Emotional well-being in COVID-19 mass quarantine: the role of personal response and life activity: a 14-day diary study in China

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Acknowledgements:
We would like to thank all participants for voluntarily donating their time to our study when they were under quarantine, and the two anonymous reviewers for their valuable comments on the early draft of this paper. We also would like to thank our family members for their supports in a difficult time conducting the study under lockdown.

This work was partially funded by Fundação para a Ciência e a Tecnologia (FCT) Portugal, Grant UIDB/00315/2020

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Abstract

Objectives: This study aims to explore quarantined individuals' emotional well-being over time and how personal response and life activity predict emotional well-being and its change.

Design/Methods: Daily data were collected from 134 participants with 71 having 14 consecutive days' data. Hierarchical linear modeling (HLM) and General Linear Model (GLM) were used to examine the primary tests.

Results: Overall, positive and negative emotions declined significantly during the surveyed period. Meanwhile, differences were observed in the level of positive, depressed, and negative emotions and/or patterns of change among different population categories. The personal response of worrying about work and life was positively related to depressed and negative emotions at baseline, but was negatively related to the development of both depressed and negative emotions over time. Among life activities, family stressor was a significant predictor for both depressed and negative emotions while social support predicted positive emotions. Moreover, health & hygiene activity was positively related to positive emotions at baseline.

Conclusions: The results provide scientific evidence for public health policymakers on quarantine policies and inform the general public about quarantine life. They highlight the importance of addressing the needs of vulnerable groups (parents with young children, divorcees, clinicians) during the pandemic, and demonstrate the benefits of promoting healthcare and hygiene activity, having a sense of worry and access to social support.

Keywords:

Emotional Well-being, Stress, Quarantine, Pandemic of COVID-19, Diary Study

Introduction

The unprecedented COVID-19 pandemic has cost nearly three million lives, with millions of people in European countries (e.g., Germany and Italy) living under lockdown again in the fight against the third wave of coronavirus started in spring 2021 as we write this article. On 23 January 2020, Wuhan, the then epicentre of the coronavirus pandemic, was put under lockdown to contain the spread of COVID-19. During this lockdown, residents' movements were restricted (see Tang et. al 2020). For instance, they were not allowed to go grocery shopping but had to buy daily necessities from designated neighbourhood committees; all public transport (airplane, train, bus, metro, and taxi) was suspended, and the use of private vehicles was forbidden. Since the lockdown in Wuhan in January 2020, an estimated one billion people across China have had their movements restricted due to varying degrees of confinement (Wang et al. 2020). Indeed, since then lockdown has been a strategy frequently used by Chinese governments in fight against the COVID-19pandemic.

Similar scenarios have since played out in the rest of the world. When the World Health Organization (WHO) announced on 11 March 2020 that the COVID-19 outbreak was a pandemic, Italy, Spain, Portugal, Iran, India and South Africa rapidly declared national lockdowns. At one point in April 2020, more than 90% of the US population was under mandatory lockdown orders. By early April 2020, over half of the world's population (3.9 billion) was under some form of lockdown.

Lockdowns and stay-at-home orders are both mass quarantine strategies to mitigate the pandemic that require residents to stay home except for essential tasks. Neither lockdown nor stay-at-home is a technical term used by the public health community; this study uses the term "mass quarantine" to refer to the obligatory restriction of movement as a government order to mitigate the COVID-19 pandemic. More specifically, mass quarantine refers herein to all situations involving restrictions of movement in which people have been ordered to stay at home or in a government-designated facility, typically under a state or city lockdown or a stay-at-home order.

While the pandemic is, in itself, a major threat to the well-being of the general public (Chew et al., 2020), this threat may be exacerbated by the confinement of stay-at-home policies that increase social isolation and relationship difficulties (Van Bavel et al., 2020). For example, depression and post-traumatic stress disorder (PTSD) were reported from quarantined persons in the 2003 SARS (Severe Acute Respiratory Syndrome) outbreak (Hawryluck et al., 2004), and quarantined people reported more negative emotions like anxiety and anger during the MERS (Middle East Respiratory Syndrome) outbreak (Jeong et al., 2016). The literature suggests that quarantine can cause negative psychological effects (Brooks, et al. 2020). Emerging studies from the COVID-19 pandemic (e.g. Hu et al., 2020; Tang et al., 2020; Zhang et al., 2020) report mixed results and were mostly cross-sectional. Given the scale of people living under quarantine and the prolonged nature of the pandemic, policymakers worldwide need rigorous scientific evidence on which to base informed guidance.

We built on the findings from this pandemic and literature (Brooks et al., 2020; Chew et al., 2020) and conducted a diary study to explore individuals' emotional well-being under quarantine with two objectives. First, we aim to document people's daily emotional well-being over 14 days, including examining how positive, depressed and negative emotions develop over time, and the extent to which different sub-groups' emotions may differ. Second, we examine whether the personal response to the epidemic and life activity under quarantine are associated with emotions and whether emotions change over time.

Specifically, we address the following questions: 1) what are the average levels of positive emotions, depressed emotions and negative emotions in a 2-week mass quarantine period? 2) how does emotional well-being change over time? 3) are there differences in emotional well-being among different population categories? (e.g. gender, geographic location, education, clinician group, family)? 4) how does the personal response to the epidemic and life activity under quarantine predict emotions and their change over time?

This comes in response to the call for researchers "*to mobilize rapidly to produce research to directly inform policy and individual/collective behavior in response to the pandemic*" (Van Bavel et al., 2020), contributing in understanding how people respond to and cope with the threat of a global pandemic. In addition, this study may contribute to the literature on the study of emotion and stress (Veer et al., 2020; Kuppens & Verduyn, 2017) with a unique sample collected using a diary method in

an unprecedented pandemic context. It adds to the literature by providing data from a 14-day longitudinal analysis of emotions, as well as by examining a possible mechanism for emotion dynamics.

We explore the above questions using daily diaries reported by participants in a mass quarantine situation in March 2020 in Wuhan and other cities in China. This method helps obtain repeated measurements of participants' emotions under specified quarantine conditions, enabling the study of within-person emotional well-being over time. It provides much needed data for research into emotional well-being and its development over time under quarantine and provides an opportunity to explore the possible factors associated with the dynamics.

Methods

Procedure and Participants

The study used a diary method to collect data from participants under quarantine. It took place over 14 consecutive days (2 weeks), which is the incubation period for the virus and the required quarantine period after travelling in China. Participants were recruited through personal networks and the snowball method. Specifically, we first identified from our network and contacted potential subjects who were under quarantined situation in our social media group (WeChat). Existing subjects were then asked to introduce the research project to their social circles and encourage others with the necessary quarantine characteristics to participate in the study. These steps

were repeated until the needed sample size was achieved. The contributors in this research work in higher-education and healthcare organizations whose networks (colleagues, friends, students) gave them access to quarantined populations in China. Judging from the sociodemographic characteristics of the sample (Table 1), the subjects were from a diverse professional background and geographical areas. The influence of uncontrolled factors with snowball sampling is not evident.

