



## Original Research

## Mental distress and its associations with behavioral outcomes during the COVID-19 pandemic: a national survey of Chinese adults



L. Ma<sup>a</sup>, L.W. Gao<sup>a</sup>, J.T-f. Lau<sup>b</sup>, A. Rahman<sup>c</sup>, B.T. Johnson<sup>d</sup>, A.F. Yan<sup>e</sup>, Z.M. Shi<sup>f</sup>, Y.X. Ding<sup>a</sup>, P. Nie<sup>g,a</sup>, J.G. Zheng<sup>a</sup>, Y.F. Wang<sup>a,h</sup>, W.D. Wang<sup>i,\*\*</sup>, Q.L. Xue<sup>j,\*</sup>

<sup>a</sup> Global Health Institute, School of Public Health, Xi'an Jiaotong University Health Science Center, Xi'an, Shaanxi, China

<sup>b</sup> Jockey Club School of Public Health and Primary Care, Chinese University of Hong Kong, Hong Kong, China

<sup>c</sup> Department of Primary Care and Mental Health, Institute of Population Health, University of Liverpool, Liverpool, United Kingdom

<sup>d</sup> Department of Psychological Sciences, Institute for Collaboration on Health, Intervention, and Policy, University of Connecticut, Storrs, USA

<sup>e</sup> Division of General Internal Medicine, Department of Medicine, Center of Advancing Population Science, Medical College of Wisconsin, Milwaukee, WI, USA

<sup>f</sup> Human Nutrition Department, College of Health Sciences, QU Health, Qatar University, Doha, Qatar

<sup>g</sup> School of Economics and Finance, Xi'an Jiaotong University, Xi'an, Shaanxi, China

<sup>h</sup> Fisher Institute of Health and Well-Being, Department of Nutrition and Health Science, College of Health, Ball State University, Muncie, IN, USA

<sup>i</sup> Department of Sociology, School of Sociology and Population Studies, Renmin University of China, Beijing, China

<sup>j</sup> Department of Medicine, Division of Geriatric Medicine and Gerontology, School of Medicine and the Center on Aging and Health, The Johns Hopkins University, Baltimore, MD, USA

## ARTICLE INFO

## Article history:

Received 10 January 2021

Received in revised form

16 June 2021

Accepted 26 July 2021

Available online 8 September 2021

## Keywords:

COVID-19

Mental distress

Sociodemographic and disease factors

Change in behavioral outcomes

Adults

China

## ABSTRACT

**Objectives:** This study aimed to evaluate associations between mental distress and COVID-19-related changes in behavioral outcomes and potential modifiers (age, gender, educational attainment) of such associations.

**Study design:** This was a cross-sectional study.

**Methods:** An online survey using anonymous network sampling was conducted in China from April to May 2020 using a 74-item questionnaire. A national sample of 10,545 adults in 31 provinces provided data on sociodemographic characteristics, COVID-19-related mental distress, and changes in behavioral outcomes. Structural equation models were used for data analyses.

**Results:** After adjusting for covariates, greater mental distress was associated with increased smoking (odds ratio [OR] = 1.42, 95% confidence interval [CI]: 1.20–1.68 and OR = 1.54, 95% CI: 1.31–1.82 per one standard deviation [SD] increase in mental distress) and alcohol consumption (OR = 1.67, 95% CI: 1.45–1.92 and OR = 1.47, 95% CI: 1.24–1.75 per one SD increase in mental distress) among current smokers and drinkers and with both increased and decreased physical activity (ORs ranged from 1.32 to 1.56). Underweight adults were more likely to lose body weight ( $\geq 1$  kg; OR = 1.63, 95% CI: 1.30–2.04), whereas overweight adults were more likely to gain weight (OR = 1.61, 95% CI: 1.46–1.78) by the same amount. Association between mental distress and change in physical activity was stronger in adults aged  $\geq 40$  years (ORs ranged from 1.43 to 2.05) and those with high education (ORs ranged from 1.43 to 1.77). Mental distress was associated with increased smoking in males (OR = 1.60, 95% CI: 1.37–1.87) but not females (OR = 1.11, 95% CI: 0.82–1.51).

**Conclusions:** Greater mental distress was associated with some positive and negative changes in behavioral outcomes during the pandemic. These findings inform the design of tailored public health interventions aimed to mitigate long-term negative consequences of mental distress on outcomes.

© 2021 The Royal Society for Public Health. Published by Elsevier Ltd. All rights reserved.

\* Corresponding author. Department of Medicine, Division of Geriatric Medicine and Gerontology, School of Medicine and the Center on Aging and Health, The Johns Hopkins University, 2024 E. Monument Street, Suite 2-700, Baltimore, MD, 21205, USA. Tel.: +410 502 7808, Fax: +410 614 9625.

\*\* Corresponding author. Department of Sociology, School of Sociology and Population Studies, Renmin University of China, Beijing, 100000, China. Tel.: +010 62510695. E-mail addresses: [wwd@ruc.edu.cn](mailto:wwd@ruc.edu.cn) (W.D. Wang), [qxue1@jhu.edu](mailto:qxue1@jhu.edu) (Q.L. Xue).

## Introduction

Globally, the COVID-19 pandemic has led to elevated levels of mental distress attributed to prolonged lockdowns and social isolation.<sup>1,2</sup> It is assumed that relaxing lockdown restrictions might reduce mental distress in China, as the economy and social connections begin to normalize<sup>1</sup> even while the global impact of the pandemic continues to escalate. It is important to investigate the correlates of mental distress at various time points during the COVID-19 pandemic. Studies from China during the initial COVID-19 outbreak showed that sociodemographic factors (e.g. marital status and female gender)<sup>3,4</sup> and pre-existing chronic diseases<sup>1</sup> were associated with increased mental distress in adults, whereas associations with age were found to be mixed.<sup>5,6</sup> Socio-economic adversity (e.g. increasing unemployment and financial insecurity) was associated with increased mental distress in adults.<sup>7</sup>

Associations of mental distress with behavioral outcomes and body weight during the pandemic is less explored. Psychological theories have suggested that mental distress can result in adaptive coping that includes health promotion behaviors and/or maladaptive coping that involves health-compromising behaviors.<sup>8</sup> There is ample empirical evidence existed before the COVID-19 pandemic. For example, systematic reviews showed that experiencing anxiety and depression was associated with weight gain.<sup>9,10</sup> Mental distress also changed lifestyles such as smoking and less physical activity (PA) in adults.<sup>11</sup> Limited such studies however have been conducted during the COVID-19 pandemic.<sup>12</sup> It is conceivable that lockdown and social distancing measures for controlling COVID-19 spread necessarily entail modifying people's behavioral patterns.<sup>13</sup> Therefore, it is contended that mental distress may be associated with body weight and behavioral outcomes during the COVID-19 pandemic.

