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Computers in Human Behavior 127 (2022) 107058

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Meaning in life as a mediator between interpersonal alienation and smartphone addiction in the context of Covid-19: A three-wave longitudinal study

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ARTICLE INFO

Keywords:
Covid-19 epidemic
Interpersonal alienation
Meaning in life
Smartphone addiction
Longitudinal tracking

ABSTRACT

In the context of the Covid-19, the present study designed a longitudinal study to examine the relationship among interpersonal alienation, meaning in life and smartphone addiction. Meanwhile, with the development of the epidemic whether there would be changes in the three variables was also examined. A sample of 579 university students (baseline mean age = 20.59, *SD* = 2.20) finished the anonymous questionnaires about interpersonal alienation, meaning in life and smartphone addiction. Three repeated measurements were obtained in June, September and December 2020. The finding indicated that university students' interpersonal alienation and meaning in life significantly increased, and the risk of smartphone addiction significantly decreased with the epidemic under control. Besides, meaning in life in the middle mitigating period of the epidemic mediated the relationship between interpersonal alienation in the early severe period of the epidemic and smartphone addiction in the basic end period of the epidemic. The study contributes to our understanding of how low levels of interpersonal alienation may improve meaning in life and reduce the risk of smartphone addiction. What' s more, it provides scientific suggestions for the prevention and intervention of the adverse effects during public health emergencies.

1. Introduction

As of May 5, 2021, there were over 100 million confirmed cases of Covid-19 and 3.21 million deaths around world (World Health Organization, 2021). Compared with SARS with 8,422 infections and 919 deaths in 2003, Novel influenza A (H1N1) with estimated 151.7 to 575.5 thousand deaths in 2009, and Ebola virus epidemic with about 1,145 deaths in 2014, the Covid-19 has caused the greatest damage to humans' physical and mental health (Charoensukmongkol & Phungsoonthorn, 2020b; Islam et al., 2020; World Health Organization, 2020).

During the severe epidemic period, individuals mainly used internet technology to connect with the world and obtain information about epidemic when isolated at home (App Annie, 2020). What' s more, in order to escape and relieve the depressed emotions caused by isolation, the most likely and convenient way was to surfing the internet through smartphones (Blasi et al., 2019). Therefore, because of the spatial closeness of home isolation and the convenience of smartphones, people were most likely to develop smartphone addiction, that is, individuals' intense or uncontrollable focus on smartphone use to the extent that they neglect other aspects of their life causing psychological and behavioral problems (Bianchi & Phillips, 2005; Ching et al., 2015; Horvath et al., 2020; Liu, Yang, Lin, Yu, & Zhou, 2017). University students are the fastest adopters of smartphone technology. Reports showed that almost every university student owned a smartphone. Especially, when isolated at home they had more time to use the smartphones, so the risk of smartphone addiction increased (Lepp, Barkley, & Karpinski, 2014; Poushter, 2016).

Furthermore, the sudden epidemic has also disrupted people' s normal life. Individuals were unable to work and study as usual. Meanwhile, plans and goals that have already been set were difficult to achieve. As a result, individuals in various industries, such as university students attending on educational institutions in the present study, might experience negative emotion, and lose direction as well as motivation in life (Charoensukmongkol & Phungsoonthorn, 2020a, 2020b;

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https://doi.org/10.1016/j.chb.2021.107058
Received 21 May 2021; Received in revised form 27 September 2021; Accepted 13 October 2021
Available online 16 October 2021

Puyod & Charoensukmongkol, 2021; Schiff, Zasiekina, Pat-Horenczyk, & Benbenishty, 2021). At the same time, people were faced with the uncertainty of employment, economy, and physical as well as mental health caused by the epidemic every day fearfully, which could cause their meaning in life impaired (Charoensukmongkol & Phungsoonthorn, 2020b; Freeston et al., 2020; Park, Malone, Suresh, & Rosen, 2008). Meaning in life refers to that individuals understand the meaning in life, and make clear the tasks and goals in life. It includes searching for meaning in life and presence of meaning in life (Steger, Kawabata, Shimai, & Otake, 2008). People can experience meaning in life when they know the meaning of their own existence and have a goal to pursue (Steger, Kashdan, Sullivan, & Lorentz, 2008).

Although the epidemic had a great negative impact on personal psychology (e.g. meaning in life) and behaviors (e.g. smartphone addiction), in the face of the epidemic, people united and encouraged each other to jointly fight the pneumonia virus, truly "isolating the virus, not isolating love". Thus, the connections between people were more closed contributing to reducing interpersonal alienation referring to the negative emotions experienced by individuals who are unable to properly handle relationships with others and have difficulty in establishing a good connection with their corresponding groups such as family, school and friends (Xu & Zhang, 2008), so university students' interpersonal alienation was at relatively a low level during the epidemic (Jiang & Bai, 2014).