We defined selection criteria as living under mass quarantine status with restrictions on movement outside the residential area (including home, government quarantine facility and hotel) due to the COVID19 pandemic. All respondents agreed to voluntarily participate in the study. Ethical approval was obtained from a hospital in China (where one of the authors works). The data were anonymous even though participants were gathered through invitation. Our contact with the participants was obtained through the inviters (agents) who were primarily the authors and their close networks. The confidentiality of participants' data was assured, and they were given the option of withdrawing from the study at any time.

The data collection procedures were as follows: after agreeing to participate in the research and qualification criteria for participation had been confirmed, the participants were asked to complete an online background questionnaire (survey 1) providing information on social demographics, quarantine situation, their worries about work and life, and knowledge of the COVID-19 epidemic under the quarantine prior to starting the diary-survey. Then, the participants were asked to complete a

short online questionnaire (survey 2) each evening before going to bed over 14 consecutive days to capture their daily emotions, family stressor, and the social support they received. When participants were unable to complete the diary in the evening, they were allowed to do so the next morning. One of the authors inspected the online survey every evening and sent a reminder to the participant(s) when appropriate. A thank-you note was sent to participants on the 7th day and they were encouraged to continue their commitment. Lastly, those who fully completed the 14-day survey were asked to fill out a final questionnaire (survey 3), measuring their health & hygiene activity and entertainment, among other aspects, over the past 14 days.

From 29 February to the end of March 2020, one hundred and thirty-four (134) volunteers participated in the online survey, fifty-eight per cent of whom (77 persons) completed all 14 diary entries. Six samples were excluded because the diary had been completed too early (before 2 pm). The final sample consisted of 71 participants with complete data of 994 entries (71 x 14).

Measures

Daily emotions

Depressed was adopted from the Affects Balance Scale (Derogates, 1975) used by Bolger et al. (1989). Positive emotions and negative emotions were adopted from the modified Rochester Interaction Record (from Tidwell et al., 1996). Participants

were asked to rate the extent to which they had felt or experienced each of these feelings in the past 24 hours. Each of the 22 items of emotions was rated on a 4-point scale from 0 (*not at all*) to 3 (*a lot*). Principal components analyses were conducted for the 22 items of emotions and the number of factors was determined by eigenvalues and the scree test. Nine items (rejected, hurt, worried, irritable, tense, guilty, tired, afraid, angry) did not significantly load on one or more of the components and were dropped from further analysis. A principal components analysis of these 13 items using Kaiser's criterion and direct oblimin rotation yielded a three-component solution that accounted for 76% of the total variance (see appendix 1). The three factors were named positive emotions (accepted, caring, relaxed, needed and happy), depressed emotions (discouraged, helpless, worthless and resentful), and negative emotions (bored, sad, lonely and frustrated) respectively. The Cronbach's alphas are 0.93, 0.91 and 0.82 for positive emotion, depressed emotion, negative emotion respectively, indicating good internal reliability and discriminant validity. Daily scores for each emotion category were obtained by averaging the rating of the relevant items.

Personal response to pandemic

It was difficult to find and use standardized measures to assess the personal response to pandemic and life activity under quarantine in this unprecedented COVID-19 pandemic, and we had to develop these measures that can best reflect people's

behaviors and life situation under quarantine in Chinese context. The principal components analysis data for each construct was provided in appendix 2.

***Worry about work and life*:** Following telephone/virtual interviews with several persons under quarantine, we developed 5-items scale that reflected quarantined people's worry on work, family and education. Participants were asked to indicate how much they worried about the following during the mass quarantine: 1) my employer; 2) my employer's business; 3) my work; 4) my family's health; 5) my own and/or family members' studies. They were rated on a 4-point scale from 0 (*not at all*) to 3 (*a lot*). A Cronbach's alpha of 0.87 was obtained.

***Knowledge of COVID-19*:** We measured the participants' knowledge of the COVID-19 epidemic by including three items which reflected essential facts about the epidemic. The self-developed items were: 1) COVID-19 can be transmitted from person to person; 2) Quarantine is a measure to prevent the spread of COVID-19; 3) COVID-19 is an epidemic. The participants were asked to indicate their agreement on the three statements on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A Cronbach's alpha of 0.88 was obtained.

Life activity under quarantine

Based on our personal quarantine experience and virtual interviews with people under quarantine for months in Wuhan city, we developed the items that tried to capture key life activities under quarantine. The life activities included four variables: family

stressor, social support, entertainment and health & hygiene activity. The first two variables were measured in the daily questionnaire (2nd survey) and the last two in the final questionnaire (3rd survey).

***Family stressor*:** We included four items reflecting family demands and pressure in the daily questionnaire and participants were asked to rate them on a 4-point scale from 0 (*not at all*) to 3 (*a lot*). The 4 items were: 1) overload of housework; 2) the need to care for family member; 3) demand to meet the needs of family and relatives; 4) conflict with family member. A Cronbach's alpha of 0.69 was obtained.

***Social support*:** We included three items in the daily questionnaire to measure social support, namely "Today, I received comfort from others (spoken or written)", "someone has listened to me patiently today", and "I received parcels from a relative/friend". The participants reported whether they had experienced the above supports within the previous 24 hours. This dichotomous variable was coded 0 for "none" and 1 for "yes". A Cronbach's alpha of 0.74 was obtained.

***Entertainment*:** The participants were asked to think about their engagement on entertainment activities during quarantine. They rated two items on a 4-point scale from 0 (not at all) to 3 (all most every day): 1) watching TV; 2) surfing internet for shopping or chatting online. A Cronbach's alpha of 0.80 was obtained for entertainment.

Health and hygiene activity: Similarly, participants were asked to rate retrospectively 3 health and hygiene activity items on a 4-point scale from 0 (not at all) to 3 (all most every day). By keeping in mind their behaviors during quarantine, they assessed the following activities: 1) sanitizing house; 2) physical exercise; 3) seeking counselling from healthcare professional. A Cronbach's alpha of 0.54 was obtained for health and hygiene activity."

Social Demographics

The participants' social-demographic data were collected in the background questionnaire (1st survey) before the daily diary survey. In addition to age, gender, marital status, number of children, education, we were particularly interested in the following: 1) the reason for quarantine, for which participants could choose from: state/city lockdown; quarantine after travel; other; 2) quarantine facility, with two choices: at home and other (e.g. government-designated facility); 3) quarantine region/city for which there were three possible responses: Wuhan, Hubei province; Hubei cities other than Wuhan; the Rest of Mainland China apart from Hubei); this information was necessary due to the different levels of epidemic severity and strictness of quarantine policy across the regions and country; 4) days of quarantine when participated in the study; participants were asked in the background survey "up to today, how many days have you been quarantined?". 5) participant's occupation profile for which there were five possible responses: student; teacher; enterprise employee; state or public organization employee; other. 6) clinician group for which

participants were asked “Are you a clinician?”, and the response options were “1 (yes)” and “0 (no)”.

