal training in cognitive reappraisal. *Emotion, 14*(2), 425–433. https://doi.org/10.1037/a0035276

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50.

Fleming, J., & Ledogar, R. J. (2008). Resilience, an evolving concept: A review of literature relevant to Aboriginal research. *Pimatisiwin, 6*(2), 7.

Guessoum, S. B., Lachal, J., Radjack, R., Carretier, E., Minassian, S., Benoit, L., & Moro, M. R. (2020). Adolescent psychiatric disorders during the COVID-19 pandemic and lockdown. *Psychiatry Research, 113264*. https://doi.org/10.1016/j.psychres.2020.113264

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. (2006). *Multivariate data analysis* (6th ed.). Pearson Prentice Hall.

Jermann, F., Van der Linden, M., d'Acremont, M., & Zermatten, A. (2006). Cognitive emotion regulation questionnaire (CERQ). *European Journal of Psychological Assessment, 22*(2), 126–131. https://doi.org/10.1027/1015-5759.22.2.126

Jacobs, M., & Harville, E. (2015). Long-term mental health among low-income, minority women following exposure to multiple natural disasters in early and late adolescence compared to adulthood. *Child & Youth Care Forum, 44*(4), 511–525. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10566-015-9311-4.

John, S., Cisler, J., & Sigel, B. (2017). Emotion regulation mediates the relationship between a history of child abuse and current PTSD/depression severity in adolescent females. *Journal of Family Violence, 32*(6), 565–575. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10896-017-9914-7.

Kline, R. B. (2010). Principles and practice of structural equation modeling (3rd ed.). Guilford.

Liu, N., Zhang, F., Wei, C., Jia, Y., Shang, Z., Sun, L., … Liu, W. (2020). Prevalence and predictors of PTSS during COVID-19 outbreak in China hardest-hit areas: Gender differences matter. *Psychiatry Research*. https://doi.org/10.1016/j.psychres.2020.112921

Lewis, K., Langley, J., & Jones, R. (2015). Impact of coping efficacy and acculturation on psychopathology in adolescents aollowing a wildfire. *Journal of Child & Family Studies, 24*(2), 317–329. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10826-013-9838-7.

Lau, J. T., Yu, X., Zhang, J., Mak, W. W., Choi, K. C., Lui, W. W., & Chan, E. Y. (2010). Psychological distress among adolescents in Chengdu, Sichuan at 1 month after the 2008 Sichuan earthquake. *Journal of Urban Health, 87*(3), 504–523. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s11524-010-9447-3.

Mossholder, K. W., Bennett, N., Kemery, E. R., & Wesolowski, M. A. (1998). Relationships between bases of power and work reactions: The mediational role of procedural justice. *Journal of management, 24*(4), 533–552.

MacKinnon, D. P. (2008). *Introduction to Statistical Mediation Analysis*. Erlbaum.

Mackinnon, D. P., Fritz, M. S., Williams, J., & Lockwood, C. M. (2007). Distribution of the product confidence limits for the indirect effect: Program PRODCLIN. *Behavior Research Methods, 39*(3), 384–389.

Mętel, D., Arciszewska, A., Daren, A., Frydecka, D., Cechnicki, A., & Gawęda, Ł. (2019). Resilience and cognitive biases mediate the relationship between early exposure to traumatic life events and depressive symptoms in young adults. *Journal of Affective Disorders, 254*, 26–33.

McRae, K. (2016). Cognitive emotion regulation: A review of theory and scientific findings. *Current Opinion in Behavioral Sciences, 10*, 119–124.

Nickerson, A., Bryant, R. A., Schnyder, U., Schick, M., Mueller, J., & Morina, N. (2015). Emotion dysregulation mediates the relationship between trauma exposure, post-migration living difficulties and psychological outcomes in traumatized refugees. *Journal of Affective Disorders, 173*, 185–192.