In all, individuals might overuse smartphones in severe epidemics, and their meaning in life was also damaged. However, low levels of interpersonal alienation, namely good interpersonal relationship, can provide timely assistance and reduce the damage to people during the epidemic. Could low levels of interpersonal alienation be effective in improving individuals' meaning in life and reducing the risk of smartphone addiction throughout the epidemic? What is the underlying mechanism among these three variables? Literature have suggested low levels of interpersonal disturbance and alienation contribute to reducing the risk of smartphone addiction (Gao, Zhu, & Zhang, 2019; Huang, Li, et al., 2015; Lian & Ling, 2017; Tang, Huang, & Wang, 2018; Xu, Ding, Du, & Zhang, 2016). Regardless of this finding, the role of interpersonal alienation under the COVID-19 is still noticeably lacking. Similarly, although the existing evidence has confirmed effect of good interpersonal relationship on improving meaning in life of university students (Huang, Liu, & Zhang, 2015; Liu, Zhang, Liu, & Liu, 2016; Stillman et al., 2009; Van Tongeren et al., 2015; Wang, 2016), and effect of meaning in life on alleviating their smartphone addiction (Chen, Bao, & Huang; Chen, Xiao, & Wang, 2019; Ge, 2016; Rammazi, Askarizadeh, Ahmadi, & Divsalar, 2018; Yao, Jia, Chen, & Jiao, 2016), the relations among the three variables during the epidemic have not been studied yet simultaneously, let alone in a longitudinal study. Guided by the cognitive-behavioral model proposed by Davis (2001), this study used a longitudinal tracking design to examine whether low levels of interpersonal alienation (distal factor, perception of external interpersonal relationships) could alleviate individuals' smartphone addiction through increasing meaning in life (proximal factor, perception of internal meaning). This longitudinal mediation model can examine the important effect of interpersonal relationship on individuals' psychology and behaviors as well as advance our understanding of interpersonal alienation during a crisis. Furthermore, the results are expected to make theoretical contributions in terms of providing greater understanding of how interpersonal alienation influences meaning in life and smartphone addiction during a crisis.

2. Literature review

2.1. Interpersonal alienation and smartphone addiction

According to interpersonal theory (Liu & Kuo, 2007; Rudolph, Lansford, & Rodkin, 2016), accessing internet is helpful to satisfy the social needs of individuals. When people with high levels of interpersonal alienation are ignored by others and do not achieve their sense of belonging well in real life, they will use smartphones for social networking to increase social connections and enhance sense of belonging (Assunção, Costa, Tagliabue, & Matos, 2017; McEwan, 2013; Nongpong & Charoensukmongkol, 2016). This can enable individuals to form positive attitudes and expectations towards smartphones, making it easier to develop into smartphone addiction (Ang, Abu Talib, Tan, Tan, & Yaacob, 2015; Ko, Cho, & Roberts, 2005; Smock, Ellison, Lampe, & Wohn, 2011).

Researchers claimed that people with weak ties to family, peers, or school may choose another group, such as social networking sites in smartphone, as their socialization environment (Oetting & Donnermeyer, 1998). Social networking sites like a community can provide people having high levels of interpersonal alienation with resources for socialization, thus increasing the risk of smartphone addiction (Huang & Leung, 2009). In addition, in the virtual social network, individuals can choose their own groups to obtain friendship according to the preferences, so the helplessness and frustration caused by lacking of interpersonal relationship in real life can be compensated (Gross, Juvonen, & Gable, 2010; Ann & Auhagen, 2000). And the more compensation they get from the internet, the more likely they are to depend on the internet (Gao et al., 2019; Jahng, 2019; Lian & Ling, 2017; Michael, 2003; Tang et al., 2018; Xu et al., 2016). Therefore, during severe epidemics, it is reasonable to consider the low levels of interpersonal alienation will contribute to reducing the risk of smartphone addiction among university students.

2.2. Interpersonal alienation and meaning in life

Interpersonal relationship has been widely considered to be a source of meaning in life (Ebersole, 1998). General meaning maintenance model suggested that the consistency between expected interpersonal relationship and the actual interpersonal relationship plays an important role in the individual' s meaning in life (Proulx & Inzlicht, 2012). When there is a significant difference between the actual interpersonal and the expected interpersonal relationship, people will have a high level of interpersonal alienation, thus leading to a sense of meaninglessness.

Previous empirical studies were also consistent with the theory. They found good personal relationships such as good peer relationships and harmonious family relationships could significantly maintain and promote an individual' s meaning in life. However, when individuals feel interpersonal alienation, they will be more inclined to make negative attributions, often feeling down, pessimistic and disappointed. Meanwhile, it is difficult for them to feel the support from others accurately. As a result, their meaning in life will be destroyed (Auhagen, 2000; Huang, Liu, & Zhang, 2015; Lambert et al., 2013; Liu et al., 2016; Niu, Huang, Huang, & Lee, 2015; O'Donnell, Bentele, Grossman, Le, & Steger, 2014; Schlegel, Hicks, King, & Arndt, 2011; Stillman et al., 2009; Van Tongeren et al., 2015; Wang, 2016). Additionally, a recent cross-lagged analysis of freshmen further found that interpersonal disturbance could negatively predict individuals' meaning in life up to one year later (Ying, 2020). In consequence, good interpersonal relationships, namely low levels of interpersonal alienation, will facilitate mitigating the damage to an individual' s meaning in life caused by the epidemic, because of obtaining the parental support and social support from the networking during the epidemic.

2.3. Meaning in life and smartphone addiction

Frankl (1963)' s meaning therapy theory suggested that the fundamental drive for human existence is to search for meaning and purpose in life constantly. The meaning in life is an essential element to feel the happiness of life for individuals. People with low levels of meaning in life lack the motivation and goals to pursue the meaning of life, so they are prone to makeing up for the gap in their lives with some addictive

behaviors such as internet addiction (Zhang et al., 2015), smoking (KonkolÿThege, Urbán, & Kopp, 2013), alcoholism (Thurang & Bengtsson Tops, 2013), and drug abuse (Eryilmaz, 2014). Moreover, individuals also can use smartphones to carry out a number of online activities for escaping reality. During the epidemic, when individuals felt empty and anxious due to the lack of meaning in life, they might be addicted to the internet to escape from the boring life and release negative emotions, thus leading to smartphone addiction (Aboujaoude, 2010; Chen, Bao, & Huang, 2019; Chen, Xiao, & Wang, 2019; Ge, 2016; Meng, 2017; Morahan–Martina & Schumacher, 2003; Rammazi; Ann & Auhagen, 2000; Steger, Oishi, & Kashdan, 2009; Yao et al., 2016; Zhao, 2015; Zhang, Qin, & Huang, 2019). Zhang and Wang et al. (2019) used a one-year cross-lagged analysis to explore the relationship between social support, meaning in life and online game addiction in a sample of university students. The result showed that meaning in life played a longitudinal mediating role in the association between social support and online game addiction, and meaning in life could directly negatively predicted online game addiction. With a large number of video games on smartphones, individuals with lower levels of meaning in life are more likely to be addicted to smartphones (Zhao et al., 2020b).