Analyses

General Linear Model (GLM) was used to explore the sociodemographic characteristics and the main effect of the quarantine situation on emotional well-being and their interaction effect. Least significant difference (LSD) post hoc test was used for pairwise comparison. We employed hierarchical linear modeling (HLM) for our primary tests regarding emotional changes across the surveyed quarantine period, and the prediction of personal response (worry about work and life, and knowledge of COVID-19) and life activity (family stressor, social support, entertainment, health & hygiene activity). We performed standardized data imputation techniques (Newman, 2009) to account for missing values in the HLM analysis. We adopted the series mean imputation method, in which the missing value is replaced considering the variable and the mean of the available cases (Rantou et al., 2017). This allowed us to preserve the size and representativeness of the original sample (n =134). We used SPSS 20.0 software and HLM 6 software for GLM and HLM analysis, respectively.

Results

In the final sample (n=71), participants had an average age of 32 years (Table 1). Sixty-five per cent of participants were female, and fifty-nine per cent were married (35% single and the rest divorced or in another situation). Sixty per cent were raising children, and 17% had two or more children. Eighty per cent of participants had

higher education (college, bachelor or postgraduate). Sixty-two per cent were under city lockdown, 22.5% quarantined after travel and 15.5% for another reason. Eighty-nine per cent were at home while the rest were living at a state-designated facility or hotel. Twenty-five per cent of participants were in Wuhan city, the then hot spot, 23% elsewhere in the Hubei province, and 52% somewhere in China other than Hubei province. On starting the diary survey, the participants had been quarantined for an average of 29 days (mean = 28.9, S.D. = 17.2); however, for 20% of participants the diary survey began at the start of their quarantine. Twenty-one per cent of participants were students, 18% were state or public employees, 13% were teachers, 13% were business organization employees and 11% were clinicians.

Table 1 Sociodemographic characteristics (n=71)

Description	% or mean (*SD*)
Age, mean years (*SD*)	32(7.7)
Gender (Female)	64.8
Marital Status	
Married	59.2
Single	35.2
Other (e.g. divorce)	5.6
Children	
0	39.4
1	43.7
2+	16.9
Education	
High school or below	19.7
College or bachelor	50.7
Master and above	29.6
Reason for Quarantine	
City Lockdown	62
After travel	22.5
Other	15.5
Quarantine Facility	
At home	88.7
Other (e.g. state-designated facility)	11.3
Quarantine Region/City	
Wuhan Hubei Province	25.4
Hubei Province, apart from Wuhan	22.5
Mainland China apart from Hubei	52.1
Quarantined Days at start of survey	
0 or 1 (day)	19.7
3-16 (days)	8.5

20-56 (days)	71.8
Professional	
University student	21.1
Teacher	12.7
Enterprise employee	12.7
State or public employee	18.3
Other	35.2
Clinicians	11.3

Correlations are reported in Table 2. Depressed emotions and negative emotions correlated moderately with each other (r = .64, p < 0.01), and both correlated negatively with positive emotions (r = -.17, p < 0.01; r =-.27, p < .01). The correlations of emotion variables indicate reasonable levels of discriminant validity.

As personal responses to the pandemic, worry about work and life was positively related to depressed emotions (r = .11, p < 0.01) and negative emotions (r = .07, p < 0.05), but was not related to positive emotions. Knowledge of COVID-19 was positively related to positive emotions (r = .20, p < 0.01), but negatively related to depressed emotions (r = -.07, p < 0.05).

Among life activities under quarantine, family stressor was positively related to depressed emotions (r = .37, p < 0.01) and negative emotions (r = .35, p < 0.01), but not related to positive emotions. As expected, social support and positive emotions were positively correlated (r = .23, p < 0.01). Entertainment was positively but weakly related to depressed emotions (r = .15, p < 0.01) and negative emotions (r = .18, p < 0.01). Lastly, there was a positive and moderate association between health & hygiene and positive emotions (r = .30, p < 0.01), and a negative and weak correlation between health & hygiene and depressed emotions (r = -.07, p < 0.05) as well as negative emotions (r = -.14, p < 0.01).

Table 2 Correlations between key variables (n=71)

	Mean (S.D.)	1	2	3	4	5	6	7	8
1.Positive Emotions	0.99 (.75)								
2.Depressed Emotions	0.24 (.47)	-.17**							
3.Negative Emotions	0.42 (.54)	-.27**	.64**						
4.Worry about Work and Life	1.57 (0.89)	0.01	.11**	.07*					
5.Knowledge of COVID-19	4.40 (0.85)	.20**	-.07*	.04	.34**				
6.Family Stressor	0.44 (.47)	-.03	.37**	.35**	.23**	-.05			
7.Social Support	0.15 (.23)	.23**	.07*	-.05	.00	-.14**	-.32**		
8.Entertainment	1,71 (.85)	.01	.15**	.18**	.13**	-.15**	.33**	.13**	
9.Health & Hygiene	0,94 (.52)	.30**	-.07*	-.14**	.02	.13**	.00	.16**	.17**

* $p < .05$; ** $p < .01$

Quarantine Days and Emotion Change

We performed HLM analysis to examine whether time significantly explains the change in emotions (model 1). The emotional change was estimated by the following two-level equations. In level 1, the predictor was "day", ranging from day 1 to 14.

Level 1:

Positive emotions/Depressed emotions/Negative emotions = $\beta_0 + \beta_1 * Quarantined\ Days + r$

Level 2:

Positive emotions/Depressed emotions/Negative emotions:

$\beta_0 = \gamma_{00} + \gamma_{10} + r$

$\beta_1 = \gamma_{00} + \gamma_{10} + r$

Overall, an inverse relationship was observed between positive and negative emotions and quarantine time in the HLM analysis (Table 3). Specifically, positive and negative emotions decrease as quarantine days increase.

Table 3 Predicting Daily Emotions from Quarantine Days (n=134)

		Fixed Effect			Random Effect		
		coefficient	SE	T		V	χ^2
Positive	γ_{00}	1.216	0.061	19.999***	μ_0	0.67721	4221.30869 ***
Emotions	γ_{10}	-0.022	0.004	-4.921**	μ_1	0.18497	--
Depressed	γ_{00}	0.288	0.038	7.521***	μ_0	0.17225	2736.79646***
Emotions	γ_{10}	-0.001	0.002	-0.895	--	--	--
Negative	γ_{00}	0.553	0.043	12.652***	μ_0	0.47788	3160.71873***
Emotions	γ_{10}	-0.011	0.002	-5.110**	μ_1	0.00075	226.19281 ***

* p< .05; ** p< .01; *** p< .001.