To fill these knowledge gaps at this important time during the COVID-19 pandemic, this national cross-sectional study aims to examine the correlates of mental distress and its impacts on change in behavioral outcomes (PA, smoking, and alcohol consumption) and body weight and whether such impacts were modified by age, gender, and education attainment among Chinese adults as shown in our conceptual framework in Fig. 1.

## Methods

### Study design and participants

The China COVID-19 survey was an anonymous online study administered from April 25 to May 11, 2020, via WeChat, China's leading social networking with more than one billion users. We used both snowball and convenience sampling to recruit a diverse national sample across China. Data were obtained from 10,545 adults aged 18–80 years in all 31 province-level administrative units in mainland China. The Institutional Review Board at Xi'an Jiaotong University Health Science Center approved study procedures, and participants provided consent online. An incentive of 1–10 RMB was provided after completing the survey.

### Study variables and measurements

#### Mental distress

Mental distress was assessed with a 5-item scale to assess the respondent's mental distress experienced during the COVID-19 pandemic. As we wanted to evaluate symptoms related to COVID-19 stress, we adapted items from the widely used and validated Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition—based civilian version of the posttraumatic stress disorder checklist (PCL-C).<sup>14</sup> The scale asks about symptoms in relation to

“stressful experiences” and can be used with any population. It measures the intensity of symptoms encountered in the past month: (1) *anhedonia*, loss of interest in activities you liked in the past; (2) *sleep problems*, difficulty falling asleep, or staying asleep, or waking up frequently or early; (3) *anger*, got easily irritable or angry; (4) *difficulty concentrating*, and (5) *repeated disturbing dreams related to COVID-19*. Response options for each question include a 5-point scale from “not at all” to “extremely.” We chose these items based on our pilot study in more than 400 adults in China, which showed that these mental distress symptoms were most frequently reported in adults during the pandemic.

#### Changes in behavioral outcomes

Changes in PA, smoking, and alcohol consumption were measured by self-reported individual items extracted from the Kadoorie Study of Chronic Disease in China<sup>15</sup> and from the China Chronic Disease and Risk Factor Survey<sup>16</sup> developed by the China Center for Disease Control Chronic Disease Control Center. The items include (1) *changes in PA* measured by “Has your usual weekly PA changed compare to that before the COVID-19 pandemic?” (2) *Change in smoking* measured by “Has your smoking pattern changed compared to that before the COVID-19 pandemic?” (3) *Changes in alcohol consumption* measured by “Whether your alcohol consumption has changed compare to that before the COVID-19 pandemic?” Each response used a 5-point Likert scale, which ranged from “increased a lot” = 1 to “reduced a lot” = 5; Data analyses on changes in smoking and alcohol consumption were limited to those who were current smokers ( $n = 1633$ ) and alcohol drinkers ( $n = 2354$ ) at the time of the survey.

#### Change in body weight

Participants' self-reported weight changes (current weight compared with weight before the COVID-19 outbreak) were measured. Responses included “no change (change within 1 kg)” = 1, “increased 1–2.5 kg” = 2, “increased >2.5 kg” = 3, “decreased 1–2.5 kg” = 4, “decreased >2.5 kg” = 5, and “I don't know” = 99.

#### Other study variables

Associations of sociodemographic and pandemic-related factors with mental distress were examined, and sociodemographic factors were included as covariates in the models for investigating the independent associations of mental distress with behavioral outcomes and body weight. Sociodemographic factors included age, gender, marital status (unmarried, married, cohabiting, widowed, divorced, or separated), ethnicity (Han and Not-Han), educational attainment ( $\leq$ primary school, secondary school/technical secondary school/technical school, and undergraduate/graduate school), current work status (students, have job, jobless, and retirement), residence (urban, town, and rural), health insurance (yes or no), and presence of any chronic diseases (total number of having chronic diseases were calculated).

Factors related to the COVID-19 pandemic included impact on family income (great impact, slight impact, and no impact), impact on daily life because of financial difficulties during the COVID-19 pandemic (great difficulty, slight difficulty, and no difficulty), and loss of job due to COVID-19 (yes or no).<sup>17</sup> Worry of contracting COVID-19 (not worried at all, a little worried, somewhat worried, and very worried) and perceptions about the likely of contracting COVID-19 (not at all likely, not that likely, somewhat likely, and very likely) were measured with respective single item adapted from a recent COVID-19 awareness, attitude, and action questionnaire.<sup>18</sup>

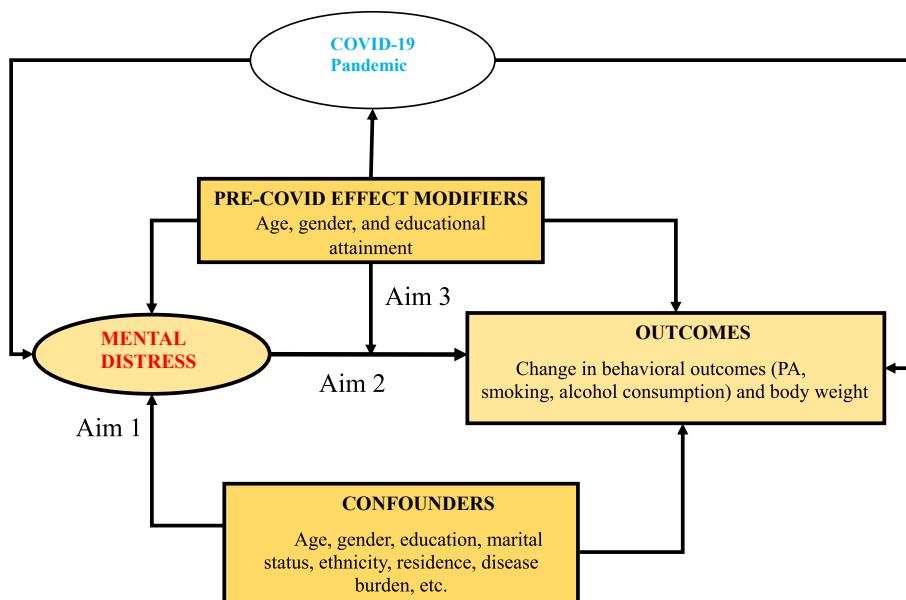


Fig. 1. Conceptual framework of the mental distress and behavioral outcomes and body weight during the pandemic of COVID-19.