2.4. Early interpersonal alienation, meaning in life, and later university students' smartphone addiction

According to Davis (2001)' s cognitive-behavioral model about addictive behaviors, interpersonal alienation as a psychosocial variable is the distal factor, and maladaptive cognition is a proximal factor for the formation of smartphone addiction. While the effects of distal factors on smartphone addiction needs to be realized through the mediating role of proximal factors (Mai et al., 2012). As a consequence, distal interpersonal alienation (perception of external relationships) may influence individuals' smartphone addiction through proximal meaning in life (perception of internal meaning). Therefore, low levels of external interpersonal alienation during a severe epidemic was a particular important resource that could reduce smartphone addiction through increasing individuals' meaning in life.

Based on the most aforementioned literatures, low levels of interpersonal alienation during Covid-19 may alleviate an individual' s smartphone addiction through increasing their meaning in life. However, relatively few empirical studies have explored the mediating role of the meaning in life in the relationship between interpersonal alienation and smartphone addiction in the context of public health emergencies. They are primarily cross-sectional studies of how social support or loneliness influences internet addiction through meaning in life (Liu, Yang, & Wang, 2020). From the perspective of study design, there is a problem with the mediating effect obtained in the cross-sectional study. That is, the effect of simultaneity is unable to separate and control the autoregressive effect of variables, thus leading to the path coefficient of the mediating effect deviating from the real value (Maxwell & Cole, 2007).

As a result, the present study used a three-time tracking design with cross-lagged analysis to examine whether interpersonal alienation affected individuals' meaning in life and then their smartphone addiction during the Covid-19.

2.5. Changes of interpersonal alienation, meaning in life and smartphone addiction in the context of epidemic

In the context of Covid-19, people' s interpersonal alienation, meaning in life and smartphone addiction may change as the epidemic progresses. During the epidemic, university students mainly lived with their families, from whom they received much support. In addition, individuals would receive a lot of encouragement and help through the internet because of the whole nation committing to fighting the epidemic. And because social support can significantly reduce an individual' s interpersonal alienation, university students were relatively low in interpersonal alienation when the epidemic was more serious (Jiang & Bai, 2014). As the epidemic was brought under control and life returned to normal, the social support available to individuals would decrease, and then their interpersonal alienation would increase to a certain extent.

As a negative event, Covid-19 is a direct source of stress for individuals' meaning in life (Lai & Jiang, 2013). The deeper people' s perception of negative events, the stronger the stress response will be. They are therefore more vulnerable to feeling frustrated and have negative life experience that reduces their sense of having meaning (Li, 2016). Previous studies also found adolescents' stress negatively predicted their meaning in life when faced with stressful life events (Ye & Zheng, 2014). What' s more, measures to suppress the spread of Covid-19 (such as spatial, social and family isolation) can cause negative emotions such as sadness, fear, anger and anxiety in individuals (Islam et al., 2020). In order to escape and relieve the negative emotions in real life, individuals tended to participate in some online activities, such as watching videos, gaming online and socializing online, thus easily leading to the problem of smartphone addiction (Blasi et al., 2019). As life returned to normal, the individual' s sense of panic diminished. University students also continued to go back completing their studies, and the risk of smartphone addiction would be reduced. Accordingly, the present study hypothesized that as the epidemic gradually gets under control, individuals' interpersonal alienation and meaning in life will increase, while the risk of smartphone addiction will decrease. To sum up, this study proposes the following hypothesis:

H1. With the epidemic gradually under control, a) university students' interpersonal alienation has increased; b) meaning in life has increased; c) the risk of smartphone addiction has decreased.

H2. In the context of Covid-19, meaning in life plays a longitudinal mediating role in the relationship between interpersonal alienation and smartphone addiction among university students.

3. Method

3.1. Participants

The data for this study was drawn from a 3-wave longitudinal study, and this study was approved by the Research Ethics Committee of the corresponding author' s institution. Participants came from universities all over China. Measures of the relevant constructs were administered to the students at three time points with three-month intervals. A total of 579 students (29.5% male; age: $M = 20.59$ years, $SD = 2.20$) took part in this study at Time 1 (T1), with 91 (15.72% of T1) students lost at Time 2 (T2), and 125 (21.59% of T1) students lost at Time 3 (T3). In terms of internet use, 71.9% of students used smartphone to access the internet. Additionally, 89.2% of students were online over 2 years.

The chi-square tests and independent sample t-tests were conducted to analyze whether the loss of participants was biased. Specifically, the data of participants who completed all three questionnaires was encoded as 1. Otherwise, it was encoded as 0. Demographic variables and important variables at T1 were used for analysis. Results showed there was no significant difference in the gender ($\chi^2 = 0.02$, $df = 1$, $p > 0.05$), age ($\chi^2 = 3.27$, $df = 4$, $p > 0.05$), interpersonal alienation ($t = 0.96$, $p > 0.05$), meaning in life ($t = 1.64$, $p > 0.05$), and smartphone addiction ($t = -0.99$, $p > 0.05$) between complete and incomplete data. It suggested the missing data was not different from a random pattern. Therefore, the missing data was processed by full information maximum likelihood. The method makes full use of all available information which is helpful to improve the statistical testing power and obtain unbiased coefficient estimation (Enders, 2010).