To illustrate the evolution of change in emotions, timeline visualization of the trend was made (Figure 1). The variable on the Y-axis is the mean emotion of all individuals on each day, and the variable on the X-axis is the surveyed days under quarantine.

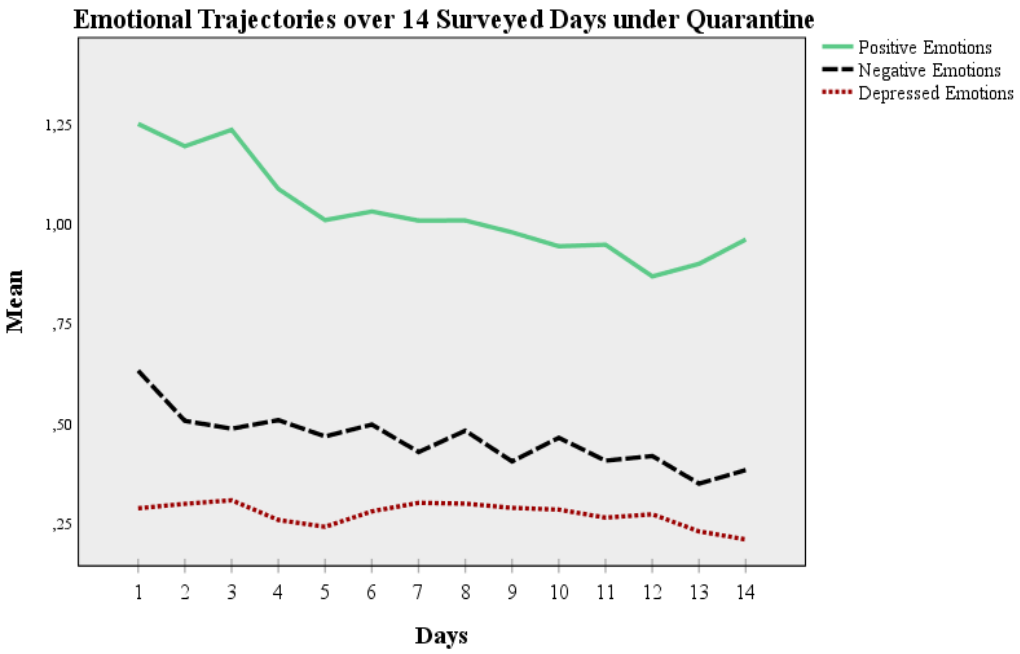

Fig. 1. Positive Emotions, Depressed Emotions and Negative Emotions over 14 Surveyed Days (n = 134)

Evolution of positive emotions over time

Over the 14 days, 85.3% of participants reported positive emotions to varying degrees. As illustrated in Figure 1, positive emotions decreased over time during quarantine (B = -0.022, t = -4.921, $p < 0.01$). A significant drop was observed from the surveyed day 3 to day 4 ($p < 0.001$), but thereafter the decline was gradual.

Evolution of depressed emotions over time

Over the 14 days, 32.7% of participants reported depressed emotions to varying degrees. Overall, there was a trend of decreasing depressed emotions over the 14-day period, but it was not significant (B = -0.001, t = -0.895, $p > 0.05$). It can be observed (Figure 1) that the mean level of depressed emotions remained relatively stable until the end of the period, reaching its lowest point on the 14th surveyed day.

Evolution of negative emotions over time

Over the 14 days, 60.2% of participants reported negative emotions to varying degrees. Similar to positive and depressed emotions, negative emotions decreased over the 14 surveyed days (B = -0.011, t = -5.110, $p < 0.01$). Although it can be seen (Figure 1) that negative emotions are more inconstant, they tend to decrease over the 14 days, and the mean level reported on the first surveyed day was higher than all other days.

Predicting emotions in quarantine from personal response and life activity

We examined how family stressor and social support predict daily emotions by conducting HLM analyses in which the daily reported family stressors and social

support were used to predict the extent to which the participants felt positive emotions, depressed emotions and negative emotions (model 2). The daily emotions were estimated by the following equations:

Level 1:

Positive emotions/Depressed emotions/Negative emotions = β_0 + β_1 Quarantined Days + β_2 Family Stressor or Social Support + β_3 (Quarantined Days) * (Family Stressor or Social Support) + r

Level 2:

$\boldsymbol{\beta_0 = \gamma_{00} + \gamma_{10} + \gamma_{20} + r}$

$\boldsymbol{\beta_1 = \gamma_{00} + \gamma_{10} + \gamma_{20} + r}$

$\boldsymbol{\beta_2 = \gamma_{00} + \gamma_{10} + \gamma_{20} + r}$

$\boldsymbol{B_3 = \gamma_{00} + \gamma_{10} + \gamma_{20} + r}$

The results (Table 4) suggest that in addition to the prediction by the level of positive emotions at baseline (B = 0.93, t = 11.05, $p < 0.001$) and quarantine days (B = -0.02, t = -8.188, $p < 0.001$), social support is a valid predictor for positive emotions (B = 0.89, t = 4.579, $p < 0.01$), but family stressor is not. In relation to depressed emotions, the levels of depressed emotions at baseline (B = 0.10, t = 1.98, $p < 0.01$; B = 0.29, t = 5.16, $p < 0.001$) and family stressor (B = 0.42, t = 5.52, $p < 0.001$) were significantly related to depressed emotion, but not social support. The level of negative emotions at baseline (B = 0.40, t = 6.74, $p < 0.001$; B = 0.58, t = 9.06, $p < 0.001$) and quarantine days (B = -0.01, t = -5.09, $p < 0.01$; B = -0.01, t = -5.12, $p < 0.01$) were both consistently associated to negative emotions. In contrast

with the prediction of positive emotions, family stressor (B = 0.33, t = 3.67, $p <$ 0.001) was significantly related to negative emotions, but not to social support. The above results suggest the significant detrimental effect of family stress on people's well-being under quarantine.

Table 4 Predicting Daily Emotions from Family Stressor and Social Support (n=134)

		Family Stressor		Social Support	
		B	T	B	T
Positive Emotions	γ_{00}	1.18	13.61***	0.93	11.05***
	γ_{10}	-0.02	-8.21***	-0.02	-8.19***
	γ_{20}	0.07	-0.59	0.89	4.58***
Depressed Emotions	γ_{00}	0.10	1.98*	0.29	5.16***
	γ_{10}	-0.00	-0.85	-0.00	-0.90
	γ_{20}	0.42	5.52 ***	-0.01	-0.06
Negative Emotions	γ_{00}	0.40	6.74 ***	0.58	9.06***
	γ_{10}	-0.01	-5.09***	-0.01	-5.12***
	γ_{20}	0.33	3.67***	-0.10	0.52

* $p < .05$; ** $p < .01$; *** $p < .001$.