Statistical analysis

First, descriptive analysis was conducted. Then, percentage differences in sociodemographic and pandemic-related factors by mental distress quartile were tested. For descriptive purpose, the quartiles were formed based on the summed score of the five items. Chi-squared test and analyses of variance were used to compare categorical and continuous variables, respectively.

For inferential analyses, we first evaluated the dimensionality and internal construct validity of mental distress scale using exploratory factor analysis in the overall sample. To account for the ordinal scale of the item responses, polychoric correlations were used in model fitting by treating the ordinal scale for each item as a discretized continuous latent response scale via a probit link. Based on principal components analysis in conjunction with Horn’s parallel analysis,<sup>19</sup> one common factor was found to be sufficient for explaining the covariation among the five indicators of mental distress. This one-factor model accounted for 81% of the total variation, with a Cronbach’s alpha of 0.87 (root mean square error of approximation [RMSEA] = 0.124, 90% confidence interval [CI] = 0.117–0.131; Comparative Fit Index [CFI] = 0.995; Tucker–Lewis Index [TLI] = 0.989).

To identify the correlates of mental distress (Fig. 1, Aim 1), we fit a structural equation models (SEMs) with mental distress factor as the dependent latent variable with covariates including socio-demographic and pandemic-related factors. The model was fit using a weighted least square minimum variance estimator. Fit statistics including the RMSEA, the Standardized Root Mean Residual, the TLI, and the CFI were used to assess model fitness.

To examine the impact of mental distress on change in behavioral outcomes and body weight (Fig. 1, Aim 2), we fit an SEM that consisted of a factor measurement model for mental distress and a multinomial logistic structural model for associations between mental distress during COVID-19 pandemic and changes in the behavioral outcome and body weight. Sociodemographic factors were adjusted in all models.

To explore the potential modification of the relationships between mental distress and behavioral changes by pre-COVID-19 factors, including age, gender, and educational attainment (Fig. 1, Aim 3), multiple-group SEMs were conducted under the assumptions of measurement invariance and structural variance. Separate models were fit for each outcome variable with and without constraining the path coefficient between mental distress and the outcome to be the same between levels of the effect modifier. The

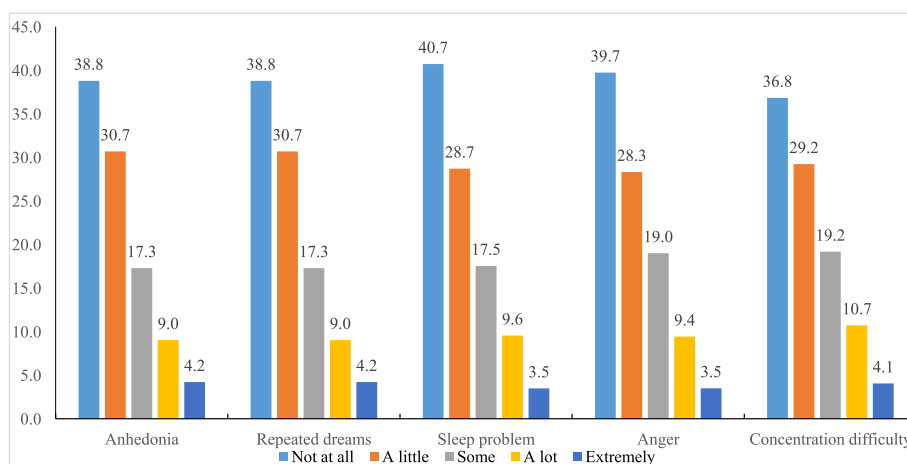


Fig. 2. Percentage of five items related to mental distress of Chinese adults (n = 10,545) during the pandemic of COVID-19.

effect modification was tested using the Satorra–Bentler scaled Chi-squared difference test.<sup>20</sup> The SEMs were fit using maximum likelihood with robust standard errors in Mplus version 8.

Analyses were performed using STATA 16.1 (Stata Corporation, College Station, TX, USA), except Mplus version 8.0 was used for SEM. Statistical significance was considered when  $p < 0.05$ .

## Results

### Mental distress

Fig. 2 shows the distribution of symptoms of mental distress of participants. Approximately 13% of them reported experienced “a lot” or “extreme” anhedonia, and a similar proportion reported sleep problems, repeated disturbing dreams or irritability, and anger in the past month. About 15% had “a lot” to “extreme” difficulties in concentrating.

### Sociodemographic and COVID-19-related factors associated with mental distress

The SEM with all covariates in the models revealed that those with higher levels of mental distress tended to be male, of younger age, cohabiting, absence of health insurance, either having a job or jobless, having a household size of >5 people, underweight, self-reported poor health, having chronic diseases, having family income impacted by COVID-19, experiencing at least mild difficulty with the family’s daily life due to COVID-19-related financial strain, being somewhat or very worried about contracting COVID-19, and perceiving self or family somewhat or very likely to contracting COVID-19. However, educational attainment, ethnicity, and residence were not associated with mental distress (Table 1).

### Adjusted associations between mental distress and changes in behavioral outcomes and body weight during the COVID-19 pandemic

Fig. 3 shows the distribution of changes in PA, smoking, alcohol consumption, and body weight by quartiles of mental distress summary score. Across the quartiles of the mental health score from low to high, the distributions of change in PA, change in smoking, change in alcohol consumption, and change in body weight changed significantly.

To account for the effect of baseline weight status on the associations between mental distress and changes in body weight, we stratified our population by weight status (i.e. underweight, normal weight, and overweight/obesity). After adjusting for covariates, among underweight participants, the odds of reporting an increase or decrease in weight by at least 1 kg versus no change was, respectively, 40% (95% CI: 1.20–1.63) and 63% (95% CI: 1.30–2.04) higher per one standard deviation (SD) increase in mental distress; among overweight or obese participants, the odds of reporting an increase or decrease of body weight by at least 1 kg versus no change was, respectively, 61% (95% CI: 1.46–1.78) and 48% (95% CI: 1.26–1.73) higher per one SD increase in mental distress; and among participants with normal weight, the odds of reporting an increase or decrease of body weight by at least 1 kg versus no change was, respectively, 52% (95% CI: 1.43–1.62) and 62% (95% CI: 1.45–1.82) higher per one SD increase in mental distress (Table 2).