3.2. Procedure

All materials and procedures were approved by the Research Ethics

Committee of the authors' institution. After obtaining informed consent from participants, we invited them to complete the questionnaires online anonymously. Written informed consent was from the participants and they were informed that they may terminate participation at any time. The first wave of data was collected in June 2020 measuring the psychological and behavioral characteristics from January to March recalled by participants (the severe period of the epidemic). The second and third waves of data was collected measuring the current psychological and behavioral characteristics of participants in September 2020 (the basic control period of the epidemic), and in December 2020 (the basic end period of the epidemic). The participants completed questionnaires on demographic variables, interpersonal alienation, meaning in life, and smartphone addiction in both three waves.

3.3. Measures

3.3.1. Interpersonal alienation

Our scale was adapted from the interpersonal alienation dimension of Adolescent Alienation Scale (Yang, Zhang, & Huang, 2002). That consists of 3 items evaluating the degree to which the university students perceive interpersonal alienation (e.g., "I feel very lonely"). Participants registered their degree of agreement with a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Each subscale is averaged into a mean score and higher scores indicate higher interpersonal alienation. Good psychometric properties were reported in previous studies (Li, 2015; Xu, Zhang, & Zhang, 2009). In the present study, the items had good internal consistency in the first wave ($\alpha = 0.87$), in the second wave ($\alpha = 0.85$), and in the third wave ($\alpha = 0.85$).

3.3.2. Meaning in life

The scale consulting the research done by our predecessors (Liu & Gan, 2010), we used 9 items including presence of meaning (e.g., "I know the meaning of my life") and searching of meaning (e.g., "I am searching for the meaning of my life") to assess meaning in life of university students. Participants responded on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree). The scores across 9 items are averaged and higher scores indicate a higher level of meaning in life. The scale was used successfully in Chinese participants (Duan, 2019; Zhu, Gan, Li, & Zhang, 2017). The Cronbach' s α for the scale with nine items was 0.91 in the first wave, 0.88 in the second wave, and 0.88 in the third wave.

3.3.3. Smartphone addiction

This scale was adapted from Smartphone Addiction Scale developed by Su et al. (2014). We used 6 items to assess smartphone addiction among university students (e.g., "I overuse apps on my phone"). Participants responded on a 5-point scale ranging from 1 (not at all true) to 5 (always true). The scores across 6 items are averaged and higher scores indicate a higher level of smartphone addiction. In the present study, the items had good internal consistency in the first wave ($\alpha = 0.80$), in the second wave ($\alpha = 0.82$), and in the third wave ($\alpha = 0.82$).

3.4. Statistical analysis

The SPSS (version 17.0) and Mplus (version 7.4) were used for all analyses in the present study. First of all, descriptive statistics and correlations for our variables were presented. Then, single sample t-tests were used to examine the changes of interpersonal alienation, meaning in life and smartphone addiction at three waves. Moreover, three-wave longitudinal panel designs were employed to analyze the temporal relationship between interpersonal alienation, meaning in life and smartphone addiction. The indexes of model fitness include a comparative fit index (CFI), a standardized root-mean of the residual (SRMR), and a root-mean square error of approximation (RMSEA) (Hu & Bentler, 1999; Kline, 2005). Specifically, CFI values of more than 0.95, SRMR and RMSEA values of less than 0.05 suggest a good fit. The chi-squared test of difference ($\Delta\chi^2$) was used to compare the fit of the models. If the $\Delta\chi^2$ revealed a $p > 0.05$, the two models were considered to provide an equal fit for the data.

Model 1 is measurement model consisting of all observed and latent variables from each time with freely estimated parameters. Compared Model 1, Model 2 is a more restrictive model in which all the indicators of latent variable factors were specified as being equal across time. Model 3 is autoregressive model, accounted for only change within interpersonal alienation, meaning in life, and smartphone addiction. Based on Model 3, Model 4 adds cross-lagged predictive paths from interpersonal alienation and meaning in life to smartphone addiction, from meaning in life and smartphone addiction to interpersonal alienation, and from interpersonal alienation and smartphone addiction to meaning in life. Additionally, we compared Model 3 with Model 4, then chose the best-fit model according to chi-square and longitudinal path coefficients.

4. Results

4.1. Descriptive statistics and difference test

Descriptive statistics and correlations between interesting variables in the present study were presented in Table 1. The results showed that meaning in life was negatively correlated with interpersonal alienation and smartphone addiction. In addition, the differences of interpersonal alienation, meaning in life and smartphone addiction at three time points were tested to explore their changes with the development of the epidemic. Specifically, the single sample t-tests were conducted to examine the difference values of T2-T1, T3-T2, and T3-T1. The results indicated interpersonal alienation at T3 was significantly greater than at T1 and T2. Meaning in life at T2 and T3 were significantly greater than at T1. Smartphone addiction at T2 and T3 were significantly lower than at T1 (see Table 2). Interpersonal alienation and meaning in life were on the rise, while smartphone addiction was on the decline. The changes in interpersonal alienation were shown in Fig. 1, the changes in life meaning were shown in Fig. 2, and the changes in smartphone addiction were shown in Fig. 3.

4.2. Measurement invariance and model comparison

In the longitudinal study, the test of equivalence of measurement is the premise of study (Geiser, 2013). Firstly, we constructed a measurement model (unconstrained model) exhibiting good fit indexes (see M1 in Table 3). Additionally, the model fit indices for metric invariance model were also accepted (see M2 in Table 3), fitting the data equally as well as the measurement model did ($\Delta\chi^2 = 24.68$, $\Delta df = 15$, $p > 0.05$). It revealed the measurement model satisfied equivalence.

The next step was to test an autoregressive model including autoregressive paths between the T1, T2, and T3 measures of interpersonal alienation, meaning in life and smartphone addiction. All the autoregressive paths were significant (in Fig. 4), and fit indices met the metrological criteria (see M3 in Table 3). Building on the autoregressive model, we constructed and tested the fit of cross-lagged model with mediation (in Fig. 4). The cross-lagged model with mediation exhibited good fit indexes (see M4 in Table 3), fitting the data significantly better than the autoregressive model did ($\Delta\chi^2 = 45.04$, $\Delta df = 12$, $p < 0.05$).