To examine the prediction of entertainment and health & hygiene, worrying about work and life, and knowledge of COVID-19, we added the predictors in the first level equation in model 1 to obtain model 3 as follows:

Level 1:

Positive emotions/Depressed emotions/Negative emotions = $\beta_0 + \beta_1 * Quarantined\ Days + \beta_2 * variable + r$

Level 2:

Positive emotions/Depressed emotions/Negative emotions:

$\beta_0 = \gamma_{00} + \gamma_{01} + \gamma_{10} + \gamma_{11} + r$

$\beta_1 = \gamma_{00} + \gamma_{01} + \gamma_{10} + \gamma_{11} + r$

$\beta_2 = \gamma_{00} + \gamma_{01} + \gamma_{10} + \gamma_{11} + r$

The variable includes entertainment, health & hygiene activity, worrying about work and life, and knowledge of COVID-19.

Table 5 reports results of the analyses. After controlling for entertainment, the development of positive emotions was negatively related to quarantined days (B = -0.03, t = -4.60, $p < 0.001$). After controlling for health & hygiene activity, the development of positive emotions was negatively associated with quarantined days (B = -0.02, t = -3.17, $p < 0.001$). Moreover, health & hygiene was positively related to positive emotions at baseline (B= 0.39, t= 2.59, $p < 0.01$).

For personal response, after controlling for worrying about work and life, the impact of quarantined days on positive and depressed emotions is significant (respectively, B= -0.01, t= -2.10, $p < 0.05$; B= 0.01, t= 2.37, $p < 0.05$). Moreover, worrying about work and life was positively associated to both depressed and negative emotions at baseline (respectively, B= 0.13, t= 2.98, $p < 0.01$; B= 0.11, t= 2.19, $p < 0.05$), but was negatively associated to the development of both depressed emotions over time (B= -0.01, t = -3.30, $p < 0.001$) and negative emotions over time (B= -0.01, t = -2.82, $p < 0.05$). Knowledge of COVID-19 was not significantly related to positive, depressed and negative emotions, neither at baseline, when controlled in the model nor over time.

Table 5 Predicting Daily Emotions from life activity and personal response (n=134)

		Entertainment		Health & Hygiene		Worrying about Work/Life		Knowledge of COVID-19	
		B	T	B	T	B	T	B	T
Positive Emotions	γ_{00}	1.07	7.70***	0.83	5.25***	1.20	10.08***	0.45	1.05
	γ_{01}	0.08	1.18	0.39	2.59**	0.01	0.14	0.17	1.78
	γ_{10}	-0.03	-4.60***	-0.02	-3.17***	-0.01	-2.10*	-0.01	-0.82
	γ_{11}	0.01	1.16	-0.00	-0.49	-0.01	-2.43	-0.00	-0.53
Depressed Emotions	γ_{00}	0.29	3.25***	0.35	3.43***	0.10	1.29	0.35	1.27
	γ_{01}	-0.00	-0.01	-0.06	-0.65	0.13	2.98**	-0.01	-0.22
	γ_{10}	0.00	0.10	-0.00	-0.60	0.01	2.37*	0.01	0.93
	γ_{11}	-0.00	-0.54	0.00	0.24	-0.01	-3.30***	-0.00	-1.09
Negative Emotions	γ_{00}	0.51	5.08***	0.65	5.61***	0.39	4.59***	0.34	1.08
	γ_{01}	0.02	0.45	-0.10	-0.91	0.11	2.19*	0.05	0.69
	γ_{10}	-0.01	-2.00	-0.01	-1.44	-0.00	-0.19	0.00	0.31
	γ_{11}	-0.00	-0.23	-0.00	0.88	-0.01	-2.82*	-0.00	-1.17

* $p < .05$; ** $p < .01$; *** $p < .001$.

Variance Analysis of Emotions and Emotion Change

We conducted GLM (General Linear Model) analysis to exam the difference in emotions over quarantine days in relation to the sociodemographic characteristics (age, gender, marital status, number of children, education, occupation, clinicians) and the context of quarantine (reason for quarantine, quarantine facility, quarantine region). No significant differences were observed in terms of age, gender, occupation, reason for quarantine, quarantine facility and quarantine region. For the sake of simplicity, only the variables with a significant outcome are reported in Table 6.

Table 6 Variance Analysis of Emotions and Emotion Change (n=71)

	Marital Status	Children	Education	Clinicians
Positive Emotions	F=3.28*	F=4.02*	F=3.62*	n.s.
Days	n.s.	n.s.	F=2.64**	n.s
PE x Days	n.s.	n.s.	n.s.	n.s
Depressed Emotions	n.s.	n.s.	n.s.	n.s.
Days	n.s.	n.s.	n.s.	n.s.
DE x Days	F=1.80*	F=1.67*	n.s.	n.s.
Negative Emotions	n.s.	n.s.	n.s.	F=7.23**
Days	F=3.10*	F=3.25*	F=3.16*	F=3.25*
NE x Days	n.s.	n.s.	n.s.	$F=1.87^{+}$

Note: $^{+}p < 0.1$; *$p < 0.05$; ** $p < 0.01$. PE=Positive Emotions; DE=Depressed Emotions; NE=Negative Emotions.

First, the married group reported a lower level of positive emotions than the other two groups (F= 3.28, $p < 0.05$) (Fig. 2). Although no significant difference was found in depressed emotions among the married group, singles and others, there was an interaction between marital status and quarantine days (F= 1.80, $p < 0.05$). In other words, the three different groups of participants experienced different levels and patterns of depressed emotions over time as illustrated in Fig. 2. For example, the married group reported the highest level of depressed emotions on surveyed day 3, followed by a significant drop to the lowest on surveyed day 4 ($p < 0.05$), and then rebounding to a similar level to that of the first two surveyed days with a slow upward trend. However, the pattern for the other groups demonstrated greater fluctuations.