After adjusting for covariates, among current smokers and alcohol drinkers, greater mental distress was associated with significant increase (“some” or “a lot”) in smoking (odds ratio [OR] = 1.42, 95% CI: 1.20–1.68 and OR = 1.54, 95% CI: 1.31–1.82 per one SD increase in mental distress). Similar increase was seen in

alcohol consumption (OR = 1.67, 95% CI: 1.45–1.92 and OR = 1.47, 95% CI: 1.24–1.75 per one SD increase in mental distress; Table 2).

Greater mental distress was significantly associated with both increase and decrease in PA (ORs ranged from 1.32 to 1.56; Table 2).

### Potential modifying effects of age, gender, and educational attainment on associations between mental distress and behavioral outcomes

Educational attainment significantly moderated the association between mental distress and change in PA. In general, the odds of PA increase “some” or “a lot,” or “decrease a little” among adults with undergraduate/graduate school (OR = 1.77, 95% CI: 1.58–1.98; OR = 1.64, 95% CI: 1.49–1.79; OR = 1.43, 95% CI: 1.30–1.56, respectively, per one SD increase in mental distress) were higher than those education attainment less than undergraduate/graduate school (OR = 1.36, 95% CI: 1.22–1.51; OR = 1.57, 95% CI: 1.42–1.73; OR = 1.25, 95% CI: 1.12–1.39, respectively, per one SD increase in mental distress; Supplemental Table 1).

Age significantly moderated the association between mental distress and change in PA. In general, the odds of PA “increase a little” or decrease “a little” or “a lot” (OR = 2.05, 95% CI: 1.72–2.46; OR = 1.54, 95% CI: 1.31–1.81; OR = 1.93, 95% CI: 1.62–2.29, respectively, per one SD increase in mental distress) among adults aged  $\geq 40$  years were higher than among those adults aged 30–39 years (OR = 1.50, 95% CI: 1.34–1.67; OR = 1.16, 95% CI: 1.03–1.30; OR = 1.61, 95% CI: 1.41–1.84, respectively, per one SD increase in mental distress) or 18–29 years (OR = 1.51, 95% CI: 1.38–1.65; OR = 1.40, 95% CI: 1.27–1.55; OR = 1.38, 95% CI: 1.24–1.54, respectively, per one SD increase in mental distress; Supplemental Table 2).

Gender significantly moderated the association between mental distress and change in smoking. Among current smokers, the odds of smoking increase “some” or “a lot” were significant among male (OR = 1.60, 95% CI: 1.37–1.87 per one SD increase in mental distress) not among female (OR = 1.11, 95% CI: 0.82–1.51 per one SD increase in mental distress; Supplemental Table 3).

## Discussion

To our knowledge, this is the first large nationwide survey in China on adults’ mental distress related to COVID-19 pandemic and its impact on changes in behavioral outcomes and body weight. The study provides an opportunity to explore patterns of associations between mental distress and changes in health-related behaviors within the COVID-19 context and highlights the issues that are likely to confront the public health systems in China and globally.

We found that economic impacts and risk for contracting COVID-19 negatively affected mental health. A reduction in family income or financial strains because of COVID-19 were associated with greater mental distress. The potential fallout of an economic downturn on mental health is likely to be profound. It will be vital to understand the mental health implications of policies to manage the pandemic in the short-term, and the challenges of reviving the economy in the longer term, all of which would inevitably have serious effects on mental health by increasing unemployment and poverty.<sup>2</sup> Worry about being infected and perception of self or family members being infected by the COVID-19 were associated with greater mental distress. These findings indicate that effective and rapid communication about the COVID-19 information is essential, as is ensuring that vital general and medical supplies are available to maintain a sense of security in the population.<sup>21</sup>

Greater mental distress was associated with both increase and decrease in PA. Although long-standing distress is known to be associated with chronic physical conditions, the impact of acute distress on behaviors is less well known. It could lead to positive

**Table 1**Study sample characteristics in all and by mental distress status of Chinese adults attending the 2020 China COVID-19 survey ( $n = 10,545$ ).