4.3. The associations among interpersonal alienation, meaning in life and smartphone addiction

The cross-lagged model including interpersonal alienation, meaning in life and smartphone addiction, and its standardized path coefficients were shown in Fig. 4. Firstly, smartphone addiction at T1 predicted interpersonal alienation at T2 ($\beta = 0.11$, $p < 0.05$). Then, it was about the mediating effect of meaning in life. In the first half of the mediation, interpersonal alienation at T1 was a significant predictor of meaning in

Table 1
Descriptive statistics and correlations among interpersonal alienation, meaning in life and smartphone addiction.

	M±*SD*	1	2	3	4	5	6	7	8
1. T1 IA	3.00 ± 1.47								
2. T2 IA	3.10 ± 1.50	0.56**							
3. T3 IA	3.27 ± 1.50	0.52**	0.66**						
4. T1 MIL	4.62 ± 1.08	−0.18**	−0.22**	−0.18**					
5. T2 MIL	5.23 ± 0.92	−0.21**	−0.31*	−0.26*	0.44**				
6. T3 MIL	5.20 ± 0.90	−0.14**	−0.28*	−0.32**	0.46**	0.60**			
7. T1 SA	3.29 ± 0.77	0.21**	0.22**	0.15**	−0.11**	−0.11*	−0.09		
8. T2 SA	3.18 ± 0.77	0.20**	0.25**	0.20**	−0.12**	−0.07	−0.06	0.55**	
9. T3 SA	3.18 ± 0.76	0.19**	0.24**	0.23*	−0.13**	−0.15**	−0.14**	0.47**	0.67**

Note. IA = Interpersonal alienation; MIL = Meaning in life; SA = Smartphone addiction. T1 = Time 1; T2 = Time 2; T3 = Time 3. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 2
Pairwise comparisons of interpersonal alienation, meaning in life, and smartphone addiction over a three-wave test.

Variable	Time	*M*±*SD*	*t*	*p*
Interpersonal alienation		0.09 ± 1.40	1.44	0.15
Meaning in life	T2-T1	0.67 ± 1.06	13.95***	0.00
Smartphone addiction		−0.13 ± 0.73	−3.84***	0.00
Interpersonal alienation		0.15 ± 1.25	2.47*	0.01
Meaning in life	T3-T2	−0.04 ± 0.81	−0.97	0.34
Smartphone addiction		−0.02 ± 0.63	−0.53	0.60
Interpersonal alienation		0.28 ± 1.45	4.17***	0.00
Meaning in life	T3-T1	0.62 ± 1.03	12.80***	0.00
Smartphone addiction		−0.13 ± 0.78	−3.57***	0.00

Note. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

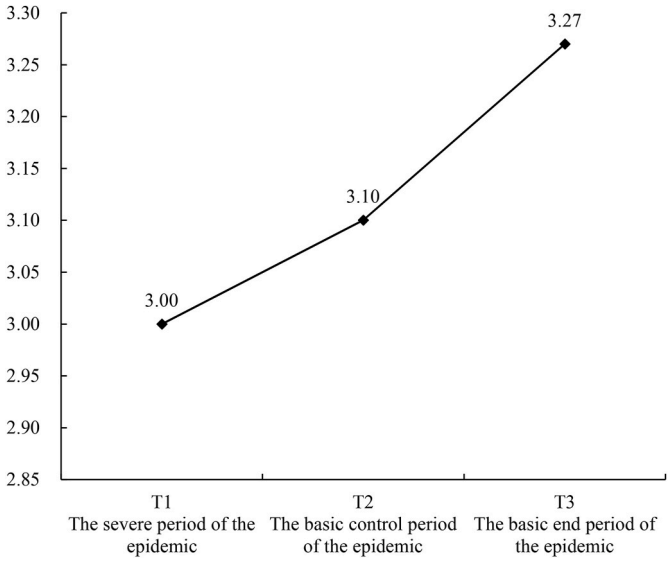

Fig. 1. The changes in interpersonal alienation at three time points.

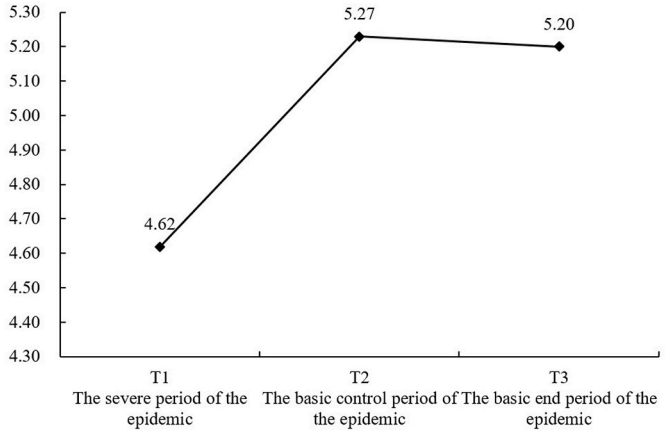

Fig. 2. The changes in meaning in life at three time points.

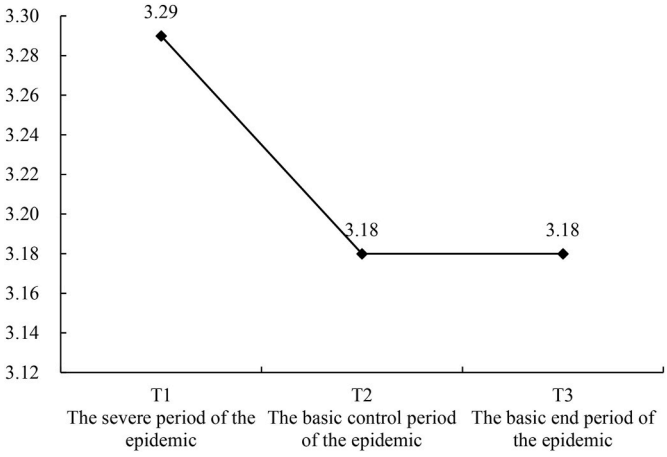

Fig. 3. The changes in smartphone addiction at three time points.

life at T2 ($\beta = -0.12$, $p < 0.05$). In the second half of the mediation, meaning in life at T2 was a significant predictor of smartphone addiction at T3 ($\beta = -0.13$, $p < 0.01$). It suggested there was a significant mediating pathway from interpersonal alienation at T1 to smartphone addiction at T3 through meaning in life at T2. The significance of the indirect effects is shown in Table 4.