O'Leary, A., Jalloh, M. F., & Neria, Y. (2018). Fear and culture: Contextualising mental health impact of the 2014–2016 Ebola epidemic in West Africa. *BMJ Global Health*. https://doi.org/10.1136/bmjgh-2018-000924

Olsson, C. A., Bond, L., Burns, J. M., Vella-Brodrick, D. A., & Sawyer, S. M. (2003). Adolescent resilience: A concept analysis. *Journal of adolescence, 26*(1), 1–11.

Orejuela-Dávila, A. I., Levens, S. M., Sagui-Henson, S. J., Tedeschi, R. G., & Sheppes, G. (2019). The relation between emotion regulation choice and posttraumatic growth. *Cognition and Emotion, 33*(8), 1709–1717.

Peng, T. K., Kao, Y. T., & Lin, C. C. (2006). Common method variance in management research: Its nature, effects, detection, and remedies. *Journal of Management, 23*(1), 77–98.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879–891.

People's Government of Hubei Province (2020). Wuhan plans to lift community blockade. http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202003/t20200328_2195490.shtml.

People's Government of Hubei province. (2020). Notice of Hubei province new coronavirus infection pneumonia prevention and control headquarters. http://www.hubei.gov.cn/zhuanti/2020/gzxxgzbd/zxtb/202005/t20200501_2257964.shtml.

Pfefferbaum, B. J., Reissman, D. B., Pfefferbaum, R. L., Klomp, R. W., & Gurwitch, R. H. (2008). *Handbook of injury and violence prevention* (pp. 347–358). Springer.

Reyes, A. T., Constantino, R. E., Cross, C. L., Tan, R. A., Bombard, J. N., & Acupan, A. R. (2019). Resilience and psychological trauma among Filipino American women. *Archives of Psychiatric Nursing, 33*(6), 177–185.

Raykov, T., & Marcoulides, G. A. (2008). *An introduction to applied multivariate analysis*. Taylor & Francis.

Ruggiero, K., Danielson, C., Adams, Z., Cohen, J., Youngstrom, E., Soltis, K., … Ruggiero, K. J. (2017). Clinical decision-making following disasters: Efficient identification of PTSD risk in adolescents. *Journal of Abnormal Child Psychology, 45*(1), 117–129. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10802-016-0159-3.

Suleiman, S. R. (2008). Judith Herman and contemporary trauma theory. *WSQ: Women's Studies Quarterly, 36*(1), 276–281.

Schumacker, R. E., & Lomax, R. G. (2004). A beginner's guide to structural equation modeling (2nd ed.). Lawrence Erlbaum Associates.

Steel, Z., Silove, D., Phan, T., & Bauman, A. (2002). Long-term effect of psychological trauma on the mental health of Vietnamese refugees resettled in Australia: A population-based study. *The Lancet, 360*(9339), 1056–1062.

Siriwardhana, C., Ali, S. S., Roberts, B., & Stewart, R. (2014). A systematic review of resilience and mental health outcomes of conflict-driven adult forced migrants. *Conflict and Health, 8*(13). http://www.conflictandhealth.com/content/8/1/13.

Sippel, L. M., Pietrzak, R. H., Charney, D. S., Mayes, L. C., & Southwick, S. M. (2015). How does social support enhance resilience in the trauma-exposed individual? *Ecology and Society, 20*(4).

Torkzadeh, G., Koufteros, X., & Pflughoeft, K. (2003). Confirmatory analysis of computer self-efficacy. *Structural Equation Modeling: A Multidisciplinary Journal, 10*(2), 263–275. https://doi.org/10.1207/S15328007SEM1002_6

Van Bortel, T., Basnayake, A., Wurie, F., Jambai, M., Koroma, A. S., Muana, A. T., … Nellums, L. B. (2016). Psychosocial effects of an Ebola outbreak at individual, community and international levels. *Bulletin of the World Health Organization, 94*(3), 210.