Variables	Mental distress quartile, $n$ (%) or mean $\pm$ SD					$P^a$	Mental distress total score (as a latent dependent variable) <sup>b</sup>					
	1 (low mental distress)	2	3	4 (high mental distress)	Estimate		SE	Estimate/SE	95% CI	$P^c$		
All	2223 (21.1)	2935 (27.9)	2614 (24.8)	2773 (26.2)								
Gender						<0.001						
Male	4605 (43.7)	968 (43.5)	1131 (38.5)	1092 (41.8)	1414 (51.0)		Reference					
Female	5940 (56.3)	1255 (56.5)	1804 (61.5)	1522 (58.2)	1359 (49.0)		−0.05	0.02	−2.43	−0.09	−0.01	0.015
Age (years)	31.8 $\pm$ 9.9	32.7 $\pm$ 10.3	33.2 $\pm$ 10.6	31.8 $\pm$ 9.9	29.5 $\pm$ 8.5		−0.01	0.00	−8.74	−0.01	−0.01	<0.001
Marital status						<0.001						
Unmarried	3427 (32.5)	646 (29.1)	910 (31.0)	850 (32.5)	1021 (36.8)		Reference					
Married	6545 (62.1)	1495 (67.3)	1905 (64.9)	1641 (62.8)	1504 (54.2)		−0.07	0.03	−2.49	−0.13	−0.02	0.013
Cohabiting	365 (3.5)	36 (1.6)	64 (2.2)	70 (2.7)	195 (7.0)		0.17	0.06	3.04	0.06	0.27	0.002
Widowed	64 (0.6)	12 (0.5)	17 (0.6)	11 (0.4)	24 (0.9)		0.02	0.13	0.16	−0.23	0.27	0.874
Divorced or separated	144 (1.3)	34 (1.5)	39 (1.3)	42 (1.6)	29 (1.1)		−0.15	0.09	−1.76	−0.32	0.02	0.078
Ethnicity						0.006						
Han	9942 (94.3)	2108 (94.8)	2782 (94.8)	2477 (94.8)	2575 (92.9)		Reference					
Not-Han	581 (5.5)	113 (5.1)	144 (4.9)	131 (5.0)	193 (7.0)		0.01	0.04	0.29	−0.07	0.09	0.773
Foreigner	22 (0.2)	2 (0.1)	9 (0.3)	6 (0.2)	5 (0.2)		0.02	0.18	0.10	−0.34	0.38	0.917
Educational attainment						<0.001						
Primary school	191 (1.8)	46 (2.1)	29 (1.0)	33 (1.3)	83 (3.0)		Reference					
school/Technical secondary school/Technical school	3985 (37.8)	835 (37.6)	979 (33.4)	970 (37.1)	1201 (43.3)		−0.07	0.07	−1.01	−0.22	0.07	0.315
Undergraduate/Graduate school	6369 (60.4)	1342 (60.3)	1927 (65.6)	1611 (61.6)	1489 (53.7)		−0.12	0.07	−1.66	−0.27	0.02	0.096
Health insurance (yes, %)						<0.001						
Yes	9238 (87.6)	1977 (88.9)	2655 (90.5)	2285 (87.4)	2321 (83.7)		Reference					
No	1307 (12.4)	246 (11.1)	280 (9.5)	329 (12.6)	452 (16.3)		0.117	0.033	3.53	0.052	0.182	<0.001
Residence						0.015						
City	6493 (61.6)	1414 (63.6)	1825 (62.2)	1576 (60.3)	1678 (60.5)		Reference					
Town	2470 (23.4)	505 (22.7)	682 (23.2)	653 (25.0)	630 (22.7)		0.01	0.02	0.38	−0.04	0.06	0.707
Village	1582 (15.0)	304 (13.7)	428 (14.6)	385 (14.7)	435 (16.8)		−0.05	0.03	−1.68	−0.11	0.01	0.093
Current work status						<0.001						
Students	2075 (19.7)	400 (18)	590 (20.1)	498 (19.1)	587 (21.2)		Reference					
Have job	7015 (66.5)	1554 (69.9)	1970 (67.1)	1727 (66.1)	1764 (63.6)		0.15	0.03	4.83	0.09	0.21	<0.001
Jobless	1135 (10.8)	199 (9)	256 (8.7)	320 (12.2)	360 (13.0)		0.16	0.04	3.94	0.08	0.24	<0.001
Retirement	320 (3.0)	70 (3.1)	119 (4.1)	69 (2.6)	62 (2.2)		0.08	0.07	1.17	−0.06	0.22	0.244
Household size (Total number)						<0.001						
1	92 (0.9)	27 (1.2)	22 (0.7)	24 (0.9)	19 (0.7)		Reference					
2	684 (6.5)	160 (7.2)	187 (6.4)	163 (6.2)	174 (6.3)		0.14	0.11	1.30	−0.07	0.36	0.195
3	4383 (41.6)	991 (44.6)	1379 (47)	1036 (39.6)	977 (35.2)		0.15	0.11	1.46	−0.05	0.36	0.146
4	2680 (25.4)	557 (25)	713 (24.3)	702 (26.9)	708 (25.5)		0.17	0.11	1.64	−0.03	0.38	0.101
5	1692 (16.0)	308 (13.9)	415 (14.1)	420 (16.1)	549 (19.8)		0.21	0.11	2.02	0.01	0.42	0.044
$\geq 6$	1014 (9.6)	180 (8.1)	219 (7.5)	269 (10.3)	346 (12.5)		0.25	0.11	2.35	0.04	0.46	0.019
Weight status												
Normal weight	6429 (61.0)	1397 (62.8)	1834 (62.5)	1601 (61.3)	1597 (57.6)		Reference					
Underweight	1093 (10.3)	200 (9.0)	219 (7.5)	290 (11.0)	384 (13.9)		0.11	0.03	3.40	0.05	0.17	0.001
Overweight	2108 (20.0)	436 (19.6)	642 (21.8)	506 (19.4)	524 (18.9)		−0.04	0.02	−1.47	−0.08	0.01	0.140
Obesity	915 (8.7)	190 (8.6)	240 (8.2)	217 (8.3)	268 (9.6)		−0.07	0.04	−1.88	−0.14	0.00	0.060
Impact on family income by COVID-19						<0.001						
No impact	1245 (11.8)	484 (21.8)	392 (13.4)	184 (7.0)	185 (6.7)		Reference					
Great impact	3997 (37.9)	624 (28.1)	883 (30.1)	1058 (40.5)	1432 (51.6)		0.15	0.04	3.80	0.07	0.22	<0.001
Slight impact	5303 (50.3)	1115 (50.1)	1660 (56.5)	1372 (52.5)	1156 (41.7)		0.14	0.03	4.19	0.08	0.20	<0.001
Impact on daily life by financial difficulties during the COVID-19 pandemic						<0.001						
No difficulty	3463 (32.8)	749 (33.7)	1281 (43.7)	1399 (53.5)	1273 (45.9)		Reference					
Great difficulty	2380 (22.6)	1090 (49)	1287 (43.8)	669 (25.6)	417 (15)		0.56	0.04	16.25	0.49	0.63	<0.001
Slight difficulty	4702 (44.6)	384 (17.3)	367 (12.5)	546 (20.9)	1083 (39.1)		0.35	0.03	14.34	0.30	0.40	<0.001

(continued on next page)



Table 1 (continued)