5. Discussion

5.1. The changes of interpersonal alienation, meaning in life and smartphone addiction with the development of the epidemic

This study indicates that interpersonal alienation in the basic end

Table 3
Model comparison and fitting index.

Model	χ^2/df	RMESA	CFI	TLI	SRMR	$\Delta\chi^2$ (Δdf)	*p*
M1	1.68	0.03	0.95	0.95	0.07		
M2	1.68	0.03	0.95	0.95	0.07	24.68 (15)	>0.05
M3	1.74	0.04	0.95	0.94	0.08		
M4	1.72	0.04	0.95	0.94	0.07	45.04 (12)	<0.05

Note. M1 = unconstrained model, M2 = metric invariance model, M3 = autoregressive model, M4 = cross-lagged model with mediation.

Table 4
Bootstrap analysis for significance test of mediating effect.

Indirect path	Indirect effect (*SE*)	95% Bootstrap	
IA→MIL→SA	0.02 (0.01)	0.004	0.033

Note. IA = Interpersonal alienation; MIL = Meaning in life; SA = Smartphone addiction.

period of the epidemic (December) is significantly higher than that in the severe period (January to March) and the basic control period (September), namely with the epidemic gradually under control, the levels of interpersonal alienation among university students show an upward trend (confirmation of Hypothesis 1a). During the quarantine period with serious epidemic, most university students had returned home smoothly. Therefore, they mainly stayed with their parents keeping close contact with their families and receiving a lot of love and support. Additionally, during home isolation, individuals were primarily connected to others by internet where people encouraged each other through difficult times. Thus, although people were isolated at home during severe epidemic, isolation of the virus did not block love. Individuals still felt social support from family, friends and strangers online. Nowadays, many studies have found that social support is a main factor affecting interpersonal alienation among university students. Specifically, social support is negatively correlated with interpersonal alienation (Jin et al., 2019; Wang, 2016; Ye et al., 2018). As a consequence, the family support and networking social support obtained by university students can effectively reduce the interpersonal alienation in the severe period of the epidemic and make it at a low level. This is inconsistent with the few studies that have found high levels of interpersonal alienation among individuals during Covid-19 (Zhu, Shen, Zhou, & Yang, 2020; Zhu, Zhang, Zhou, Li, & Yang, 2021). It may be due to differences in the subjects studied. Previous studies have focused on individuals isolated alone during the severity of the epidemic, most of whom have not returned home, suspected or infected. For individuals isolated, the reduction of direct contact with family, friends and society easily cause damaged interpersonal relationships, helplessness and loneliness. As a result, interpersonal alienation of the individuals isolated during the severity of the epidemic also increased, which was the opposite of how university students felt about interpersonal alienation. Since then, as the epidemic has gradually been brought under control, university students have been leaving their parents to return to school for offline study. Everyone mainly focuses on their studies without extra time for social activities. Moreover, because of long isolation at home, individuals spending less time interacting with classmates and friends face-to face may lead to a sense of alienation from others, thus resulting in a rising level of interpersonal alienation (Xiao, 2020).

The meaning in life in the basic control period (September) and the basic end period (December) is significantly higher than that in the severe period (January to March), that is, with the epidemic gradually under control, the levels of meaning in life among university students show an upward trend (confirmation of Hypothesis 1 b). When the epidemic was severe, the number of new deaths and diagnoses in China continued to climb every day, with the highest number of new deaths reaching 254 and the highest number of new diagnoses exceeding 3500 in a single day. It was easy to feel scared and helpless in the face of ever-increasing numbers. They worried constantly that they could get Covid-19, thus losing a sense of control over their lives. The decrease of the sense of control would further lead to the impairment of the individual' s meaning in life (Wang, 2014). In addition, in negative situations, individuals may not be able to explore the positive meaning implied by them. Instead, they see negative events as only hurtful and destructive, and constantly avoid dealing with them. It can lead to a critical, destructive, low levels of meaning in life (Joseph & Linley, 2005; Power & Brewin, 1997). Hence, Covid-19 as a negative event may reduce university students' meaning in life. As the epidemic gradually gets under control, individuals have less negative experience of life with a feeling of survivability. Accordingly, they will be more cherished for life and strive to live, in turn enhancing the meaning in life.

The smartphone addiction in the basic control period (September) and the basic end period (December) is significantly lower than that in the severe period (January to March), namely with the epidemic gradually under control, the levels of smartphone addiction among university students show a decreasing trend (confirmation of Hypothesis 1c). When isolated at home because of serious epidemic, university students needed to use a variety of educational software such as Tencent Conference and Ding Talk to study online; access the internet to communicate with friends online to satisfy interpersonal needs; engage in some specific online activities such as online games to escape and alleviate the negative emotions caused by the epidemic. These online activities increased the risk of individuals' intense use of smartphones (Islam et al., 2020). Besides, during home isolation, university students spent less time exercising due to space constraints and were prone to having a sedentary lifestyle. These undesirable lifestyles led individuals to spend more time on activities such as social media use and online gaming, thus