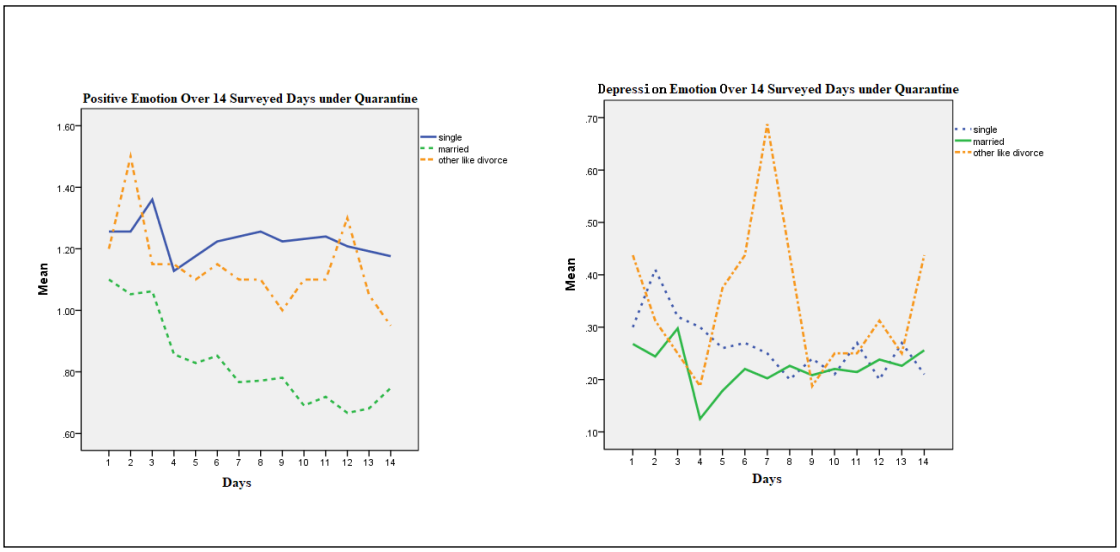

Fig. 2. Positive and Depression Emotions over 14 Surveyed Days under Quarantine

The group of participants with children (regardless of the number) reported a lower level of positive emotions than those without children (F=4.02, $p < 0.05$) (see Fig. 3). Moreover, the number of children x quarantine days interaction on depressed emotions was significant (F = 1.67, $p < 0.05$). The group with two or more children

documented a steady rise in depressed emotions after day 4, and particularly on surveyed day 14; the depressed emotions felt by this group were significantly higher than in the no-child ($p < 0.05$) and one-child group ($p < 0.05$).

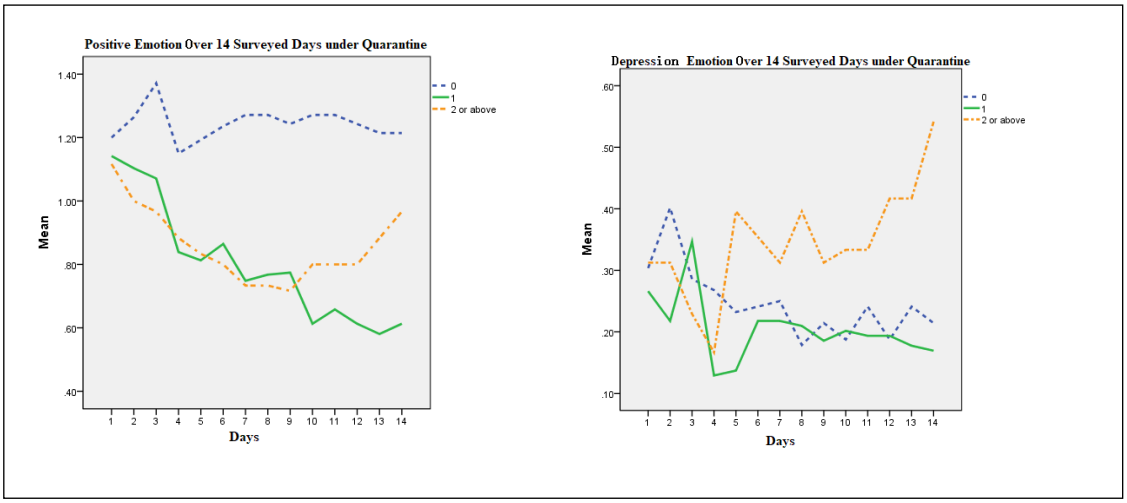

Fig. 3. Positive and Depression Emotions over 14 Surveyed Days under Quarantine

Significant differences were found in the positive emotions experienced in quarantine between participants with different levels of education (Fig. 4). Specifically, those with higher education (college, bachelor and postgraduate) reported a higher level of positive emotions than those with high school education or below ($F = 3.62$, $p < 0.05$).

We also did a comparative analysis of the emotions experienced by clinicians and non-clinicians. As expected, clinicians reported a significantly higher level of negative emotions than the non-clinician group ($F = 7.23$, $p < 0.05$). Moreover, clinician x quarantine days interaction on negative emotions was marginally significant ($F= 1.87$, $p = 0.055$). No significant differences were found between clinicians and non-clinicians in positive emotions and depressed emotions.

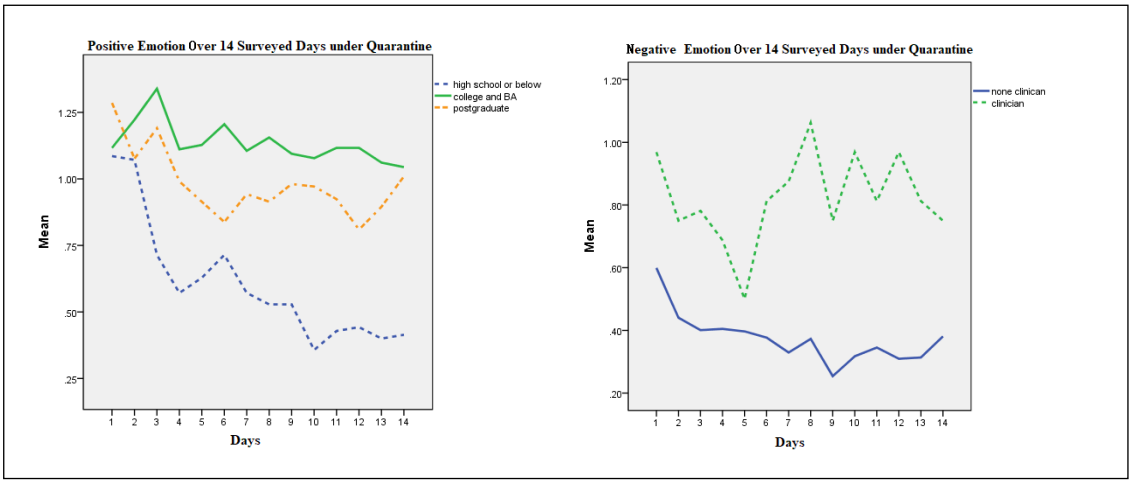

Fig. 4. Positive and Negative Emotions over 14 Surveyed Days under Quarantine

Discussion

Key findings

This diary study of individuals who lived in a quarantine situation documented the presence and intensity of positive, negative and depressed emotions experienced in this period and, more importantly, reported the trajectory of emotions over the surveyed period. Overall, the study documented participants' emotional well-being, its development and its associations with personal response and life activity under the COVID-19 pandemic quarantine in China.