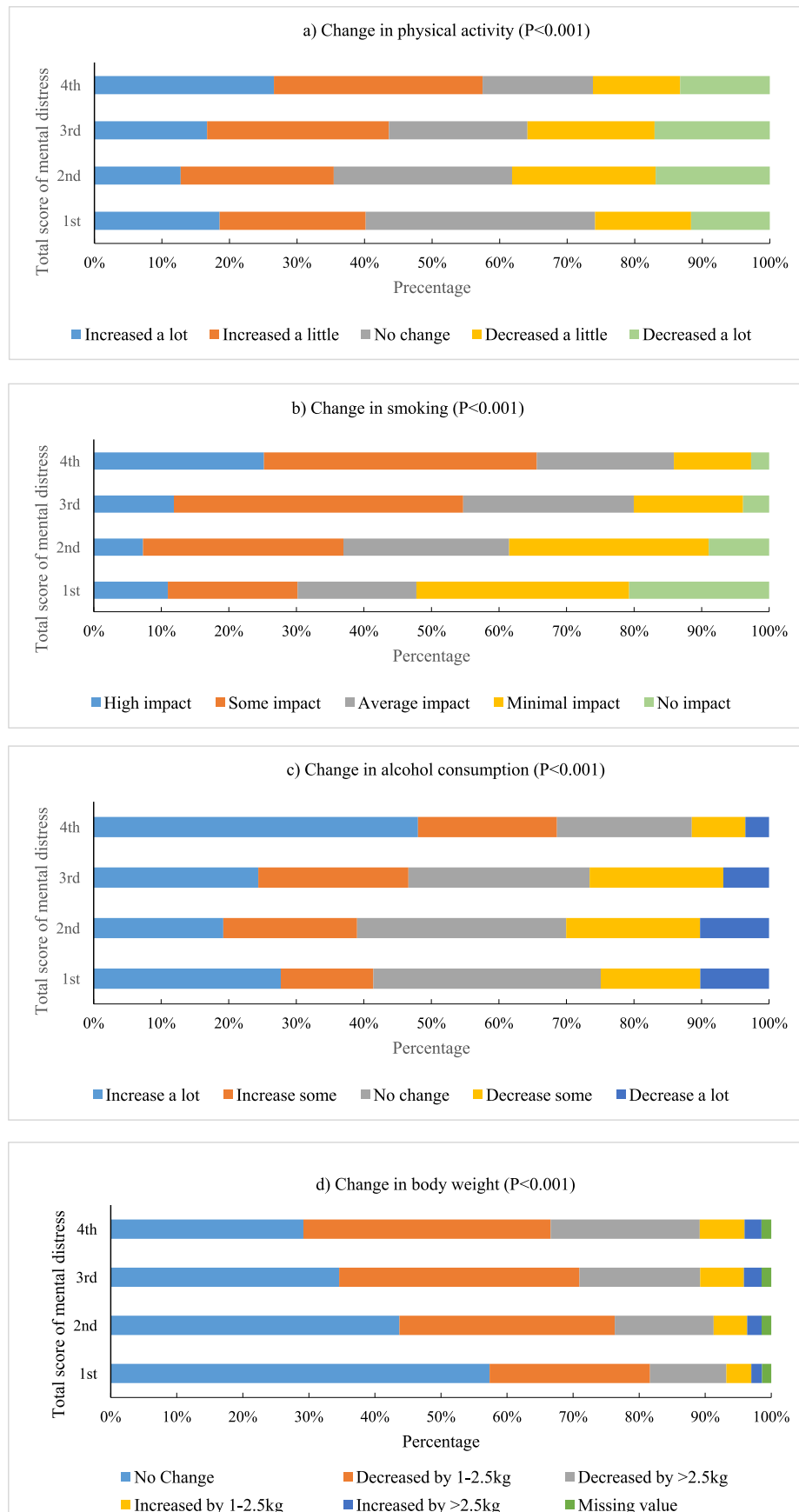
Variables	Mental distress quartile, <i>n</i> (%) or mean $\pm$ SD					<i>p</i> <sup>a</sup>	Mental distress total score (as a latent dependent variable) <sup>b</sup>					
	1 (low mental distress)	2	3	4 (high mental distress)	Estimate		SE	Estimate/SE	95% CI	<i>p</i> <sup>c</sup>		
Loss of job because of COVID-19						<0.001						
Yes	3561 (33.8)	520 (23.4)	751 (25.6)	932 (36.7)	1358 (49.0)		Reference					
No	6984 (66.2)	1703 (76.6)	2184 (74.4)	1682 (64.3)	1415 (51.0)		-0.12	0.02	-4.93	-0.16	-0.07	<0.001
Total number of chronic diseases <sup>d</sup>						<0.001						
0 (no chronic disease)	8431 (80.0)	1953 (87.8)	2528 (86.1)	2118 (81)	1832 (66.1)		Reference					
1	1024 (9.7)	142 (6.4)	266 (9.1)	272 (10.4)	344 (12.4)		0.23	0.03	6.66	0.16	0.29	<0.001
2	591 (5.6)	68 (3.1)	79 (2.7)	139 (5.3)	305 (11.0)		0.46	0.05	10.22	0.37	0.54	<0.001
$\geq 3$	499 (4.7)	60 (2.7)	62 (2.1)	85 (3.3)	292 (10.5)		0.55	0.05	12.28	0.46	0.64	<0.001
How worried are you about being infected with COVID-19?						<0.001						
Not worried at all	484 (4.6)	211 (9.5)	108 (3.7)	54 (2.0)	111 (4.0)		Reference					
A little worried	2375 (22.5)	603 (27.1)	785 (26.8)	515 (19.7)	472 (17.0)		0.02	0.05	0.49	-0.07	0.12	0.624
Somewhat worried	3608 (34.2)	651 (29.3)	1096 (37.3)	974 (37.3)	887 (32.0)		0.13	0.05	2.66	0.03	0.23	0.008
Very worried	4078 (38.7)	758 (34.1)	946 (32.2)	1071 (41)	1303 (47.0)		0.17	0.05	3.46	0.07	0.26	0.001
Do you think you or your family might be infected with COVID-19 this year						<0.001						
Not at all likely	2024 (19.2)	696 (31.3)	517 (17.6)	381 (14.6)	430 (15.5)		Reference					
Very likely	1237 (11.7)	215 (9.7)	182 (6.2)	247 (9.4)	593 (21.4)		0.27	0.04	7.36	0.20	0.34	<0.001
Somewhat likely	2573 (24.4)	380 (17.1)	625 (21.3)	743 (28.4)	825 (29.8)		0.21	0.03	7.10	0.15	0.27	<0.001
Not that likely	4711 (44.7)	932 (41.9)	1611 (54.9)	1243 (47.6)	925 (33.4)		0.04	0.03	1.50	-0.01	0.09	0.133
Self-reported health												
Excellent	4211 (39.9)	1371 (61.7)	1055 (36.0)	757 (29.0)	1028 (37.1)		Reference					
Very good	4235 (40.2)	648 (29.1)	1372 (46.8)	1170 (44.8)	1045 (37.7)		0.32	0.02	14.68	0.28	0.36	<0.001
Good	1790 (17.0)	182 (8.2)	473 (16.1)	594 (22.7)	541 (19.5)		0.48	0.03	17.21	0.42	0.53	<0.001
Fair/poor	309 (2.9)	22 (1.0)	35 (1.1)	93 (3.6)	159 (5.7)		0.80	0.05	15.73	0.70	0.90	<0.001

<sup>a</sup> Chi-squared test for categorical variables.