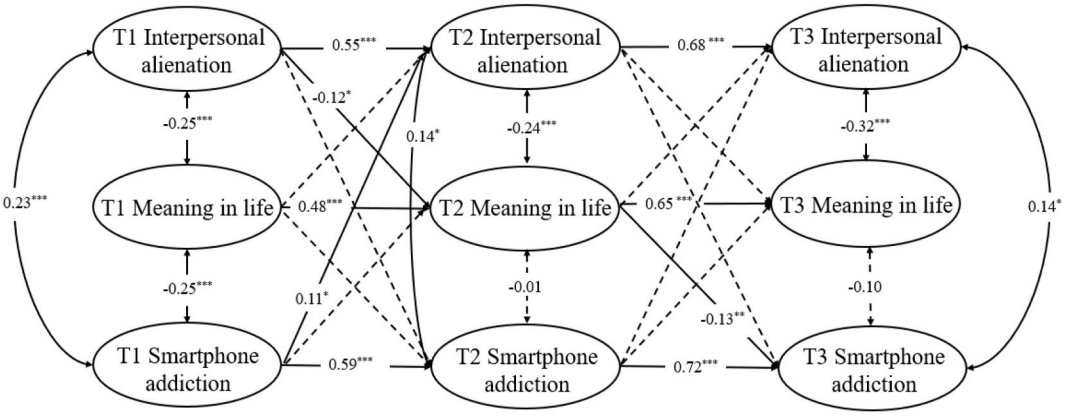

Fig. 4. Cross-lagged model of interpersonal alienation, meaning in life, and smartphone addiction. The solid line represents $p < 0.05$; the dotted line represents $p > 0.05$.

resulting in smartphone addiction (Aşut, Abuduxike, Acar-Vaizoğlu, & Cali, 2019; Hassan, Alam, Wahab, & Hawlader, 2020; Islam & Hossin, 2016). As the epidemic was brought under control, life began to return to normal with less panic, online learning as well as socializing moving offline, and regular physical activity resuming. These all can facilitate reducing the risk of smartphone addiction.

5.2. The associations between interpersonal alienation and smartphone addiction

The results illustrated that smartphone addiction positively predicted interpersonal alienation among university students. Although this is an unexpected result of this study, it is still consistent with some previous studies (Elisheva, 2002; Lepp, Li, & Barkley, 2016; Li, 2010; Rasmussen et al., 2015). These studies demonstrated that due to smartphone addiction displacing more beneficial social interactions, internet addiction negatively predicted both parent and peer relationship, thus causing interpersonal alienation. In fact, smartphone plays a dual role in individuals' social relationship. Using smartphones can develop social networking (i.e., enhance), while it wastes time that might be devoted to more personalized activities, such as face-to-face communication, thereby weakening social relationships (i.e., displacement) (Ahn & Shin, 2013; Synder, Li, O'Brian, & Howard, 2015). Therefore, smartphone addicts tend to withdraw from social behaviors in reality, leading to more serious interpersonal problems, such as high levels of interpersonal alienation.

5.3. The longitudinal mediating role of meaning in life in the relationship between interpersonal alienation and smartphone addiction

As expected, this study shed light on that meaning in life mediated the relationship between interpersonal alienation and smartphone addiction among university students (confirmation of Hypothesis 2). It is in accordance with the conclusion of previous similar research, such as social support or natural connection could affect an individual' meaning in life and then influence their internet addiction (Chen, Xiao, & Wang, 2019; Fung, 2016; Liu et al., 2020; Liu & Cai, 2015). In addition, our finding supports the cognitive-behavioral model (Davis, 2001), that is, interpersonal alienation as a psychosocial factor can predict individuals' smartphone addiction through their inner meaning in life. Furthermore, the finding also shows that the resources owned by individuals can promote individuals to better adapt to risk situations. In the severe phase of the epidemic, individuals were at a high risk of smartphone addiction and low levels of meaning in life. The low levels of interpersonal alienation played an important role, which can reduce the smartphone addiction among university students in the basic end of the epidemic by improving meaning in life in the basic control period. Firstly, in this special period of the epidemic, good interpersonal relationships contributed to helping people in need. It can help individuals to actively explore the positive meaning contained in negative events and integrate it into their own meaning system, which is conducive to maintaining a high level of life meaning and promoting self-growth (Huang, Liu, & Zhang, 2015; Zhang & Li, 2018; Joseph & Linley, 2005). Secondly, when individuals have a high level of meaning in life, they will own a clear life goal and pay attention to long-term life content. Even the negative situation of the current epidemic would not make individuals produce a negative attitude towards life or feel empty and boring, conversely, individuals would give more meaning to life and constantly improve themselves, so the risk of smartphone addiction would be greatly reduced (Vallacher & Wegner, 1985; Vohs & Schmeichel, 2003; Zhang, Qin, & Huang, 2019).

Furthermore, according to the context-process-outcome model (Roeser, Midgley, & Urdan, 1996), school situational factors can influence students' academic achievements and other developmental outcomes through their psychological processes. In essence, this model is an explanation of the mediating process about situational factors acting on a developmental process to produce a certain outcome. This study also found that during the epidemic period, interpersonal alienation as one of situational factors could also affect the smartphone addiction through its effect on the individual' s psychological process (meaning in life). Specifically, good situational factors have a positive effect on individual psychology and behaviors (Vanderbilt-Adriance & Shaw, 2008; Wyman, Cowen, Work, Hoyt-Meyers, & Fagen, 1999). In the present study, good interpersonal relationships (low levels of interpersonal alienation) can effectively mitigate the damage of the epidemic to the individual' s meaning in life (Van Tongeren et al., 2015). Then high levels of meaning in life can help individuals face negative events in the epidemic more bravely with an enhanced sense of control over their life and self, thereby reducing the possibility of escapism such as smartphone addiction (Zhang, Qin, & Huang, 2019). Our finding not only supports the context-process-outcome model, but also extends its application scope to the context of public emergencies, which further proves the cross-domain consistency of the model in both generalized and specialized situations.