The participants had already been in quarantine for an average of 29 days at the start of the survey, and they reported three distinct emotions: positive, negative and depressed. Most participants (85.3%) reported positive emotions (mean = 1.05, S.D. = .81); fewer reported negative and depressed emotions (60.2%, 32.7% respectively) and the magnitude of these emotions was lower (mean = .47, S.D. = .59; mean = .28, S.D. = .52, respectively). In addition, positive and negative emotions significantly

declined over the surveyed period. The findings of the study show that emotional well-being of the sample population with an average of one-month quarantine was challenging, but better than generally thought, given that positive emotions had a stronger presence and intensity, while negative and depressed emotions had a weaker presence and intensity and also due to the downward trend in negative and depressed emotions. Other studies provide mixed findings on this regard. For example, the study by Wang et al. (2020) reported that 53.8% of the respondents surveyed in the first two weeks of the outbreak (from 31 January to 2 February 2020 in China) rated the psychological impact of the outbreak as moderate or severe. On the other hand, Zhang et al. (2020) surveyed Chinese adults on 20-21 February 2020 and documented a low score of distress (mean = 1.41, S.D. = 0.46) measured by the Kessler psychological distress scale (K6). Another study conducted in China from 19-26 February 2020 (Hu et al., 2020) reported a mild psychological impact of the quarantine during the COVID-19 outbreak, and the authors claimed that longer durations of quarantine did not increase the anxiety level. Studies outside China tend to converge on a low level of stress (Ozamiz-Etxebarria et al., 2020; Shevlin et al., 2020). For example, the study by Shevlin et al. (2020) reported a COVID-19 depression rate of 22.12% and anxiety rate of 21.63% with data collected between 23 and 28 March 2020 from the UK population. The mixed results may be explained by the timing (stage of the outbreak) of data collection and assessment tools. But overall, the results suggest people have strong resilience and adaptivity (Shevlin et al., 2020; Veer et al., 2020) in the months-

long mass quarantine. We now discuss further evidence related to changes in emotions.

It is interesting to note that both positive and negative decrease as quarantine days increase. In literature, there is a debate on the issue of whether positive and negative affects (emotions) operate inversely from each other (the unidimensional, bipolar view) or whether they are independent (the bivariate view) or both bivariate and bipolar modes are valid under specific conditions, the integrative view (the Dynamic Model of Affect, DMA) (e.g. Reich, Zautra & Davis, 2003). Taking the correlation and HLM analysis into consideration, the findings of present study appear to support the DMA approach. Specifically, the present study reported a weak and inverse correlation between positive and negative emotions ($r = -.27$, $p < .01$). This result is in line with the argument by Zautra et al (2000, p.944) that the size of inverse correlation between positive and negative affects became negative during a stressful period (but there was no significant correlation when there was low or no stress), supporting the bipolar view. However, HLM analysis revealed that both positive and negative emotions decrease as quarantine days increase, suggesting evidence for the bivariate view.

Our interpretation for such "conflicting" finding is that during the quarantine period, people can experience both positive emotions and negative emotions at the same time as researchers (Larsen, McGraw & Cacioppo, 2001) argue that happiness and sadness may co-occur in emotionally complex situations (quarantine under pandemic in this case). Indeed, in our study, there were 85.3% and 60.2% of

participants reported positive emotions and negative emotions respectively to varying degrees, suggesting a significant proportion of people experienced both positive and negative emotions under quarantine. However, during the quarantine period, there were occasions when the participants might feel stressed and, in such occasions, positive emotions and negative emotions were inversely related (Reich, Zautra & Davis, 2003; Zautra et al 2000). In short, the conflicting findings appear to show evidence for both bipolar view and bivariate view, thus supporting the integrative approach.

Differences were observed in the level of positive, depressed and negative emotions and/or patterns of change among different population categories. The married respondents reported a lower level of positive emotions and an upward trend in the depressed emotions felt after surveyed day 4. Overall, the married respondents reported lower emotional well-being under quarantine. This result was supported by findings from other studies. For example, Leonhard et al. (2020) stated that interactions with one's spouse were associated with a lower positive affect and a higher negative affect. It should also be noted that the emotional variability showed by the divorced group was greater (larger emotional deviations from average emotional level) for positive, negative and depressed emotions across time. Given the significant negative association between variability and psychological well-being (Houben et al., 2015), this suggests that the divorced group (and possibly also single parents) may be among the “vulnerable groups” in need of greater attention and support in the pandemic (Stephenson et al., 2014).

Consistent with the finding of the married group, respondents with children demonstrated lower emotional well-being than those without children. Our study revealed that respondents with children (regardless of number) experienced a significantly lower level of positive emotions than respondents without children, and respondents with two or more children reported a steady increase in depressed emotions after surveyed day 4. Similarly, other studies (Leonhard et al., 2020; Shevlin et al., 2020) have showed that having children at home and home-schooling children was associated with psychological distress or a negative effect. Moreover, parents face challenges to care children need for socialization and physical activity under quarantine circumstance (Idoiaga Mondragon et al. 2020).

Our findings show that those with lower education (high school or below) reported a lower level of positive emotions than those with higher education. Similarly, the study by Wang et al. (2020) found that the population with no formal education was more likely to be depressed during the epidemic. These findings present evidence of the less educated population being at a disadvantage in the pandemic context. While the positive association between education and health is well established in the literature (Ross & Wu, 1995), the association between education and emotional well-being is less clear, suggesting the potential for future study.

Clinician participants reported a significantly higher level of negative emotions than non-clinicians. Moreover, there was a marginal interaction between clinicians x quarantine days on negative emotions ($F= 1.865$, $p = 0.055$). The clinicians reported

greater variability and instability of negative emotions than non-clinician participants. All these results suggest that the psychological effects felt by clinicians are more severe than among the general population. The significant number of infected patients has put clinicians fighting the unknown virus without effective treatments under great strain. The high risk-to-self due to exposure to patients, the shortage of personal protective equipment (PPE) and the increased risk of infection for family members are also major stressors (Galbraith et al., 2020). The low emotional well-being is alarming considering the important role played by clinicians in the pandemic. They need resources and support to ensure they are able to do their job well.

Consistent with the association between married status, having children and the low level of emotional well-being, family stressor was a significant predictor for both depressed and negative emotions. All these findings highlight the vulnerability of families with children in a quarantine situation. It is fair to say that most parents under the month-long quarantine were physically and emotionally exhausted from managing the time of work-from-home, childcare and homeschooling and housework. As expected, social support was significantly and positively related to positive emotion, suggesting that the more social support available to the participants under quarantine, the more positive emotions they felt. This finding is in line with the argument that social interaction helps improve people's ability to cope with stress (Johnson & Acabchuk, 2018).

Worrying about work and life was positively related to both depressed and negative emotions at baseline but it was also negatively related to the development of both depressed and negative emotions over time; this suggests that the depressed and negative emotions of people who worried more about work and life attenuate over time, even though their level of depressed emotion at baseline may have been higher. In other words, a higher level of worrying about work and life at baseline is associated with an attenuation of depressed and negative emotions over time in this study. These results were both surprising and intriguing. They could be explained by the avoidance theory of worry (Borkovec et al., 2004) with the notion that worry functions to anticipate and avoid the occurrence of a future catastrophe. Llera and Newman (2010) found that prior worry led to reduced negative affects in response to a sad clip. This finding is in line with the argument that a greater perceived susceptibility and a higher level of general anxiety are associated with a greater likelihood of taking avoidant behaviour during a pandemic (Bish & Michie, 2010).