<sup>b</sup> Model fit statistics: RMSEA = 0.022 (90% CI: 0.021–0.023), CFI = 0.990, TLI = 0.988, SRMR = 0.015.

<sup>c</sup> Associations between sociodemographic and diseases factors and mental distress were examined using structural equation model, all the variables were in the same model.

<sup>d</sup> The chronic diseases measured in this survey included high blood pressure, diabetes, heart disease, stroke, tumor/cancer, asthma, chronic lung disease, chronic kidney disease, liver disease, compromised immune system, depression, and others.



**Fig. 3.** Distribution of changes in behavioral outcomes and body weight of Chinese adults (n = 10,545) by quartile of mental distress summary score.

**Table 2**

Adjusted<sup>a</sup> odds ratio (95% confidence interval) of change (vs no change) in body weight and behavioral outcomes of Chinese adults during COVID-19 pandemic associated with one standard deviation unit increase in mental distress.

Outcome	Baseline status	Response category	Total score of mental distress (per SD)	P
Change in body weight (n = 10,545)	Underweight (n = 1093)	No change	Reference	
		Decreased by ≥1 kg	1.63 (1.30–2.04)	<0.001
		Increased by ≥1 kg	1.40 (1.20–1.63)	<0.001
	Normal weight (n = 6429)	No change	Reference	
		Decreased by ≥1 kg	1.62 (1.45–1.82)	<0.001
		Increased by ≥1 kg	1.52 (1.43–1.62)	<0.001
	Overweight/Obese (n = 2876)	No change	Reference	
		Decreased by ≥1 kg	1.48 (1.26–1.73)	<0.001
		Increased by ≥1 kg	1.61 (1.46–1.78)	<0.001
Change in smoking (n = 1633)		No change	Reference	
		Increased a lot	1.54 (1.31–1.82)	<0.001
		Increased some	1.42 (1.20–1.68)	<0.001
		Decreased some	1.04 (0.87–1.23)	0.679
		Decreased lot	0.81 (0.65–1.02)	0.068
Change in alcohol consumption (n = 2354)		No change	Reference	
		Increased a lot	1.47 (1.24–1.75)	<0.001
		Increased some	1.67 (1.45–1.92)	<0.001
		Decreased some	1.15 (1.01–1.32)	0.032
		Decreased lot	1.12 (0.97–1.28)	0.116
Change in physical activity (n = 10,545)		No change	Reference	
		Increased a lot	1.53 (1.42–1.64)	<0.001
		Increased a little	1.56 (1.47–1.66)	<0.001
		Decreased a little	1.32 (1.24–1.41)	<0.001
		Decreased lot	1.51 (1.40–1.62)	<0.001

<sup>a</sup> Age, gender, marital status, educational attainment, ethnicity, residence, and number of chronic diseases were adjusted in all structural equation models. Separate models were fit for each outcome variable, respectively.

behaviors, for example, a survey in the United Kingdom (n = 344) found that negative emotions, especially anxiety in response to the COVID-19 pandemic, predicted adaptive health-compliant behavior change (e.g. hand washing).<sup>22</sup> A 2014 systematic review with 55 studies also indicated that individuals' response to mental distress because COVID-19 may vary by one's baseline attitudes to PA.<sup>23</sup> In some individuals, engaging in PA could be a task-oriented way of dealing with mental distress. PA may serve to both deal with and steer away from mental distress. In this study, for adults with higher mental distress, 57.5% of them reported increased "a lot" or "a little," and 26.2% of them reported decreased "a lot" or "a little." Additional strategies to promote PA among adults reduced their PA are needed.

However, our study indicates that some distressed people had chosen unhealthy coping behaviors. We found that among current smokers and alcohol drinkers, mental distress was associated with increase in smoking and alcohol consumption. This might also indicate that individuals with mental distress might increase these behaviors to cope with or relieve psychological distress during the pandemic.<sup>24</sup> Our findings indicate that people adopt both adaptive and maladaptive behaviors to cope with mental distress during the COVID-19 pandemic. Thus, one-size-fits-all public health strategies may not be the answer to the array of behaviors adopted to relieve mental distress and associated behaviors, and a more tailored approach might be warranted.

Age and educational attainment moderated associations between mental distress and change in PA. Our findings indicate that during this pandemic, the associations between mental distress and increase in PA were stronger among adults with more education and among adults aged ≥40 years. Among current smokers, increase in mental distress resulted in increasing "some" or "a lot" in smoking were found only among male not female. Future policy makers and researchers should consider these pre-COVID-19 effect modifiers to maximize the effects of psychological intervention on behavioral outcomes.

This study shows that acute distress of significant severity persisted in approximately 13% of the population as the immediate

effects of the lockdown began to ease. The fact that approximately 1 in 10 adults had significant mental distress symptoms was alarming. Mental distress is likely to be exacerbated when economic hardships, joblessness, and disparities set in. Moreover, our findings suggest variability in the associations of mental distress with adaptive and maladaptive coping behaviors. Those who are already vulnerable, for example, smokers and alcohol consumers, were more likely to adopt maladaptive coping behaviors. Effective ways must be found to provide both psychological and behavioral interventions, so chronic conditions can be avoided. Digital technology holds promise for improving access to and quality of mental health care.<sup>25</sup>

The present study has limitations. First, this survey was cross-sectional, making causal inferences difficult. A longitudinal study design could provide evidence on the potential causal relationships of mental distress with behavioral outcomes and body weight. Second, mental distress was based on anonymous self-administered questionnaires. However, anonymous surveys can better gauge people's honest answers and are more feasible in such special situations, such as COVID-19. Moreover, the items were extracted from PCL-C, not the full scale; this may have underestimated the prevalence of mental distress. Third, we could not rule out the possibility that some of the respondents might have been infected with COVID-19. As such, we were not able to assess the direct impact of COVID-19 infection on mental distress. Fourth, selection bias may exist because of the convenience and snowballing sampling method. Finally, we could have run a sensitivity analysis to see if the results might be different in some provinces, such as Hubei where the pandemic started. However, the sampling selection bias and uneven sample sizes across provinces may yield unreliable and biased estimates.