5.4. Limitations and future directions

There are some limitations to the present study that should be noted. Firstly, the moderators are not included. There are many factors affecting individuals' performance in Covid-19, such as self-regulation (Kietzmann, Hermkens, McCarthy, & Silvestre, 2011), cognitive evaluation (Choi, Jung, & Lee, 2013), relative deprivation (Lin & Liu, 2020; Xie, Wang, Wang, Zhao, & Lei, 2018), and parent-child communication (Liu, Lin, Zhou, & Zhang, 2019). Future studies can include them as moderators to further explore the psychology and behaviors of people in public health emergencies and how to reduce the negative impact of negative events on individuals. Secondly, the subject sampling is limited. The present study only focused on university students, and thus it should be cautious to extend this conclusion to other groups. Further tests with various populations, particularly who are from various countries are needed to enhance the generalizability of the results and further to shed light on the cultural differences. For example, Chinese construed suffering more positively than Euro-Canadians during the COVID-19 pandemic, thereby their perceptions of meaning in life may differ (Ji et al., 2020; Power & Brewin, 1997). Thirdly, the form of the questionnaire survey is limited. Online questionnaire survey was adopted in this study. Although it is convenient and efficient as well as satisfy the safety requirements for investigation under infectious diseases, there is a lack of supervision on the actual situation of respondents' answers, so there may be problems such as inauthenticity and carelessness in filling the questionnaire. Lastly, the data of university students' smartphone addiction came from self-report, which may differ from the actual behaviors (Junco, 2013). Future research should use more objective methods to obtain data, such as using App to record or directly retrieve background data related to smartphone use (Andrews, Ellis, Shaw, & Piwek, 2015).

5.5. Implications

Despite these limitations, the present study sheds light on the internal mechanisms of interpersonal alienation, meaning in life and smartphone addiction in the context of the epidemic. The finding has important theoretical and practical implications.

5.5.1. Theoretical implications

Guided by cognitive-behavioral model of addictive behaviors, our study is the first to use a tracking design to reveal the longitudinal mediating role of meaning in life in the association between interpersonal alienation and university student smartphone addiction during the Covid-19. Our findings are an important supplement to the existed conclusion and provided empirical evidence for cognitive-behavioral model of addictive behaviors, suggesting it could be applied to the

context of crisis. In cognitive-behavioral model of addictive behaviors, as an external environmental factor, low levels of interpersonal alienation plays a crucial role in enhancing their inner meaning in life, and consequently alleviating smartphone addiction arising from the crisis (de Jong, Ziegler, & Schippers, 2020; Islam et al., 2020; Jiang & Bai, 2014; Lepp et al., 2014; Poushter, 2016; Schiff et al., 2021). It follows then that good interpersonal relationship during the Covid-19 is an essential factor to reduce the damage from the crisis (Salinas-Rehbein & Ortiz, 2020). We believe that the mediation model is important for ongoing research on the Covid-19 crisis and any future social crisis. It presents the negative psychological and behavioral manifestations that are likely to occur in the crisis, and proposes corresponding interpersonal protective factor. The contribution makes a recommendation for future research, that is to explore the role of interpersonal relationship in the crisis environment, such as, parent-child relationship, peer relationship, and teacher-student relationship into consideration. The recommendation is crucial to generate a more complete understanding of how the external interpersonal protective factors affect the behaviors of individuals by influencing their internal psychological process (Zhao, Li, Zhou, Nie, & Zhou, 2020a).

5.5.2. *Practical implications*

Furthermore, there are several important practical implications for preventing and intervening the negative effects of crisis on university students' psychology and behaviors. Firstly, this research indicated that low levels of interpersonal alienation contributed to improving meaning in life and further alleviating smartphone addiction among university students during the Covid-19. Therefore, to exercise university students' interpersonal skills, it would be effective for universities to provide students with interpersonal communication education online which will help them express themselves actively to bid farewell to isolation (Tan, Jia, & Li, 2017). Furthermore, under the help of psychotherapists, restructuring the cognition of university students to perceive the support from others positively also contributes to reducing their interpersonal alienation (Zhu et al., 2021). Secondly, the present study validated the mediating role of meaning in life in the link between interpersonal alienation and smartphone addiction, thereby it is essential to promote meaning in life for preventing university students from maladaptive outcomes, such as smartphone addiction. Researchers have proved that life-crafting intervention contributes to rebuilding meaning in life of university students effectively (de Jong et al., 2020). Specifically, during the Covid-19 pandemic, life-crafting helps university students reflect on what has been shattered for themselves in the present, and then choose a different way to pursue the original purpose, thus making their life more aligned with their values and aspirations (Schippers & Ziegler, 2019). For example, the main purpose in life of university seniors majoring in psychology may be to complete their thesis and graduate successfully. However, they could not pursue the intermediary goal to conduct offline experiments for collecting data as usual during the Covid-19. In this situation, it would be helpful for university seniors to formulate new intermediate goals, for instance, transform offline experiments into online experiments or electronic questionnaires, which still allows them to pursue their original purpose in a different way. It will help individuals regain their sense of meaning in life during the crisis and then reduce the risk of smartphone addiction.

Credit author statement

Qiong Hu: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization; **Qinxue Liu**: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition; **Zongyuan Wang**: Methodology, Writing – review & editing.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent for participate

Informed consent was obtained from all university students in the study.

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgements

We thank all university students participating in this project. Additionally, we also thank the Funds for its support of this project. This work was supported by the Fundamental Research Funds for the National Natural Science Foundation of China (No.32000764), and the Fundamental Research Funds for the Central Universities of Central China Normal University (No. CCNU20TS029). The funders had no role in study design, collection, analysis or interpretation of the data, decision to publish, or preparation of the manuscript. No competing financial interests existed.

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