Moreover, health & hygiene activity was positively related to positive emotions at baseline. The results suggest more frequent engagement in health care and hygiene activities are associated with higher levels of positive emotions. Other studies (e.g. Wang et al., 2020) also revealed hygiene and precautionary measures were associated with a lower level of depression and stress. The study by Wang et al (2020) also found that health information was associated with a lower psychological impact of the outbreak and a lower level of depression.

Knowledge of COVID-19 was not significantly related to positive, depressed and negative emotions. In our view, this evidence stems from the fact that there is still much to learn about this novel virus. Given that people's adherence with quarantine improves if they are knowledgeable about infectious diseases and the quarantine protocol (Webster et al., 2020), future studies could explore whether the current knowledge of COVID-19 has now any influence on emotional well-being.

This study is unique in that we assess a diverse group of quarantined adults with daily records of their emotions, whereas past research with diary studies had mainly used homogeneous groups of subjects (e.g. students). Moreover, unlike many emotional studies that use data from the lab, our data on emotions were collected in the quarantine context. Lastly, while most studies on the psychological impact of the COVID-19 pandemic are cross-sectional (a static perspective), our experience sampling (diary method) helps capture how emotions change across time in the pandemic.

Limitations

This study has the following limitations. First, we used convenience sampling to recruit our volunteer participants which could limit the generalization of our results to the entire population. Also, the focus on the Chinese sample also limits extrapolation to other contexts due to different quarantine policies and cultural factors. For example, Yan et al (2020) argue that under a tight culture context, Chinese citizens demonstrated high levels of obedience for the government’s quarantine policies.

Second, no standardized scales were available at the time of our study to measure personal response and life activity in quarantine, we thus had to develop items specifically for this study, which might not have validly captured these constructs. Moreover, we may not have captured all of the emotions that are relevant to people under quarantine as there was limited literature on this regard, and the rapid development of containment rules and the outbreak meant we had to design and collect our data in a short timeframe. Third, it is important to note that not all participants started the survey on day 1 of their quarantine. The variation in the days since quarantine initiation began is a limitation and should be noted in interpreting the findings. Furthermore, probing participants about their daily emotions may have reminded them constantly to address their emotions in the stressful quarantine days and therefore may have helped them manage their emotions better, distorting and changing them in the quarantine context. In addition, there may have been a self-selection effect with persons who have a high level of goodwill towards science and commitment to the 2-week survey. Lastly, as most people in China, including the authors, were quarantined when we were conducting this research, we had to opt for an online methodology of data collection. However, researchers argue there is no significant difference between data collection using electronic devices and paper diaries (see Houben et al., 2015).

Implications

Our findings have practical implications for public health policymakers and the general population facing lockdown or quarantine. First of all, although different demographic groups might have distinct levels of emotional well-being, overall our study suggests that longer durations of quarantine do not necessarily increase levels of depression; in other words, people have demonstrated great resilience and adaptivity in the pandemic (Shevlin et al., 2020; Veer et al., 2020). The findings challenge the rationale for policymakers to withdraw the necessary quarantine or stay-at-home orders for the sake of the psychological impact of mass quarantine. Second, although the quarantine period does not present a significant threat to the emotional well-being of the general population, both policymakers and the general population need to identify and recognize stressors and "vulnerable groups". The results of this study seem to imply that the focus should be on the family because family stressors are a major source of negative emotions. Our study reveals that married person with children, clinicians, and divorcees are the "vulnerable groups" that need attention and support. In addition to governmental aid, neighborhoods, charity organizations and professional associations should focus on providing help for the vulnerable and disadvantaged group (in our study, the less educated population). Individuals under mass quarantine benefit from seeking social support by contacting people for interpersonal connection and emotional support. Moreover, our findings of co-occurrence positive and negative emotions may suggest that it is beneficial to emotional wellbeing by encompassing both high level of positive emotions and low

level of negative emotion rather than trying to eliminate negative emotions to achieve positive ones. Third, the government should intensify efforts to promote knowledge of disease and encourage individuals to engage in health & hygiene activities. The use of face masks in the COVID-19 pandemic is an interesting example. Although most Western countries did not encourage their use at the beginning of the pandemic, many governments have now made it compulsory to wear a mask in public and people realize this is about self-protection and respect for others. Lastly, giving the public a sense of worry may help reduce the depressed and negative emotions during the quarantine period in the pandemic. In other words, it is not necessary or wise to hide the “bad” news.

Declaration of Competing Interest

None.

Appendix 1

Factor analysis of positive. negative. and depressed emotions

	1	2	3
1 Positive Emotions			
accepted	.92[a] (.91)[b]		
caring	.88(.89)		
relaxed	.88(.88)		
needed	.88(.85)		
happy	.86(.88)		
2 Depressed Emotions			
discouraged		.88(.88)	
helpless		.83(.86)	
worthless		.84(.86)	
resentful		.85(.83)	
3 Negative Emotions			
bored			.84(.83)
sad			.66(.68)
lonely			.69(.67)
frustrated			.62(.63)
Cronbach's alpha	.94[a](.93)[b]	.91 (.91)	.83 (.82)
Total variance explained		76.88%[a](76.25%)[b]	

Note: a: n=134. b: n=71

Appendix 2

Variable Scales: Items, Component, Alpha Reliabilities and Total Variance Explained

	Component	Conbach´s Alpha	Total variance explained %
Worry about work and life			
I worry about my employer	.89[a](.89)[b]		
my employer's business	.88(.88)		
I worry about my work	.81(.85)	.86[a](.87)[b]	65%[a](66%)[b]
I worry about my family's health	.79(.77)		
I worry about my own and/or family member´s schooling	.64(.64)		
Knowledge of COVID-19			
COVID-19 is an epidemic	.78(.84)		
COVID-19 can be transmitted from person to person	.95(.95)	.85(.88)	80%(83%)
Quarantine is a measure to prevent the spread of COVID-19	.94(.94)		
Family stressor			
overload of housework	.79(.76)		
the need to care for family member	.76(.70)		
demand to meet the needs of family and relatives	.81(.77)	.75(.69)	58%(53%)
conflict with family member	.68(.67)		
Social support			
I received comfort from others (spoken or written)	.88(.87)		
someone has listened to me patiently today	.87(.87)	.71(.74)	64%(66%)
I received parcels from a relative/friend	.61(.68)		
Entertainment			
watching TV	.89(.92)		
surfing internet for shopping or chatting online	.89(.92)	.72(.80)	78%(84%)
Health & Hygiene			
sanitizing house	.82(.76)		
seeking counselling from healthcare professional	.67(.70)	.57(.54)	54%(55%)
doing physical exercise	.71(.76)		

Note: a: n=134. b: n=71

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