Vaughn-Coaxum, R. A., Wang, Y., Kiely, J., Weisz, J. R., & Dunn, E. C. (2018). Associations between trauma type, timing, and accumulation on current coping behaviors in adolescents: Results from a large, population-based sample. *Journal of Youth & Adolescence, 47*(4), 842–858. https://doi-org.ermg.lib.knu.edu.tw/10.1007/s10964-017-0693-5.

Woud, M. L., Postma, P., Holmes, E. A., & Mackintosh, B. (2013). Reducing analogue trauma symptoms by computerized reappraisal training–Considering a cognitive prophylaxis? *Journal of Behavior Therapy and Experimental Psychiatry, 44*(3), 312–315. https://doi.org/10.1016/j.jbtep.2013.01.003

Wu, Z. L., He, Y. Y., & Li, H. (2009). What catastrophe leaved to our mind? reviewing the roots causes psychological trauma and the brain mechanisms of post-traumatic stress reaction. *Advances in Psychological Science, 17*(3), 639–644.

WHO. (2020). Coronavirus disease 2019 (COVID-19) situation report. https://www.who.int/news-room/campaigns/connecting-the-world-to-combat-coronavirus/healthyathome/healthyathome—mental-health.

Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., McIntyre, R. S., … Ho, C. (2020). A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain, Behavior, and Immunity.*. https://doi.org/10.1016/j.bbi.2020.04.028

Wang, J. L., Zhang, D. J., & Zimmerman, M. A. (2015). Resilience theory and its implications for Chinese adolescents. *Psychological Reports, 117*(2), 354–375. https://doi.org/10.2466/16.17.PR0.117c21z8

Zhang, C. H., Cheng, Y. F., Chin, H. C., & Lee, H. N. (2013). A study on the test of validity and reliability of WHOQOL-BREF when it was applied to adults with severe visual impairments. *Bulletin Educational Psychology, 44*, 521–536.

Zhang, F., Shang, Z., Ma, H., Jia, Y., Sun, L., Guo, X., … Liu, W. (2020). High risk of infection caused posttraumatic stress symptoms in individuals with poor sleep quality: A study on influence of coronavirus disease (COVID-19) in China. *MedRxiv*. https://doi.org/10.1101/2020.03.22.20034504

Zhu, X., Auerbach, R. P., Yao, S., Abela, J. R., Xiao, J., & Tong, X. (2008). Psychometric properties of the cognitive emotion regulation questionnaire: Chinese version. *Cognition & Emotion, 22*(2), 288–307. https://doi.org/10.1080/02699930701369035

Dong Yang is an Ed. D student at the Suryadhep Teachers College of Rangsit University in Thailand. So far, he worked on psychological science. He would like to make a contribution to the field of psychology and education between China and Thailand.

Address: Rangsit University, 52/347 Muang-Ake, Phaholyothin Road, Lak-Hok, Muang, Pathumthani 12000 Thailand.

Phone Number:66-959182391
Email: 423302956@qq.com

Usaporn Swekwi is an Assoc. Prof. and she works as the Dean and the director of Doctor of Education Program in Educational Studies (Ed.D.) for Suryadhep Teachers College of Rangsit University in Thailand.
Address: Rangsit University, 52/347 Muang-Ake, Phaholyothin Road, Lak-Hok, Muang, Pathumthani 12000 Thailand.
Phone Number:66-854842272
Email: usaporn.s@rsu.ac.th

Chia-Ching TU received a Ph.D. degree in Industrial Education and Technology from National Changhua University of Education (NCUE, Taiwan). She is currently a teacher of

the department of Education management at Krirk University (KRU, Thailand). She embraces an innovative spirit in curriculum theory and practice, creativity cultivation, innovation management, human resource management.

Xiao Dai is a PhD student at the International College of Krirk University in Thailand. She majors in educational administration, and she has been a researcher to focus on educational problems during the novel Coronavirus pneumonia in Hubei province.
Address: Krirk University, 43/1111 Ram-indra Road, KM.1,Bang Khen, Bangkok 10220 THAILAND
Phone Number:86-18627981231
Email: 382034609@qq.com