The study had a number of strengths. First, comprehensive information was collected from a large national sample from 31 province-level administrative units in mainland China. Second, our study for the first time provided the evidence on the associations between mental health and behavioral outcomes as the lockdown restrictions were being lifted following the COVID-19 pandemic.



In conclusion, economic impacts and risk for contracting COVID-19 negatively impact mental distress of adults, and greater mental distress was associated with some positive and negative changes in behavioral outcomes during the pandemic. Our findings can inform the design of tailored public health interventions to mitigate the negative consequences of COVID-19 and mental distress.

### Author statements

### Acknowledgments

The authors thank the study participants and collaborators and staff members who have contributed to the study. The authors thank Guorui Ruan, Lihua Yan, Bingtong Zhao, and Baibing Mi for their special assistance supporting this project.

### Ethical approval

Approval was obtained from the ethics committee of the Institutional Review Board at Xi'an Jiaotong University Health Science Center. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

### Funding

The project supported in part by research grants from the China Medical Board, China (Grant number: 16-262), the University Alliance of the Silk Road, China (Grant number: 2020LMZX002), and Xi'an Jiaotong University Global Health Institute, China.

### Competing interests

None declared.

### Authors' contributions

W.D.W., Q.L.X., L.M., Y.F.W., A.F.Y., and Z.M.S. contributed to the study design, data collection, and drafting the article. Q.L.X., L.W.G., and Z.M.S. contributed to the data analysis. L.M. and Q.L.X. drafted the article. Y.F.W. directed the data collection and provided administrative support for the project. All authors contributed to the interpretation of the data, commented on and revised the report, and approved the final version for publication.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2021.07.034>.

### References

1. Tan W, Hao F, McIntyre RS, et al. Is returning to work during the COVID-19 pandemic stressful? A study on immediate mental health status and

- psychoneuroimmunity prevention measures of Chinese workforce. *Brain Behav Immun* 2020;**87**:84–92.
2. Holmes EA, O'Connor RC, Perry VH, et al. Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *Lancet Psychiatr* 2020;**7**(6):547–60.
3. Wang C, Pan R, Wan X, et al. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *Int J Environ Res Publ Health* 2020;**17**:1729.
4. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open* 2020;**3**:e203976.
5. Özdin S, Bayrak Özdin Ş. Levels and predictors of anxiety, depression and health anxiety during COVID-19 pandemic in Turkish society: the importance of gender. *Int J Soc Psychiatry* 2020;**66**(5):504–11.
6. Huo MK, Yin Y, Jiang LZ, Duan XY. Survey of mental health status of residents in Wuhan, Huanggang, Kunming and Yuxi in the early stage of COVID-19 epidemic. *Int J Psychiatry* 2020;**47**:197–220.
7. Barr B, Taylor-Robinson D, Scott-Samuel A, McKee M, Stuckler D. Suicides associated with the 2008–10 economic recession in England: time trend analysis. *BMJ* 2012;**345**:e5142.
8. Stanislawski K. The coping circumplex model: an integrative model of the structure of coping with stress. *Front Psychol* 2019;**10**:694.
9. Geiker NRW, Astrup A, Hjorth MF, Sjödin A, Pijls L, Markus CR. Does stress influence sleep patterns, food intake, weight gain, abdominal obesity and weight loss interventions and vice versa? *Obes Rev* 2018;**19**:81–97.
10. Mannan M, Mamun A, Doi S, Clavarino A. Prospective associations between depression and obesity for adolescent males and females- A systematic review and meta-analysis of longitudinal studies. *PLoS One* 2016;**11**:e0157240.
11. Hoang D, Kristoffersen I, Li IW. All in the mind? Estimating the effect of mental health on health behaviours. *Soc Sci Med* 2019;**225**:69–84.
12. Stanton R, To QG, Khalesi S, et al. Depression, anxiety and stress during COVID-19: associations with changes in physical activity, sleep, tobacco and alcohol use in Australian adults. *Int J Environ Res Publ Health* 2020;**17**:4065.
13. Galea S, Merchant RM, Lurie N. The mental health consequences of COVID-19 and physical distancing: the need for prevention and early intervention. *JAMA Intern Med* 2020;**180**(6):817–8.
14. Reichenheim ME, Oliveira AG, Moraes CL, Coutinho ES, Figueira I, Lobato G. Reappraising the dimensional structure of the PTSD Checklist: lessons from the DSM-IV-based PCL-C. *Br J Psychiatry* 2018;**40**:154–62.
15. Chen Z, Lee L, Chen J, et al. Cohort profile: the Kadoorie study of chronic disease in China (KSCDC). *Int J Epidemiol* 2005;**34**:1243–9.
16. Yao Y, Liu G, Wang L, et al. Disease and disparity in China: a view from stroke and MI disease. *Int J Equity Health* 2019;**18**:85.
17. Conway LG, Woodard Shailee R, Zubrod A. *Social psychological measurements of COVID-19: coronavirus perceived threat, government response, impacts, and experiences questionnaires*. National Institute of Health; 2020. [https://www.nlm.nih.gov/dr2/Scales\\_from\\_Social\\_Psychological\\_Measurements\\_of\\_COVID-19.pdf](https://www.nlm.nih.gov/dr2/Scales_from_Social_Psychological_Measurements_of_COVID-19.pdf).
18. Wolf MS, Serper M, Opsasnick L, et al. Awareness, attitudes, and actions related to COVID-19 among adults with chronic conditions at the onset of the U.S. Outbreak. *Ann Intern Med* 2020;**173**(2):100–9.
19. Horn JL. A rationale and test for the number of factors in factor analysis. *Psychometrika* 1965;**30**:179–85.
20. Satorra A, Bentler PM. Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika* 2010;**75**:243–8.
21. Brooks SK, Webster RK, Smith LE, et al. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet* 2020;**395**:912–20.
22. Harper CA, Satchell LP, Fido D, Latzman RD. Functional fear predicts public health compliance in the COVID-19 pandemic. *Int J Ment Health Addict* 2020: 1–14.
23. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. *Sports Med* 2014;**44**:81–121.
24. McLachlan KJJ, Gale CR. The effects of psychological distress and its interaction with socioeconomic position on risk of developing four chronic diseases. *J Psychosom Res* 2018;**109**:79–85.
25. Naslund JA, Aschbrenner KA, Araya R, et al. Digital technology for treating and preventing mental disorders in low-income and middle-income countries: a narrative review of the literature. *Lancet Psychiatr* 2017;**4**:486–500.